A Comparison of the Effects of Yoga and Pilates for Pain, Physical Function, and Quality of Life in Adults Over 50 Years

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Abstract

This research compares the effects of yoga and Pilates for adults over 50 years, focusing on the outcomes of pain, physical function, and quality of life, exploring these activities in the relation to contraindications, physical activity guidelines, and participant history and experience in order to inform best practices in intervention design and delivery.

A narrative review was conducted to establish an understanding of the older population and the importance of their physical and psychosocial health, as well as to define mat-based yoga and Pilates as movement practices, and to locate their role in public health policy. Due to increases in life expectancy and rises in the age of pension eligibility, the United Kingdom's population aged between 50 and state pension age is growing. Older people are more prone to musculoskeletal conditions, but pain and inactivity can be offset by appropriate physical exercise, which is important for individual well-being and keeping people in work. Yoga is recommended for strength in U.K. government physical activity guidelines and both yoga and Pilates are recommended for back pain by the National Health Service. Yoga and Pilates are the top group exercise choices in the United Kingdom and particularly popular among women, who are more prone to experience chronic musculoskeletal conditions. The two practices are customarily classified together and denoted as "mind-body" classes in exercise venues, yet there is a paucity of research comparing the two. The present research defines and differentiates yoga and Pilates in a contemporary context, establishing best practices for adults over 50 years, including but not limited to those with chronic musculoskeletal conditions, and comparing their respective benefits using a mixed-methods approach.

Two systematic reviews by the researcher found that both yoga and Pilates are safe, adaptable interventions for chronic musculoskeletal conditions in a >70% female sample

with a mean age over 50. Yoga was effective for osteoarthritis and neck pain, improving physical function for osteoarthritis and sarcopenia. Pilates was effective for back, neck, osteoarthritis, and osteoporosis pain. Back pain and osteoporosis patients showed statistically significant functional and quality of life effects. The Pilates studies captured benefits over a broader range of outcomes including physical function and quality of life than did yoga, without specific modifications, and neither was found superior to other exercise comparators. This finding suggested that preferences are not always linked to orthopaedic health outcomes and informed the use of a mixed-methods approach for a better understanding of what participants experience, and what is important to them, when exercising.

A survey of yoga and Pilates participation in adults over 50 years (N=35) was then conducted, exploring exercise habits, motivators, barriers, and perceived benefits as experienced in real-world settings, where participants attend based on preference rather than assignment, and interventions are not necessarily customised for this age group as they are when in a trial setting. Participants of both tended to be long-term practitioners, indicating the appeal and sustainability of these practices in later life. However, the survey revealed that while yoga was a more popular and widely available choice than Pilates, it was less suitable for those with existing injuries, and had a higher rate of injury in participation. Back, knee, and shoulder were identified as the most prevalent injury sites. This finding further suggested that motivations to practice physical yoga may be rooted in non-physical outcomes such as mental well-being, and this supported the implementation of qualitative methods to understand this phenomenon.

The systematic reviews and survey data were then used to design a separate yoga and Pilates intervention for delivery to adults over 50 years in a comparative trial. The effective studies located in the systematic reviews, as well as existing literature on yoga injury, were used to inform exercise choice and progression, intervention frequency and duration, and outcome measures. The qualitative survey data coupled with existing yoga participation literature and studies of the use of Pilates in physiotherapy informed the approach to teaching, which emphasised a positive participant experience thought to support adherence and outcomes. The interventions were tested in an eight-week comparative feasibility trial (*N*=24) measuring back, knee, and shoulder pain on a Numerical Rating Scale (NRS), and physical function and quality of life on the SF-36. Thematic analysis of a post-trial survey was used to add depth to the finding, and in-depth interviews were used to assess the role of personal history and preference in participant experience.

Results show that Pilates significantly reduced back pain (*P*=0.024, effect size 0.65), and there were non-statistically significant reductions to pain overall. The research supports the recommendation of Pilates for back pain in general and the use of the trial's novel intervention specifically, a positive finding for the population of interest, as back pain is a leading cause of early retirement. The thematic analysis of the post-trial survey and the interviews identified themes of stress-reduction and self-confidence for yoga and Pilates participants respectively, with the interviews revealing strong personal preferences. This finding highlighted the relevance of qualitative research in assessing subjective interventions and suggested that a high importance should be placed on personal histories and preferences in exercise choice and referral. Pilates and yoga were both found to be suitable movement practices for older adults, with a recommended emphasis on personalisation and accessibility, awareness of contraindications, and evidence-based modifications for existing musculoskeletal conditions. Yoga education for physiotherapists and a systematic approach for both yoga and Pilates are recommended where the goal is specific physical or functional outcomes and the safe fulfilment of exercise guidelines.

The research fills a gap in existing knowledge by comparing yoga and Pilates, an under-explored area of study at the time of writing, using populations with chronic conditions as well as healthy older adults, to reflect real-world group exercise settings. The creation of a survey suitable for further testing and the creation and testing of original evidence-based course protocols provide new insight into the views, motivators, and barriers amongst over-50s regarding yoga or Pilates, with contextualisation and discussion of contraindications. The mixed-methods approach, underpinned by a rationale rooted in a constructivist and interpretivist position, provides a philosophical reasoning and critique on study design for analysis of subjective interventions.

Covid-19 Impact Statement

The Survey and Trial phases of this research, discussed in chapters four and six respectively, were impacted by the Covid-19 pandemic in the following ways:

Ethical approval for the yoga and Pilates participation survey (Chapter Four) was submitted in January 2020 at the beginning of the pandemic before the “lockdowns” and approved April 3, 2020. Recruitment and data collection was delayed due to the closure of group exercise facilities from March 20, 2020. Once restrictions were temporarily lifted, recruitment for the survey, from participants in local yoga and Pilates classes, took place from August 10 to October 10, 2020, and data was collected from October 14 to November 28, 2020. However, classes were at lower-than-normal capacity, attributable to the caution and uncertainty about further closures which affected the group exercise sector during this period. This resulted in a smaller than usual pool of people from which to recruit. For this reason, the inclusion criterium was not limited to those over 50 with chronic musculoskeletal conditions but included any participants over 50. This attained the small but, at the time, feasible sample of 35.

By December 2020 Covid-related restrictions were once again in place. Ethical approval for the yoga and Pilates trial was provisionally granted December 17, 2020, for implementation once restrictions were lifted. Due to further disruption to group exercise throughout 2021, the trial was postponed until 2022. An amendment to the ethics application was submitted in January 2022 with a re-designed protocol that could be administered remotely or via a hybrid of live and online session, in the event of a return to government restrictions on group gatherings. (A contingency plan whereby group classes would be delivered by Zoom was drafted but not utilised as there were no further Covid-related restrictions at the time of the trial). However, the uncertainly during this period required concessions to the methodology regarding the choice of outcomes measures so that measurements could be gathered remotely if necessary. The Senior Fitness Test, which had originally been considered for measuring physical function, was replaced by the physical function domain of the SF-36. The Visual Analog Scale, initially considered for measuring pain (as it was the most prevalently used in the statistically significant studies in the systematic reviews), was replaced with a Numerical Rating Scale. Both the SF-36 and the Numerical Rating Scale could be embedded into an online platform for participant completion and researcher scoring. The inability to use the Senior Fitness Test meant that physical function was self-reported (on the SF-36) rather than measured objectively in-person in physical tests (which comprise the Senior Fitness Test), which reduced the detail and certainty of data collected for this outcome.

Introduction

Research Aims, Context, and Definition of Central Terms

This research examines and compares the effects of yoga and Pilates, and asks whether superiority of one over the other can be determined with a focus on the outcomes of pain, physical function, and quality of life. It evaluates how yoga and Pilates are being accessed and experienced by an older population, and tests best practices when working with this population in real-world settings.

Questions explored in this research originate from the empirically observed dichotomy that the benefits attributed to yoga and Pilates in later life are sometimes offset by barriers to participation and age-related conditions. The research questions stem from a professional curiosity about how to optimise the practise and teaching experience in view of perceptions, limitations, and contraindications that may be related to ageing. The overall aim is to inform class content, teaching, and exercise referral related to the therapeutic use of these forms of physical activity.

This is a novel project using mixed methods to explore an inter-related collection of questions. The research seeks to delve into the realms of yoga and Pilates delivery from the perspective of the older learner in a creative research process that both answers questions and ask new ones. While quantitative studies are useful in positioning the benefits of Pilates and yoga in the scientific literature, bridging the gap between biomedicine and "alternative" medicine, studies of this kind do not always capture the complexities of human experience. Qualitative research allows for an exploration of subjective experiences, but due the aspects of researcher involvement and data interpretation this can present challenges in maintaining, demonstrating, and assessing rigour (Anderson, 2010). Therefore, in order to offset the limitations of solely using qualitative or quantitative, a mixed-methods approach was adopted, with the research guided by a series of research questions, involving theory building from the data collection in an exploratory process throughout the research. Further discussion of each methodology is included in the subsequent chapters.

Figure 1 illustrates the origins of the research questions, objectives, methodologies and overall aims, and how they arose from the researcher's observations and experiences prior to the commencement of the documented research (Figure 1).

Figure 1. *Origins of Research Aims and Objectives*

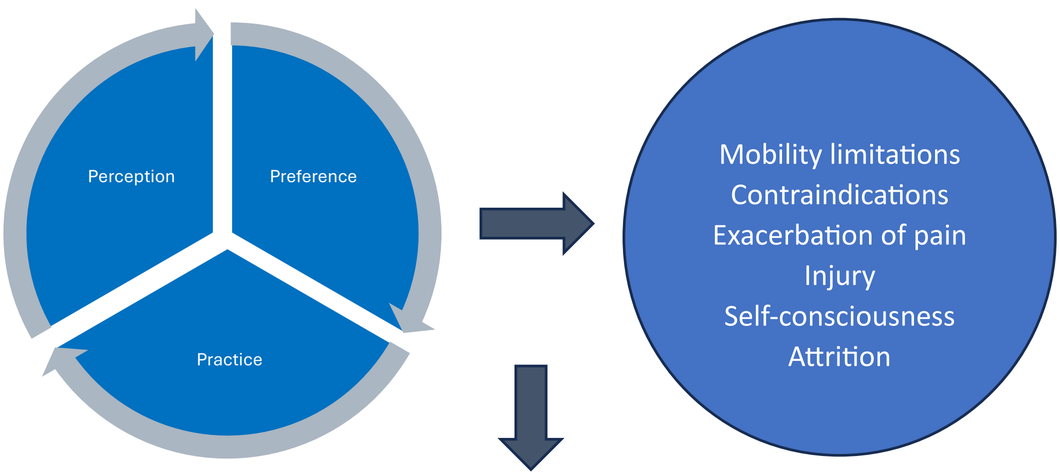
Informal Field Data from Researcher's Experience Prior to Documented Research:

Common conditions presented among students known or thought to be over 50 years:
back pain osteoarthritis difficulty with balance

Reputed benefits of yoga expressed among older students:
balance flexibility back pain reduction

Reputed benefits of Pilates expressed among older students:
core strength flexibility back pain reduction

Issues arising:



Questions, objectives, and methodologies arising:

Questions	Objectives	Methodology
What might be the benefits of yoga and Pilates from a musculoskeletal health perspective?	Assess efficacy and safety	Narrative Review Systematic Reviews
Are benefits found in controlled trials experienced in real world practice?	Consult target population	Survey
Should/how should we make yoga and or Pilates safer and more accessible to older adults?	Develop and test protocols	Feasibility trial
How can these resources be developed?	Consider : Impact Future research questions Means of dissemination	Triangulation of findings
Overall Aims		
Inform exercise referral, teaching, and therapeutic use of yoga and Pilates for older adults		

A narrative review was undertaken to establish definitions of yoga and Pilates and an understanding of the ageing population, to position yoga and Pilates within current physical activity and healthcare guidelines based on existing literature around benefits for this population, and to locate research gaps to justify further study. In this regard, the review borrows the PCC mnemonic (Population, Concept, Context) from Peters (2016) with respect to objectives for scoping reviews (Peters, 2016). The purpose of a narrative review is to provide background information and a broad overview of the research topics (Sukhera, 2022) and as such it is acknowledged that the literature search was not exhaustive, search and inclusion and exclusion criteria were subjective and assessment of quality was not included. The aim of a narrative review is not to be reproduceable (Ferrari, 2015) but to provide a meaningful summary of the topics (Sukhera, 2022), and in the case of this project this was considered an appropriate method for providing introductory context for the wider research.

The literature search strategy is shown in Appendix I.

Definition of Yoga

Yoga is a Sanskrit word translated as “yoking” and sometimes assigned the meaning “union” in English (Foxen & Kuberry, 2021). A rudimentary definition is offered by Sarbacker (2021) who describes yoga as

> a set or a system of techniques of mind-body discipline, rooted in Indian religion and philosophy, that aims to transform a practitioner into a more perfect being so as to 1) make them more powerful and/or to 2) facilitate liberation from worldly affliction. (Sarbacker, 2021, p.34)

However, the mind-body disciplines referred to by Sarbacker (Sarbacker, 2021) have continuously evolved contemporaneously in relation to culture, and a single definition of yoga has never been established or agreed upon (Foxen & Kuberry, 2021). Yoga is therefore a broad term which historically has been used in relation to a diversity of spiritual and philosophical practices, meditation techniques, as well as the physical postures and breathing exercises now commonly referred to as Hatha yoga (Foxen & Kuberry, 2021; Jain, 2015). It is therefore important to specify which practices are being referenced when the term "yoga" is used in the context of this study.

As Hatha yoga has come to dominate the practice of yoga in the second half of the twentieth century, the word "yoga" has become the colloquial term for the physical practice. In order to distinguish contemporary physical yoga practices from yoga as an esoteric abstraction, religious endeavour or philosophy, recent scholarship has utilised the term "Modern Postural Yoga" (Michelis, 2008; Singleton, 2010) or simply "Postural Yoga" (Jain, 2015). As the present research centres on yoga as a movement practice delivered in a western health and fitness context, this work will use the concept of "Modern Postural Yoga" as the convention being studied but will refer to this with the generic term "yoga".

A defining characteristic of this type of yoga is its postures, also called poses or asanas, which are practised barefoot on a mat in standing, sitting, prone, supine, or inverted positions. Postures can involve all types of movements of the trunk, limbs, and extremities (i.e., flexion, extension, abduction, adduction, rotation, and circumduction) often in a broad range of motion, through any plane of motion and involving compound movements (Coulter, 2001; Kaminoff & Matthews, 2012). Standing postures involve isometric contractions that develop muscle strength and endurance, often incorporating an active stretch of the opposing muscles groups. These are balanced with static stretches performed sitting, prone or supine (Coulter, 2001; Kaminoff & Matthews, 2012). More dynamic forms of yoga involve flowing from one pose to another in synchronicity with the breath, often in a repeated pattern of movement. Even in its dynamic forms, yoga remains a low impact activity with no plyometric movement. There is also a strong emphasis on balance, which cultivates mental concentration and strength, as well as endurance in the muscles of the weight bearing limbs (Coulter, 2001; Kaminoff & Matthews, 2012).

Postures are performed with attention and precision which cultivates focus and the experience of proprioception and kinesthesia (Nevrin 2008). The breath is used both to guide and support movement and to act as a point of focus. Stand-alone breathing, or *pranayama*, exercises are performed in a seated or supine position are also used to aid relaxation (Nevrin 2008; Sorosky et al. 2008).

The practice can be performed alone by the student but is often led by a teacher either one-to-one or in group classes. Yoga practices vary in terms of name, technique, tempo, and emphasis, according to a number of schools that have developed both in India and the west (Sorosky et al., 2008).

For the scope of this study as a whole, "yoga" will refer to the practice of physical postures or poses (asanas) in combination with breathing exercises (*pranayama*) and relaxation, which have been identified as key components by yoga historians Michelis (2008), Singleton (2010) and Jain (2015) and in academic and clinical research (Chang et al., 2016; Jain, 2015; Michelis, 2008; Nevrin 2008; Singleton, 2010; Sorosky et al., 2008; Tilbrook et al., 2011; Wieland et al., 2017). The physical, mat-based practice of yoga was chosen, rather than solely *pranayama*, meditation or philosophical teachings, in order to align with the aims of the research in assessing yoga in the context of physical activity participation amongst older adults, as well as its suitability for comparison with Pilates, another mat-based physical exercise technique. This interpretation of yoga will be applied to all studies included in this work to ensure parity of focus.

Definition of Pilates

The Pilates method was created and developed by the German Joseph Pilates, from whom the practice takes its name. Following health problems as a child, Pilates developed an interest in yoga, martial arts, Zen meditation, and Greek and Roman forms of exercise. During World War I, Joseph Pilates served as an orderly in a hospital on the Isle of Man, during which he began to develop a method of rehabilitation for non-ambulatory soldiers. In 1923, he brought his methods to the United States where he continued to develop his work, using both equipment and mat exercises (Kloubec, 2011).

This research will focus on the mat-based Pilates repertoire as the accessibility and adaptability afforded to it by the absence of large, studio-based equipment place it on parity with yoga for comparison and for the facilitation of implementing trial protocols for the present research study. Mat Pilates repertoire traditionally comprises of a series of approximately 50 repetitive exercises. Trunk and pelvic musculature, including abdominal, gluteal, and paraspinal muscles (Koublec, 2011) are consciously contracted as limbs are moved through a controlled range through various planes of motion with the objective of creating strength, endurance, and flexibility and improving posture and balance. Many mat exercises are performed in a supine, prone or seated position. Body weight provides the main resistance and body positions can be changed or limbs moved to create longer levers producing more challenge (Koublec, 2011; Sorosky et al., 2008).

The original principles set out by Pilates were centring, concentration, control, precision, breathing, and flow. In a systematic review aimed at defining Pilates, Wells and colleagues (2012) further identified posture, flexibility, movement control, strength, core stability, and mind-body connection as additional components (Wells et al., 2012).

It could be argued that Pilates was originally created with specific physical functional goals in mind (Wells et al., 2014a) whereas yoga has a fundamentally philosophical underpinning pertaining to the union of mind and body and a balanced, focused psychological state.

Nonetheless, Pilates shares many characteristics with yoga. Although the exercises differ from yoga, notably in that they involve repetitions through a moderate range of motion rather than the broad and sometimes extreme positions held in yoga, some of the benefits are similar, such as improved strength, flexibility, and balance. Like yoga, Pilates is also a low impact practice with a strong focus on correct technique which develops proprioception and creates motor patterns that strengthen weak muscles (Wells, et al., 2014a).

There is also a notable emphasis on the breath in Pilates, although this has a physiological function not generally found in yoga in that a forced exhalation is often cued specifically in tandem with contraction of the transverse abdominal muscle (Koublec 2011). As the transverse abdominal muscle contracts, it is accompanied by a contraction of the multifidus and pelvic floor muscles creating intra-abdominal pressure for spinal support (Koublec, 2011).

Pilates exercise is usually led by a qualified teacher or in the case of "clinical Pilates" by a Pilates-trained physiotherapist, either one-to-one or in group classes. Pilates, like yoga, is not a word protected by trademark, and this has led to heterogeneity in the form of various adaptations and interpretations. As with yoga there are also a number of schools of Pilates and modifications to the traditional repertoire made in the light of recent scientific knowledge and often for remedial effect (Wells, et al., 2012). However, as Pilates stems from the work of one man and has developed over a shorter period of time than yoga, there is less diversity in its form and a more precise definition of its repertoire.

The present work acknowledges that diversity in practices necessitates clarity around the exercises and approach taken in any single academic study for deductive conclusions to be reached and recommendations made. Where meta-analyses are concerned, the broadness of Pilates and yoga practices may result in an inherent limitation on generalisation, which need not preclude or devalue this type of research but will be discussed and acknowledged.

The Ageing Population

The percentage of the U.K. working population aged between 50 years and the state pension age is predicted to rise from 26% in 2012 to 35% in 2050 – an increase of approximately five million people (Harper et al., 2016). This is partly a reflection of proposed rises to the state pension age, from 66 to 67 between 2026 and 2028 and to 68 between 2044 and 2046, subject to review and based on life expectancy (Department for Work and Pensions, 2023). According to the Centre for Ageing Better report *The State of Ageing in 2020*, there were four million more workers aged 50 and over in 2020 than there were in the year 2000, compared to 1.5 million more workers aged between 25 and 49, and the employment rate of people aged between 50 and 64 has increased by 12 percentage points (Centre for Ageing Better, 2020). However, people over the age of 50 also had a higher rate of long-term unemployment and were twice as likely to have been unemployed for over 12 months than the youngest age group (13 % for age 18-24, 20% for age 25-49, 29% for age 50+) (Centre for Ageing Better, 2020). Health was the leading reason for people of this age range to be out of work (Centre for Ageing Better, 2020) and for all adults, musculoskeletal conditions were the most common reason for lost working days between 2010 and 2020

(Office for National Statistics, 2021). The health and productivity of this ageing workforce will have an impact on economic success (Harper et al., 2016) as well as on personal well-being. While age can exacerbate musculoskeletal conditions and limit physical activity (Hoy et al., 2014), these factors can be mitigated with exercise, which has been shown to reduce pain and inactivity for older adults (Prince et al., 2015) and prevent age-related conditions including sarcopenia, osteoporosis, and the risk of falls (Paintin, Cooper, & Dennison, 2018). The current recommendation is that adults of all ages engage in a mixture of aerobic and strengthening exercise, with the guidelines the same for general adults and older adults in recommending 150 minutes of moderate or 75 minutes of vigorous physical activity weekly, two days per week devoted to improving strength, and older adults advised to work on improving balance to prevent falls (Department of Health and Social Care, 2019). Therefore, there is a clear value to exercise interventions, including forms of yoga and Pilates, that are accessible to middle-aged and older adults, including those with chronic conditions. These may reduce symptoms of age-related conditions, slow their progression, and allow continuing participation in work and other activities.

Yoga and Pilates – Justification for Further Study

Both yoga and Pilates are recommended for back pain by the NHS (NHS, 2020; Royal Berkshire NHS Foundation Trust, 2022), with yoga depicted for strength on the Department of Health and Social Care's physical activity guideline infographic (Department of Health and Social Care, 2019).

Evidence has shown that yoga and Pilates provide general fitness and psychosocial benefits for older, working adults and those with chronic musculoskeletal conditions: Postural yoga has also been credited with increasing strength and stabilisation (Hayden et al., 2005) as well as improving flexibility and balance (Roland et al., 2011; Ross & Thomas, 2010). As yoga increases the ability to pursue daily activities with greater strength and reduced pain there are potential consequences for reducing anxiety levels and increasing stress resistance (Nevrin, 2008). These benefits have been shown to have preventative value. Research has shown that yoga reduces back pain and perceived stress at work (Hartfiel et al., 2011; Hartfiel et al., 2012) as well as being cost-effective in reducing absenteeism (Hartfiel et al., 2017).

Likewise, in Pilates the focus on increasing strength, control, and function can help with the reduction and self-management of pain and to challenge fear and avoidance of physical activity (Wells et al., 2014b). Pilates has also been shown to allow people with chronic musculoskeletal conditions the functional ability and independence to participate actively in hobbies and sports, providing a positive social function and psychological impact both within the Pilates classes and beyond (Gaskell & Williams, 2018).

Studies have also shown the benefits of yoga and Pilates for older adults and health conditions directly related to age. Both are low impact and have the potential to be adapted and scaled to meet the needs of a range of abilities. The World Health Organization (Europe) lists prevention of falls and the promotion of physical activity as the top two of five key priorities in its policies and priority interventions for healthy ageing (World Health Organization Europe, 2012). With their emphasis on balance and proprioception, yoga and Pilates have both been shown to reduce the risk of falls in older people (Barker et al., 2015; Hamrick et al., 2017; Newell et al., 2012; Pata et al., 2014; Roland et al., 2011; Youkhana et al., 2016). Pilates is clinically effective for improving outcomes for patients with osteoporosis, including secondary pain related to fractures, back pain resulting from postural changes, physical functioning, quality of life (Küçükçakir et al., 2013; Oksuz & Unal, 2017) as well as strength, flexibility, and balance (Oksuz & Unal, 2017). Pilates and has also been shown to significantly improve mental health and happiness in menopausal women (Abdoshahi, 2023). Yoga improves posture in older adults with hyperkyphosis (Greendale et al., 2009) and can contribute to mental and social well-being in later life (Tew et al., 2017).

Both practices align with guidelines for back pain indicating the high importance of non-pharmacological interventions to address pain, comorbidities, and consequences (Maher et al., 2017; National Institute for Health and Care Excellence, 2016).

The narrative review found encouraging evidence of the benefits of yoga and Pilates across a range of ages, but much of this was sourced from controlled trial scenarios involving carefully designed protocols. Therefore, a key aim of the present research was to use a triangulated approach that looks beyond secondary and primary quantitative randomised controlled trial data and incorporates survey and qualitative methods to establish whether the benefits promoted in guidelines are experienced in real-world practice for older adults, and to identify any contingencies. Further, given the frequent coupling and association of yoga with Pilates in fitness community settings, little research was sourced comparing the two. Informed by the narrative review on the importance of healthy ageing, the present research compares the respective effects of Pilates and yoga on adults over 50 years, with a focus on chronic musculoskeletal condition symptom-relief, injury prevention through the development of evidence-based, adaptable protocols, and potential improvements to self-efficacy and quality of life informed by experience-based qualitative data from participants.

Establishing an Ontological and Epistemological Position

The approach to understanding and interpreting phenomena that arise from the study of yoga and Pilates should be positioned within the context of ontology, the study of what exists and the relationships between these entities, and epistemology, or means of gaining and expressing knowledge (Snape & Spencer, 2003). For this purpose, two ontological positions, objectivism and constructionism and their corresponding epistemological positions, positivism and interpretivism, have been considered, using the definitions and paradigm set out by Al-Saadi (2014), and based on related literature (Bryman, 2008; Cohen, Manion, & Morrison, 2007; Crotty, 1998; Denzin & Lincoln, 2005; Hennink, Hutter, & Bailey, 2011; Ormston et al 2014; Snape & Spencer, 2003; Wellington, 2000): Objectivism maintains that external reality exists independently of human understanding or interpretation, that only the material, physical world is real, and that life is defined in measurable terms rather than inner experiences (Al-Saadi, 2014). Constructivism, in contrast, maintains that reality can only be understood by way of the human mind and socially constructed meanings, is therefore subjective, and is understood only through estimated or approximate observations or views (Al-Saadi, 2014). Positivism maintains that the world is independent of and unaffected by the researcher, that objective and value-free inquiry is possible using observational and explanatory methods yielding hard, tangible, and objective facts that are distinct from values (Al-Saadi, 2014). Interpretivism, in contrast, views facts and values as indistinct, acknowledging that the researcher's and participant perspective and values impact the research (Al-Saadi, 2014). In the approach taken in considering the ontological and epistemological positions, the objectivist/positivist position was aligned with quantitative methodologies and deductive research in which data is collected to test an existing theory, while the constructivist/interpretivist position was aligned with qualitative methodologies and inductive research whereby a theory is generated from the data collected. The methodologies used in the present research were then considered to establish its position within this framework to best capture what can be known about yoga and Pilates.

While it is possible to take objective, quantitative outcome measures from yoga and Pilates interventions to test hypotheses and explain their effects, their nature as mind-body practices that promote not only somatic breath-based and postural awareness but self-enquiry and behavioural self- awareness lends them to exploratory, qualitative methods for further depth and hypothesis generation. Therefore, following the narrative review stage which established the direction of the research, a mixed-methods approach was taken using four methodologies: Systematic reviews with the primary aim of establishing the effects of yoga and Pilates on pain, physical function, and quality of life for the population of interest; a survey, for comparison with the systematic reviews, of real-world community yoga and Pilates practice which included both quantitative (statistics) and qualitative data collection (thematic analysis of text survey responses); a trial of a customised, evidence-based yoga and Pilates intervention, for further comparison and contrast with the systematic reviews and survey data, which included both quantitative (statistical analysis of outcome scores for pain, physical function, and quality of life) and qualitative data collection (thematic analysis of post-trial survey data); a series of trial participant interviews to add further depth to the trial data, collecting solely qualitative data for thematic analysis.

Although both quantitative and qualitative data was gathered, this research is presented from a constructivist and interpretivist perspective. The research deals with two independent variables, the yoga and Pilates interventions, whose definitions are heterogeneous, with dependent variables, pain, physical function, quality of life and other aspects of exercise participation mediated by the experiences of human subjects. The movement practices of the human body are assigned meaning and organised nominally to construct “yoga” or “Pilates” as entities, but these things do not exist independently of the teacher or practitioner, as it is the perspectives and values of teacher and participants that shape the phenomenon of yoga or that mediate the principals of Pilates to differentiate these movement practices qualitatively from other forms of exercise. These elements align with the constructivist notion of entities as social constructs whose existence and meaning is contingent on human interpretation. The narrative review to define central terms and construct context is aligned with constructivist and interpretivist paradigms (Sukhera, 2022). Further, the quantitative data of the primary research was yielded from self-reported outcome measures: In the systematic reviews the data on the key outcomes of pain and quality of life (and in some cases physical function) were measured using self-reported outcome tools, and in the trial which measured the same outcomes, all measures were self-reported, meaning that even though this data is quantitative it cannot be truly objective. The same could be said of the survey statistics, which are only as reliable as the self-selecting respondents, whose responses may have been influenced by their awareness of their involvement in a research project. This notion aligns with the constructivist idea that aspects of reality can be subjective and dynamic, and knowledge of them an estimation. The role of the researcher in the design of the survey and delivery of the trial interventions, the additional exploratory qualitative methodologies which were thematically analysed and interpreted by the researcher, and the utilisation of an explanatory statement of reflexivity, all align with the interpretivist position. It is a position that acknowledges that participants' and researcher's perspective and values necessarily play a role in the generation and interpretation of findings.

Chapter One
A Systematic Review of the Effectiveness of Yoga on Pain, Physical Function, and Quality of Life in Older Adults with Chronic Musculoskeletal Conditions

Introduction

Exercise interventions for older adults are an important aspect of public health in the United Kingdom as changes to the U.K. pension age, from 66 in 2020 to 68 by 2046 (Clarke, 2017), will lead to an older workforce with the need to be productive and active (Harper, et al. 2016). The term "older" in the present review refers to adults over 50 years, encompassing "middle-age" (50-64 years of age) (Brown et al., 2017) when functional impairment may develop (Gardener et al., 2006; Valdes & Stocks, 2018). Guidelines recommend aerobic and strengthening exercise for older adults (Department of Health and Social Care, 2019) and this includes those with chronic MSK conditions (World Health Organization Europe, 2012: Foster et al., 2018; Maher et al., 2017; National Institute for Health and Care Excellence, 2016).

As noted in the preceding introduction, postural yoga increases strength, stabilisation (Hayden et al., 2005) flexibility, and balance (Roland et al., 2011; Ross & Thomas, 2010), whilst remaining an adaptable low impact intervention. It has been shown to reduce the risk of falls by addressing balance and proprioception in older people (Hamrick et al., 2017; Pata et al., 2014; Roland et al., 2011; Youkhana et al., 2016) and can contribute to well-being in later life (Tew et al., 2017).

Justification for the Review

The narrative review sourced existing yoga research focused on health conditions or the frail elderly. Less is known about the efficacy of yoga in middle-age populations, taking into consideration both the ageing process from its onset, age-related musculoskeletal conditions, and the need to stay active. This review therefore considers the effects of yoga on middle-aged and older adults, using a sample with a mean age over 50 with chronic musculoskeletal conditions.

A literature search was conducted to locate existing systematic reviews and to establish research gaps. Seven systematic reviews were found on the effects of yoga for back pain (Chang et al., 2016; Cramer et al., 2013; Hill, 2013; Holtzman & Beggs, 2013; Majid & Syahrul, 2020; Posadzki & Ernst, 2011a; Wieland et al., 2017). Yoga was shown to have an effect on pain and disability, superior to no care or usual care and as effective as non-yoga exercise including trunk stabilisation, aerobic and strengthening exercise, stretching, and non-specified exercise therapy.

Two systematic reviews focused on yoga for musculoskeletal conditions and rheumatic diseases, but without older adult age criteria. A systematic review and meta-analysis of yoga for functional ability, pain, and psychosocial outcomes in musculoskeletal conditions reported that yoga led to clinically meaningful outcomes for pain and function (Ward et al., 2013). Another systematic review was retrieved on the effect of yoga on the quality of life of patients with rheumatic diseases, without an age criterium, finding evidence that yoga may be effective in improving functional capacity, physical, emotional, general health, and social aspects of quality of life (Sieczkowska et al., 2019).

Two existing reviews used population of adults over 60 but did not focus on musculoskeletal conditions. One review of physical function and health-related quality of life in older adults (Patel et al., 2012) indicated that yoga may be superior to conventional exercise interventions for self-rated health status, aerobic fitness, strength, and balance. Another systematic review reported significant combined effects for aspects of physical function and health related quality of life (Sivaramkrishan et al., 2019).

Existing reviews of yoga for musculoskeletal conditions have noted pain and functional benefits in the general population, but in the context of ageing, have centered on balance and mental health improvements with focus on the elderly. This systematic review will instead look specifically at chronic musculoskeletal conditions evaluating the effectiveness of yoga for pain, physical function, and quality of life for a middle-aged and older population who may still be working or have dependent family, and need to maintain functional health, fitness, and activity levels.

Aims and Objectives

- To assess the musculoskeletal health benefits of yoga in a population with a mean age over 50 years
- To assess the effectiveness of yoga on pain, physical function, and quality of life
- To inform design of a future randomised comparative trial that assesses effects and experiences of yoga compared with Pilates including:
    - to gain understanding of effective yoga practices for the over-50 population
    - to determine optimum feasible intervention length, duration, and frequency
    - to identify appropriate outcome measurement tools to capture the effects of yoga
    - to assess and understand perception of and adherence to yoga

Methodology

This systematic review methodology followed PRISMA guidelines incorporating the PRISMA-P checklist for systematic review protocols (Moher et al., 2009; Moher et al., 2015). The question was constructed according to the PICO model (population, intervention, comparison, outcome), the currently recommended paradigm for evidence-based clinical research (Moher et al., 2015).

Research Question

How does yoga affect pain, physical function, and quality of life in adults of a mean age over 50 years with chronic musculoskeletal conditions?

Sub-Topics.

For older adults what are the optimum sample size, session length, frequency, intervention duration and outcome measures for capturing statically significant results relevant to practice?

For older adults, were any particular yoga styles or schools more effective than others in delivering statistically significant outcomes?

What was the perception of the intervention among participants?

Search Strategy

A literature search was undertaken using Cochrane Controlled Register of Trials (CENTRAL), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Google Scholar, PsycInfo, Pubmed, SCOPUS, Sports Discus, and Web of Science (Core Collection). To ensure against publication bias, Opengrey, and Worldcat were searched for unpublished material (Siddaway et al., 2019). Search terms are shown in Table 1.1 with MeSH terms sourced from the U.S. National Library of Medicine shown in column four. The search strategy and terms applied to Cochrane CENTRAL are also presented. Articles were screened using the inclusion and exclusion criteria show in Table 1.2. Rationales for the choice of databases are presented in Tables A1.1 and A1.2 in Appendix II.

Table 1.1 *Database Search Words*

Key Terms	Terms Used	Alternative Terms	MeSH terms
Population	Aging Ageing	Mature Senior Elderly “Old*” “Older adult” “Middle age*”	Aging -Physiology (PH) Middle Aged -Physiology (PH) Aged - physiology (PH) psychology (PX)
Intervention	Yoga		Yoga
Outcome	Pain Disability Physical Function “Quality of Life”	Ache QOL HRQOL GQOL “Health-Related Quality of Life” “Life Quality”	Pain -pathology (PA) -physiopathology (PP) -prevention & control (PC) -psychology (PX) -back pain -chronic pain -musculoskeletal pain -neck pain Physiology Quality of Life
Condition	Musculoskeletal	Arthritis “Back Pain” Chronic	Arthritis -pathology (PA) -physiopathology (PP) -prevention & control (PC) -psychology (PX) -therapy (TH)
Design	“Randomised Controlled Trial” Cohort	RCT randomised	randomised Controlled Trial Cohort Studies

Search Terms as Applied to CENTRAL Database.

Search Name: Yoga SR
Date Run: 07/03/2019 04:06:49
Search Name: Yoga SR

ID Search
#1 ag?ing in Trials
#2 MeSH descriptor: [Aged] explode all trees
#3 mature in Trials
#4 senior in Trials
#5 elderly in Trials
#6 old* in Trials
#7 "older adult" in Trials
#8 MeSH descriptor: [Middle Aged] explode all trees
#9 MeSH descriptor: [Yoga] explode all trees
#10 MeSH descriptor: [Pain] explode all trees
#11 MeSH descriptor: [Pain] explode all trees and with qualifier(s): [pathology - PA, physiopathology - PP, prevention & control - PC, psychology - PX]
#12 disability in Trials
#13 "physical functioning" in Trials
#14 "quality of life" in Trials
#15 ache in Trials
#16 QOL in Trials
#17 HRQOL in Trials
#18 GQOL in Trials
#19 "health-related quality of life" in Trials
#20 "life quality" in Trials
#21 MeSH descriptor: [Physiology] explode all trees
#22 MeSH descriptor: [Quality of Life] explode all trees
#23 musculoskeletal in Trials
#24 MeSH descriptor: [Musculoskeletal Diseases] explode all trees
#25 MeSH descriptor: [Arthritis] explode all trees
#26 MeSH descriptor: [Back Pain] explode all trees
#27 MeSH descriptor: [Arthritis] explode all trees and with qualifier(s): [pathology - PA, physiopathology - PP, prevention & control - PC, psychology - PX, therapy - TH]
#28 MeSH descriptor: [Randomized Controlled Trial] explode all trees
#29 MeSH descriptor: [Cohort Studies] 3 tree(s) exploded
#30 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8) AND #9 AND (#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27)

Table 1.2 *Inclusion and Exclusion Criteria*

Selection criteria	Inclusion Criteria	Exclusion criteria	Rationale
Population	Older adults, aged over 50, or mean age or 50 AND with chronic MSK conditions.	Adults under age 50 only Mean age under 50 Older Adults without chronic MSK conditions Adults over age 70 only Frail elderly adults only	Topic is yoga for MSK conditions in an ageing population MSK conditions more likely in older population Mean age >50 (rather than all adults over 50) to broaden scope of search Established need for older adults to remain active and working, therefore aim is to capture older, working adults 50-70 years rather than frail elderly
Condition	Chronic musculoskeletal conditions	Acute conditions Conditions caused by trauma Co-morbidities of other pathologies	Target population for future intervention and measurement
Intervention	Hatha (physical) yoga Any style of modern postural yoga (MPY) barring those in the exclusion criteria	Chair yoga Yoga computer games (WiFit) Thai Yoga Meditation only, Breathing exercises only, Stretching Non-physical forms of yoga Co-interventions	Modern postural yoga is the intervention to be used on future randomised controlled trial as part of PhD Chair yoga not considered comparable to general MPY WiFit not considered comparable to yoga class with live instructor present; different psychosocial value Thai yoga is assisted bodywork and not comparable to MPY
Comparison	Any control group	None	RCTs with any type of control group will be included for maximum recall. Trials and cohort studies without controls to be included if not enough RCT meet selection criteria
Outcome	<u>Primary Outcomes</u> Pain Disability Physical Function Quality of Life <u>Secondary Outcomes</u> Perception of intervention Expectation of outcome Adverse Effects	Studies whose main focus is not on the effectiveness of the intervention on the individual. For example, Economic or socio-economic studies, studies with a philosophical underpinning,	The research aims to assess the therapy and its effect on the individual. Focus is on clinical research.
Design	Randomised controlled trials Cohort studies	Case-control Studies Case reports Cross-sectional reviews Dissertations, unless incorporating RCT or Cohort studies	Randomised controlled trials generally considered among the most appropriate study design to accurately assess the clinical efficacy of therapy interventions (Greenhalgh, 1997). Cohort studies included if <6 RCTs meet selection criteria Other studies eliminated to reduce volume and increase quality/specificity of the SR
Language	Available in English	Not available in English	No available budget for translation

Quality Assessment

Methodological quality and risk of bias of randomised trials was assessed using the Cochrane Collaboration's tool for assessing risk of bias in randomised trials (Higgins et al., 2011). (Table A1.3 and A1.4). The Cochrane organisation is internationally notable for setting the highest standard of evidence-based health care (Koperny et al., 2016) and the Cochrane risk of bias tool was used as it aligns with the most current understanding of how bias can influence results through under or overestimation or results, and ways of determining this risk (Cochrane Methods, 2020, May 24). The Cochrane Risk of Bias tool allows for the assessment of bias according to five separate domains, rather than using solely a summary score which is discouraged (Higgins et al., 2023), enabling a comprehensive assessment of all possible sources of bias related to randomisation, deviations from the intended intervention, missing outcome data, outcome measurement, and selection of the reported result. The tool includes detailed guidelines for use and allows for bias assessments to be integrated into forest plots in Review Manager (RevMan) which provide a visual aid to the process (Higgins et al., 2020).

Two assessors performed the quality assessment to mitigate bias. Where disagreement was found between the researcher and the second assessor (the research supervisor) the assessment became an iterative process whereby the researcher re-evaluated the paper against the guidelines for the Cochrane risk-of-bias tool (Sterne et al., 2018) for any domains that had resulted in differing evaluations. In clear cases or error, these were corrected. Where discrepancies remained following the researcher’s second pass of evaluation against the criteria, these were resolved by a discussion between the two assessors, a decision was mutually agreed upon, and the bias assessment either revised or maintained.

Data Extraction

The Template for Intervention Description and Replication (TIDieR) checklist was used to gain an understanding of the yoga intervention used in each trial in order to make comparisons and differentiations when analysing results. The TIDieR checklist itemises aspects of the intervention's rationale, administration, setting, duration, frequency, cost, planning, modification, and delivery (Hoffman, et al., 2014).

Data Analysis

Information from the data extraction form for each study was uploaded into Review Manager software (Revman Version 5.1, The Nordic Cochrane Centre, Copenhagen) to calculate the interventions' effects. Heterogeneity of studies was assessed using an I^2 test (I^2 = 100% x (Q-df)/Q) which calculates the percentage of variation in the studies deriving from heterogeneity rather than chance and is not inherently dependent on the number of studies considered (Higgins and Thompson, 2002; Higgins et al., 2003). Due to heterogeneity (I^2>50%), a random-effects model and standard mean differences were used when pooling results. Forest plots were used where data was available to illustrate the pooled effect size and 95% confidence intervals and provide a visual aid to efficiently view and interpret the evidence (Verhagen and Ferreira, 2014). The meta-analysis was carried out using Revman software utilising a random effects inverse variance method, measuring continuous data for standardised mean differences. In the inverse-variance method the weighting for each study is the inverse of the variance of the effect estimate (i.e., 1 over the square of its standard error). Larger studies, with smaller standard errors, are given more weight than smaller studies with larger standard errors so as to minimizes the imprecision (uncertainty) of the pooled effect estimate (Higgins et al., 2023)

Results

Results of the Search

The search retrieved 2745 articles between March 2019 and June 2020 (Figure 1.1). Articles excluded after the full text stage are listed in Appendix II. There were 11 studies included in the review (Cheung et al., 2014; Cheung et al., 2017; Dunleavy et al., 2016; Garfinkel et al., 1994; Greendale, et al., 2009; Innes et al., 2020; Kuntz et al., 2018; Pandya, 2019; Teut et al., 2016; Ward et al., 2018; Zacharia et al., 2018).

Study Population

The total number of participants across all studies was 2221. The mean age of participants across eight of the nine studies that reported mean age was 58.12 (Garfinkel et al., 1994 reported only a range: 52-79). A notably high proportion of participants ($\geq$70%) were female, reflecting female-only recruitment in four studies, the prevalence of chronic musculoskeletal conditions in older women (Gran, 2003; Wijnhoven et al., 2006), as well the popularity of yoga amongst women (Cartwright et al., 2020) and therefore the greater likelihood for women to volunteer for a yoga trial. (Table 1.3).

Length, Frequency, and Duration of Interventions

The mean length of each group yoga session was 60 minutes. Frequency of group classes ranged from once a week to three times a week. Duration of interventions ranged from eight weeks to ten years (Table 1.4). Variance and effectiveness are depicted in Figures 1.2 and 1.3, respectively.

Figure 1.1 *Literature Search PRISMA Flow Chart*

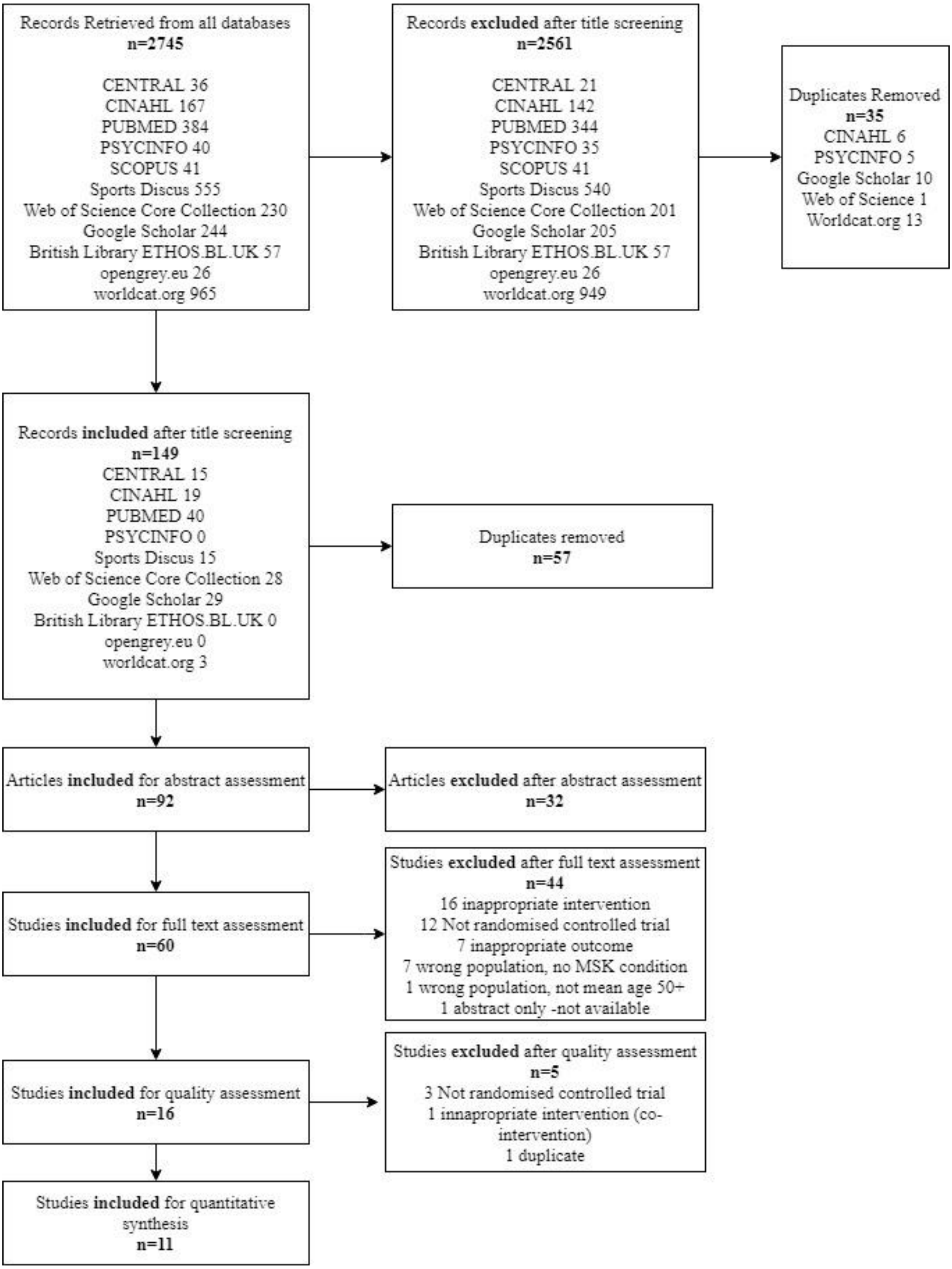


Table 1.3 *Characteristics of Included Studies - Population*

Study	Location	Population Age	Female/Male %	Population Characteristics	Sample Size Randomised	Sample analysed per group - yoga/non-exercise control/exercise comparator (total)
Cheung et al., 2014	USA	65-90, mean 71.9	100.00%	Women, Knee OA >6 months	36	18/18 (36)
Cheung et al., 2017	USA	60+ mean 71.6	84%/16%	84% Women, Knee OA> 6 months	83	32/23/28 (83)
Dunleavy et al., 2016	USA	mean 55.6	87%/13%	Chronic Mechanical Neck Pain > 3 months	88	19/17/20 (56)
Garfinkel et al., 1994	USA	52-79	NI	OA of the Hands	26	13/13 (26)
Greendale et al., 2009	USA	60+, mean 75.5	81%/19%	Adult Onset Hyperkyphosis >40 degrees, noticed after age 50	118	58/60 (118)
Innes et al., 2020	USA	24-73, mean 50.4	78%/12%	Women, RLS	41	13/17 (30)
Kuntz et al., 2018	Canada	50+, mean 66.7	100.00%	Women, Knee OA	31	10/10/10 (30)
Pandya, 2019	Asia/Africa	60+, mean 63.65 at recruitment	100%	Sarcopenia	1576	Phase 1 788/788, Phase 2 703/703
Teut et al., 2016	Germany	65+ mean 73	89%/11%	Chronic Low Back Pain > 6 months	176	61/57/58 (176)
Ward et al., 2018	New Zealand	mean 54	96%/4%	Rheumatoid Arthritis, pain >3 months	26	13/12 (25)
Zacharia et al., 2018	USA	40-64, Mean age 57	NI	Lower Limb OA> 6 months	20	10/10/ 19 from first 2 groups of 10 (20)

Key to Abbreviations: OA=Osteoarthritis, NI=No information, RLS=Restless leg syndrome, >=more than

Table 1.4 *Characteristics of Included Studies – Interventions* **Key to Abbreviations**: NA=Not applicable

Study Name/ Population	Intervention + Length Per Session	Intervention Frequency	Exercise Control + Length Per Session	Exercise Control Frequency	Duration	Non-Exercise Control	Data Collection & Follow-Up Points
Cheung et al., 2014 Knee OA (women)	**Yoga** 60 min group class and 30 min home practice	1/week and 4/week	NA	NA	8 weeks	Wait-list control	Baseline, 4, 8 & 20 week follow-up
Cheung et al., 2017 Knee OA	**Yoga** – 45 min group class and 30 min home practice	1/week and 4/week	**Aerobic + Strengthening Exercis**e 45 min (15+30 min),	1/week	8 weeks	Education control	Baseline, 4 & 8 weeks
			Home practice aerobic portion 15–30 min/day and Strengthening exercise 30 min/day on non-consecutive days	4/week and 2/week			
Dunleavy et al., 2016 Chronic Neck Pain	**Yoga** 60 min	1/week	**Pilates** 60 min	1/week	12 weeks	Control (Meditation)	Baseline, 6, 12 & 18 week follow-up
Garfinkel et al., 1994 Hand OA	**Yoga** 60 min	1/week	NA	NA	8 weeks	Control (Usual care, drug-based)	Baseline, 8 weeks
Greendale et al., 2009 Adult onset hyperkyphosis	**Yoga** 60 min	3/week	NA	NA	24 weeks	Control (Control group attended a monthly luncheon/seminar and received mailings. Designed to provide social environment similar to yoga).	Baseline, 6 months
Innes et al., 2020 Restless leg syndrome	**Yoga 75** min group class and 30 min home practice	2/week for 4 week, 1/week next 8 weeks Home practice 5/week	NA	NA	12 weeks	Educational film + homework	Baseline, 3 months
Kuntz et al., 2018 Knee OA (women)	**Yoga** 60 min	3/week	**Traditional Exercise** (60 min)	3/week	12 weeks	No-exercise, attention equivalent control	Baseline, 12 weeks
Pandya, 2019 Sarcopenia (women)	**Yoga 40** min group class + home practice	1//week class Home not-specified	Routine exercise and walking as prescribed	Not specified	10 years	NA	Baseline, 10 years
Teut et al., 2016 Chronic low back pain	**Yoga** 45 minutes	2/week (24 over 3 months)	**Qi Gong** 90 minutes	1/week (12 over 3 months)	3 months	Control	Baseline, 3 months & secondary outcomes at 6 months
Ward et al., 2018 Rheumatoid Arthritis	**Yoga** 75 min	1/week	NA	NA	8 weeks	Control (usual care)	Baseline, 9 weeks, 12 weeks
	Yoga Home Practice 20 min	3/week	NA	NA	8 weeks		
Zacharia et al., 2018 Lower limb OA	**Yoga** 60 min	2/week	NA	NA	8 weeks	None for this phase	Baseline, 8 weeks
	Yoga Relapse Prevention Self-Practice	(120 minutes per week)	NA	NA	4 weeks	Control	Baseline, 8, 12 weeks

Summary* of *Results for Primary Outcomes

(Outcome measures - Table 1.5. Results summary - Table 1.6).

Forest plots of pooled data illustrate an effect for yoga superior to non-exercise controls for pain (Figure 1.4) and physical function (Figure 1.5). No effects were found for quality of life (Figure1.6) or for yoga versus exercise controls for pain (Figure 1.7).

Pain.

Eight studies measured pain (Cheung et al., 2014; Cheung 2107; Dunleavy et al., 2016; Garfinkel et al., 1994; Kuntz et al., 2018; Teut et al., 2016; Ward et al., 2018; Zacharia et al., 2018). At short-term follow-up (8-12 weeks), six studies reported statistically significant effects (P=$\leq$0.05) for yoga, five of which were in populations with osteoarthritis (OA): three knee OA (Cheung et al., 2014; Cheung et al., 2017; Kuntz et al., 2018) and one hand OA (Garfinkel et al., 1994), (versus non-exercise controls), and one lower limb OA, pre- and post-intervention without control (Zacharia et al., 2018). Dunleavy et al., 2016 reported statistically significant results versus non-exercise control for chronic mechanical neck pain. Teut et al., 2016 (chronic low back pain [CLBP]) and Ward et al., 2018 (rheumatoid arthritis [RA]) captured no statistically significant effects for pain.

Physical Function.

Nine studies measured physical function (Cheung et al., 2014; Cheung et al., 2017; Garfinkel et al., 1994; Greendale et al., 2009; Kuntz et al., 2018; Pandya, 2019; Teut et al., 2016; Ward et al., 2018; Zacharia et al., 2018). At short-term follow-up (8-12 weeks) three studies reported statistically significant effects, all in OA populations: Knee OA (Cheung et al., 2017; Kuntz et al., 2018) versus non-exercise controls and for lower limb OA (Zacharia et al., 2018), pre- and post-intervention without control. At long-term follow-up (10 years), significant results were found for women with sarcopenia compared to non-exercise and walking (Pandya, 2019). Cheung et al., 2014 (Knee OA), Garfinkel et al., 1994 (Hand OA) , Teut et al., 2016 (CLBP), and Ward et al., 2018 (RA) (short-term follow-up), and Greendale et al., 2009 (Hyperkyphosis) (medium-term follow-up) captured no statistically significant effects for physical function.

Quality of Life.

Quality of life was measured by seven studies (Cheung et al., 2014; Cheung 2107; Greendale et al., 2009; Innes et al., 2020; Kuntz et al., 2018; Teut et al., 2016;Ward et al., 2018). At short-term (8-12 weeks) one study of restless leg syndrome (RLS) (Innes et al., 2020) reported significant results against the baseline for the yoga group in this outcome, but there was with no between-group difference between yoga group and the non-exercise control group. Six studies (Cheung et al., 2014; Cheung et al., 2017; Greendale et al., 2009; Kuntz et al., 2018; Teut et al., 2016; Ward et al., 2018) reported no significant effects for this outcome in populations with knee OA, hyperkyphosis, chronic low back pain, and rheumatoid arthritis.

Table 1.5 *Characteristics of Studies – Outcome Measures* **(bold= significant results captured)**

Study	**Primary Outcome Measures** **1. Pain** **2. Physical Function** **3. QOL**	**Secondary Outcome Measures** **1. Perception of Intervention** **2. Adverse Events**
Cheung et al., 2014	1. Pain **(WOMAC)** and single question re: medication usage. 2. Physical function: (WOMAC) 3. QOL Quality of Life Short Form 12 (SF-12) and Cantril Self-Anchoring Ladder	1. Participant rating scale for difficulty and enjoyment. 2. Monitored be research staff/participants at home
Cheung et al., 2017	1. Pain (**WOMAC; VAS**) and single question re: medication usage. 2. Physical function **(WOMAC)** 3. QOL (SF-12)	1. 4-point Satisfaction with Programme questionnaire 2. NI
Dunleavy et al., 2016	1. Pain **(NDI)** 2. NA 3. NA	1. NA 2. NI
Garfinkel et al., 1994	1. Pain (tenderness of the finger joints measured with an instrument dolorimeter; hand pain on **VAS**) 2. Physical function (hand function measured by the Stanford Hand Assessment Questionnaire). 3. NA	1. NA 2. NA
Greendale et al., 2009	1. NA 2. Physical function (**Debrunner kyphometer** assessed kyphosis angle, standing height, timed chair stands, functional reach, and walking speed.) 3. QOL (SF-36).	1. NA 2. Monthly symptom checklist
Innes et al., 2020	1. NA 2. NA 3. QOL (**SF-36)**	1. Credibility/Expectation questionnaire ; exit questionnaire 2. Weekly participant and instructor logs
Kuntz et al., 2018	1. Pain (**KOOS**; ICOAP) 2. Physical function (self-reported **LEFS**, function in activities of daily living (ADL) and sport and recreation (SR) subscales of the KOOS). 3.QOL (four-item knee related QOL subscale of the KOOS).	1. NA 2. NI
Pandya, 2019	1. NA 2. **Senior Fitness Test** 3. NA	1. NA 2. NA
Teut et al., 2016	1. Pain (FRI; VAS; medication use) 2. SF-36 QOL Scale; Physical function (back function on FFBRH scale) 3. QOL (SF-36)	1. Credibility and satisfaction scale of 1-10 2. NA
Ward et al., 2018	1. pain (VAS) 2. Physical function (functional disability, using HAQ-DI) 3. QOL (EuroQol EQ-5D-3)	1. Semi-structured questionnaire 2. Adverse Effects (Primary safety outcomes included the type and frequency of adverse events)
Zacharia et al., 2018	1. Pain **(WOMAC)** 2. Physical functional performance (**CS-PFP 10; WOMAC**) 3. NA	1. NA 2. NA

Key to Abbreviations: ADL=Activities of Daily Living, CI= confidence intervals, FfbRH=Hanover Functional Ability Questionnaire, CS-PFP10= Continuous Scale Physical Function Performance 10, FRI=Functional Rating Index, HAQ-DH=Health Assessment Questionnaire Disability Index, HRQOL=Health related quality of life, ICOAP= Measure of Intermittent and Constant Osteoarthritis Pain, KOOS= Knee Osteoarthritis Outcome Score, LEFS= Lower Extremity Functional Scale NDI=Neck disability index, NA= Not Applicable, NI= No information OA=Osteoarthritis, QOL= Quality of Life, QOL-SF12= Quality of Life Short Form 12, QOL-SF 36=Quality of Life Short Form 36, VAS= Visual Analogue Scale, WOMAC= Western Ontario and McMaster Universities Osteoarthritis Index

Table 1.6 *Results Summary*

Study	Condition	Measured?	Outcome measure	Effective vs Control ? (*P*=<0.05)	Effective vs Exercise? (Group Difference) (*P*=<0.05)
Pain					
Cheung et al., 2014	Knee OA Women	Y	WOMAC	Y	-
Cheung et al., 2017	Knee OA	Y	WOMAC	Y	Y
Dunleavy et al., 2016	Neck Pain	Y	NDI	Y	N (both effective)
Garfinkel et al., 1994	Hand OA	Y	Instrument dolorimeter; VAS	Y	-
Greendale et al., 2009	Hyperkyphosis	N	-	-	-
Innes et al., 2020	RLS	N	-	-	-
Kuntz et al., 2018	Knee OA	Y	KOOS; ICOAP	Y	N (both effective)
Pandya, 2019	Sarcopenia Women	N	-	-	-
Teut et al., 2016	CLBP	Y	FRI; VAS; medication use	N	N (neither effective)
Ward et al., 2018	RA	Y	VAS	N	-
Zacharia et al., 2018	Lower Limb OA	Y	WOMAC	Y but (no control)	-
Physical Function					
Cheung et al., 2014	Knee OA Women	Y	WOMAC	N	-
Cheung et al., 2017	Knee OA	Y	WOMAC	Y	Y
Dunleavy et al., 2016	Neck Pain	N	-	-	-
Garfinkel et al., 1994	Hand OA	Y	Stanford Hand Assessment Questionnaire	N	-
Greendale et al., 2009	Hyperkyphosis	Y	Debrunner kyphometer, standing height, timed chair stands, functional reach, and walking speed	N	-
Innes et al., 2020	RLS	N	-	-	-
Kuntz et al., 2018	Knee OA	Y	LEFS, KOOS	Y	N (both effective)
Pandya, 2019	Sarcopenia Women	Y	Senior Fitness Test	Y	Y
Teut et al., 2016	CLBP	Y	SF-36 Physical function, FFBRH scale	N	N (neither effective)
Ward et al., 2018	RA	Y	HAQ-DI	N	-
Zacharia et al., 2018	Lower Limb OA	Y	CS-PFP 10; WOMAC	Y (no control)	-
QOL					
Cheung et al., 2014	Knee OA Women	Y	SF-12; Cantril Self-Anchoring Ladder	N	-
Cheung et al., 2017	Knee OA	Y	SF-12	N	N (neither effective)
Dunleavy et al., 2016	Neck Pain	N	-	-	-
Garfinkel et al., 1994	Hand OA	N	-	-	-
Greendale et al., 2009	Hyperkyphosis	Y	SF-36	N	-
Innes et al., 2020	RLS	Y	SF-36	Y vs baseline	-
Kuntz et al., 2018	Knee OA	Y	KOOS	N	N (Yoga NS, exercise sig, but NS difference)
Pandya, 2019	Sarcopenia Women	N	-	-	-
Teut et al., 2016	CLBP	Y	SF-36	N	N (neither effective)
Ward et al., 2018	RA	Y	EuroQol	N	-
Zacharia et al., 2018	Lower Limb OA	N	-	-	-

All short-term follow-up (8-12 weeks) unless indicated: 26 weeks (medium), 10 years (long)

Key to abbreviations: ADL=Activities of Daily Living, CLBP=chronic low back pain, CS-PFP10= Continuous Scale Physical Function Performance 10, FfbRH=Hanover Functional Ability Questionnaire,FRI=Functional Rating Index, HAQ-DH=Health Assessment Questionnaire Disability Index, HRQOL=Health related quality of life, ICOAP= Measure of Intermittent and Constant Osteoarthritis Pain, KOOS= Knee Osteoarthritis Outcome Score, LEFS= Lower Extremity Functional Scale NDI=Neck disability index, OA=Osteoarthritis, QOL= Quality of Life, QOL-SF12= Quality of Life Short Form 12, QOL-SF 36=Quality of Life Short Form 36, RA=Rheumatoid arthritis, RLS=restless leg syndrome, VAS= Visual Analogue Scale, WOMAC= Western Ontario and McMaster Universities Osteoarthritis Index

Results by Intervention Delivery – Summary

Figure 1.2 *Intervention Frequency Against Duration Across all Studies (Mean Session Length 60 Minutes)*

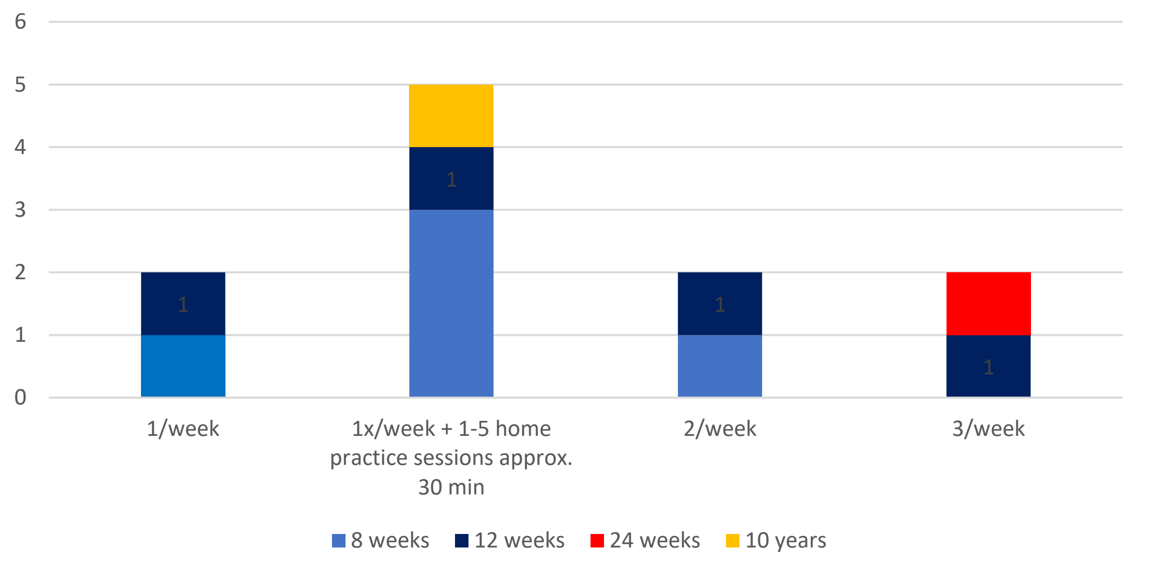
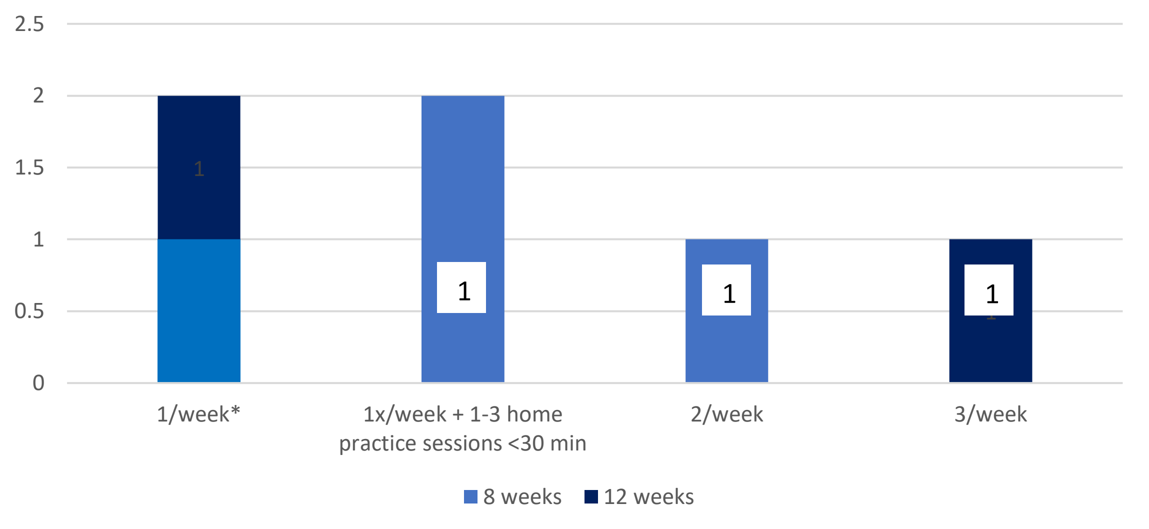


Figure 1.3 *Frequency and Duration for Studies with Statistically Signficant Results for Pain (White Square=Also Physical Function)*

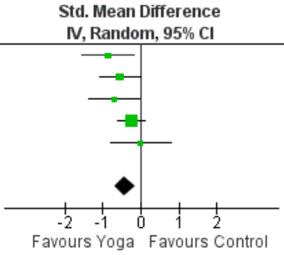


*studies did not measure physical function

Figure 1.4 *Forest Plot Comparison: Yoga vs. Non-Exercise Control*

Short-Term (8-12 week) Follow-up (Outcome: Pain)

	Yoga			Control				Std. Mean Difference	Risk of Bias				
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	A	B	C	D	E
Cheung 2014	5.8	2.8426	18	8.3	2.8426	18	13.7%	-0.86 [-1.55, -0.17]	-	-	+	+	+
Cheung 2017	5.1	2.4963	32	6.5	2.5438	23	20.7%	-0.55 [-1.09, -0.00]	?	?	+	+	+
Dunleavy 2016	8.1	5.6	19	12.5	6.8	17	14.1%	-0.69 [-1.37, -0.02]	-	-	-	-	?
Teut 2016	1.71	0.6638	61	1.89	0.8291	57	40.9%	-0.24 [-0.60, 0.12]	?	?	+	?	+
Ward 2018	33	21	13	33	32	12	10.7%	0.00 [-0.78, 0.78]	+	+	?	+	+
Total (95% CI)			**143**			**127**	**100.0%**	**-0.43 [-0.69, -0.16]**					



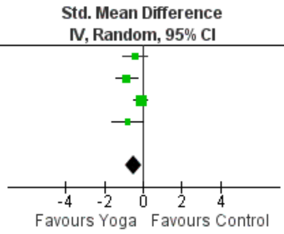
Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 4.48$, df = 4 (P = 0.34); $I^2 = 11\%$
Test for overall effect: Z = 3.16 (P = 0.002)

Risk of bias legend
(**A**) Bias arising from randomization process
(**B**) Bias due to deviations from intended intervention
(**C**) Bias due to missing outcome data
(**D**) Bias in measurement of outcome
(**E**) Bias in selection of reporting result

Figure 1.5 *Forest Plot Comparison: Yoga vs. Non-Exercise Control*

Short-Term (8-12 week) Follow-up (Outcome: Physical Function)

	Yoga			Control				Std. Mean Difference	Risk of Bias				
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	A	B	C	D	E
Cheung 2014	22	9.7581	18	26.2	9.7581	18	21.5%	-0.42 [-1.08, 0.24]	-	-	+	+	+
Cheung 2017	18.2	8.0435	32	25.2	7.8625	23	25.7%	-0.87 [-1.43, -0.30]	?	?	+	+	+
Teut 2016	59.06	17.2581	61	61.11	18.128	57	36.4%	-0.12 [-0.48, 0.25]	?	?	+	?	+
Ward 2018	0.35	0.35	13	0.83	0.76	12	16.4%	-0.80 [-1.62, 0.02]	+	+	?	+	+
Total (95% CI)			**124**			**110**	**100.0%**	**-0.49 [-0.89, -0.08]**					



Heterogeneity: $Tau^2 = 0.08$; $Chi^2 = 5.93$, df = 3 (P = 0.12); $I^2 = 49\%$
Test for overall effect: Z = 2.37 (P = 0.02)

Risk of bias legend
(**A**) Bias arising from randomization process
(**B**) Bias due to deviations from intended intervention
(**C**) Bias due to missing outcome data
(**D**) Bias in measurement of outcome
(**E**) Bias in selection of reporting result

Figure 1.6 *Forest Plot Comparison: Yoga vs. Non-Exercise Control*

Short-Term (8-12 week) Follow-up (Outcome: Quality of Life)

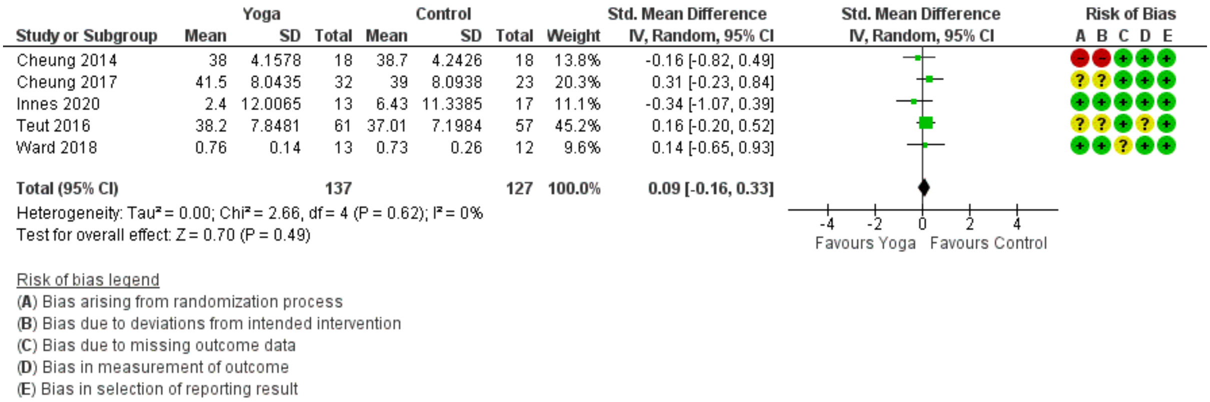
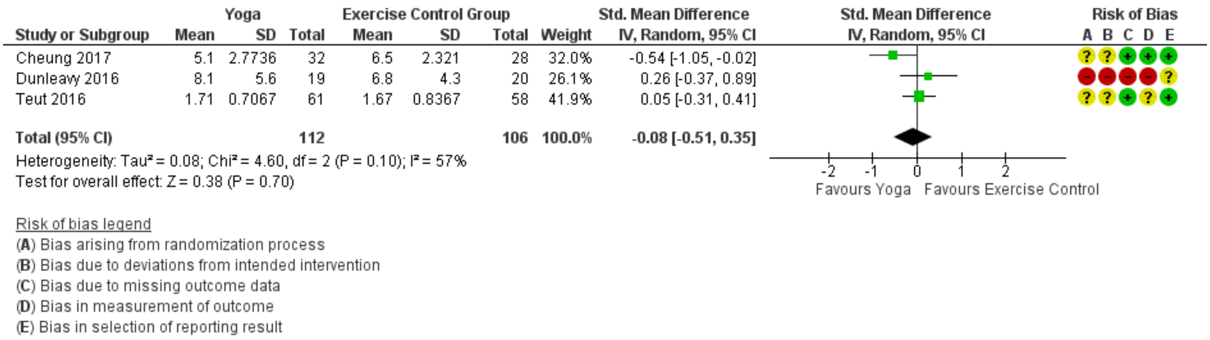


Figure 1.7 *Forest Plot Comparison: Yoga vs. Exercise Control*

Short-Term (8-12 week) Follow-up (Outcome: Pain)



Yoga Versus Other Exercise

Five studies compared yoga to other exercise (Cheung et al., 2017; Dunleavy et al., 2016; Kuntz et al., 2018; Pandya, 2019; Teut et al., 2016) (Table 1.7). Two reported significantly superior effects: Cheung et al., 2017 for pain and physical function, yoga versus aerobic and strengthening groups for a knee OA population; Pandya, 2019 for physical function, yoga versus routine exercise and walking for sarcopenia. Three reported no difference. For yoga versus Pilates (Dunleavy et al., 2016, chronic mechanical neck pain) and yoga versus traditional exercise (treadmill/cycle warm-up, lower extremity strengthening on pneumatically-resisted machines, static stretching) (Kuntz et al., 2018, female knee OA) both interventions were significantly effective with no significant group difference. In Teut et al., 2016, (yoga versus Qigong for CLBP) neither intervention was significantly effective.

Table 1.7 *Results for Yoga versus Exercise*

Study Name/ Population	**Exercise Control + Length Per Session**	**Frequency**	**Duration**	**Results for Pain**	**Results for Physical Function**	**Results for QOL**
Cheung et al., 2017 Knee OA	**Aerobic + Strengthening Exercise** 45 min (15+30 min), **Home practice** aerobic portion 15–30 min/day and Strengthening exercise 30 min/day on non-consecutive days	1/week 4/week and 2/week	8 weeks	***P*=0.038**	***P*=0.001**	*P*=0.528 (mental) *P*=0.227 (physical)
Dunleavy et al., 2016 Chronic Neck Pain	**Pilates** 60 min	1/week	12 weeks	*P*=0.41	Not measured	Not measured
Kuntz et al., 2018 Knee OA (women)	**Traditional Exercise*** 60 min	3/week	12 weeks	*P*=0.247	*P*=0.477 (daily life) P=0.925 (sports and recreation)	*P*=0.891*
Pandya, 2019	**Routine exercise walking**	NI	10 years		*P*=<0.05	
Teut et al., 2016 Chronic low back pain	**Qi Gong*** 90 minutes	1/week (12 over 3 months)	3 months	*P*=0.772 Favours exercise	*P*=0.203 (on FFbrH) P=0.230 (on SF-36) Favours exercise	*P*=0.600 (physical) *P*=0.858 (mental) Favours exercise

= Both effective (no group difference) = Neither effective (no group difference = Statistically significant effect favouring yoga
* = Exercise significantly effective, yoga not significant, but group difference clinically insignificant
(*P*=≤0.05) at short-term follow-up (8-12 weeks)
NI= No information

Sub-Groups

Osteoarthritis.

All five of the OA studies (Cheung et al., 2014 ; Cheung et al., 2017 ; Garfinkel et al., 1994 ; Kuntz et al., 2018 ; Zacharia et al., 2018) reported statistically significant results for pain and three (Cheung et al., 2017 ; Kuntz et al., 2018; Zacharia et al., 2018) for physical function.

Table 1.8 *Statistically Significant Results of Individual Osteoarthritis Studies (Primary Outcomes)*

Study Name/ Population	Group Session length	Sessions per week	30 min week home practice sessions prescribed	Duration (weeks)	Results for Pain	Results for Physical Function	Results for QOL
Cheung et al., 2014 Knee OA (women)	60 min	1	+4	8	*P*=0.01	*P*=0.20	*P*=0.65 (physical, on SF-36) *P*=.39 (mental, on SF-36)
Kuntz et al., 2018 Knee OA (women)	60 min	3	-	12	*P*=0.003 vs control P=0.247 vs exercise	*P*=0.010 vs control (daily life) *P*=0.094 vs control (sports and recreation) *P*=0.447 vs exercise (daily life) *P*=0.925 vs exercise (sports and recreation)	*P*=0.095 vs control *P*=0.091 vs exercise
Cheung et al., 2017 Knee OA	60 min	1	+4	8	*P*=0.045 vs control *P*=0.038 vs exercise	*P*=0.003 vs control *P*=0.001 vs exercise	*P*=0.302 vs control (mental) P=0.269 (physical) vs control *P*= 0.528 (mental) vs exercise *P*=0.227 (physical) vs exercise
Garfinkel et al., 1994 Hand OA	60 min	1	-	8	*P*= 0.355 (pain at rest) *P*=0.004 (pain during activity)	*P*=0.141	Not measured
Zacharia et al., 2018 Lower Limb OA	60 min	2	-	8	*P*=0.001 (vs baseline)	*P*=0.001 vs baseline	Not measured

= Statistically Significant results (*P*=≤0.05) at short-term follow-up (8-12 weeks)

Spine.

Three studies assessed conditions of the spine (Dunleavy et al., 2016, chronic mechanical neck pain; Greendale et al., 2009, adult onset hyperkyphosis; Teut et al., 2016, chronic low back pain). Only one measured all three primary outcomes (Teut et al., 2016), finding no significant effects for pain, physical function, or quality of life, compared to control or qigong. Dunleavy et al. (2016) found statistically significant results for yoga versus non-exercise control for pain (equal to Pilates). Physical function and quality of life outcomes were not measured. Greendale et al. (2009) showed marked improvement to the shape of the spine after a six-month yoga intervention for hyperkyphosis, *P*=0.006 on flexicurve kyphosis angle and *P*= 0.004 on the kyphosis index, although again results did not result in significant improvement in physical function or quality of life, and pain was not measured.

Table 1.9 *Statistically Significant Results of Individual Neck and Back Studies (Primary Outcomes)*

a. Study Name/ Population	**Session Length**	**Sessions per week**	**Duration (weeks)**	**Results for Pain**	**Results for Physical Function**	**Results for QOL**
Dunleavy et al., 2016 Chronic Mechanical Neck Pain	60 min	1	12	*P*=0.0407 vs control P=0.41 vs Pilates	Not measured	Not measured
Teut et al., 2016 Chronic Low Back Pain	45 min	2	12	*P*=0.175	*P*=0.377 (on FFbHR) P=0.503 (on SF-36)	*P*=0.0351 (physical) P=0.858 (mental)
b. Study Name/ Population	**Session Length**	**Sessions per week**	**Duration (weeks)**	**Results for Kyphosis**	**Results for Physical Function**	**Results for QOL**
Greendale et al., 2009 Adult Onset Hyperkyphosis	60 min	3	24	*P*=0.006 (on flexicurve kyphosis angle) *P*=0.004 (kyphosis index)	*P*=0.1	*P*=0.1

= Statistically Significant results (*P*=$\leq$0.05) at short-term follow-up (8-12 weeks)

Yoga Interventions

Content.

Specific hatha yoga styles were mentioned in three of the studies, Iyengar yoga (Garfinkel et al., 1994; Innes et al., 2020) and Viniyoga (Teut et al., 2016), both of which are remedial styles known for their adaptability to practitioner needs (Desikachar et al.,1994; Mehta et al., 1990). Props such as blankets, straps, blocks, and chairs were used in several studies (Cheung et al., 2017; Dunleavy et al., 2016; Greendale et al., 2009; Innes et al., 2020; Ward et al., 2018).

In six cases (Cheung et al., 2017; Dunleavy et al., 2016; Garfinkel et al., 1994; Innes et al., 2020; Pandya 2019; Teut et al., 2016) the interventions were customised and delivered by instructors who had received special training to work with older adults or those with specific health conditions.

Adverse Events.

Seven of the studies reported on adverse events (Cheung et al., 2014; Cheung et al., 2017; Dunleavy et al., 2016; Greendale, 2009; Innes et al., 2020; Kuntz et al., 2018; Ward et al., 2018) finding 5.3% experienced non-serious adverse effects.

Adherence.

Retention rates for the studies was $\geq$73% in all but one study, Greendale et al., 2009. Six studies reported adherence to home practice (Cheung et al., 2014; Cheung et al., 2017; Innes et al., 2020; Pandya, 2019; Ward et al., 2018; Zacharia et al., 2018). The percentage of participants who adhered to home practice as prescribed was low (ranging 36-59%) where reported (Cheung et al., 2014; Pandya, 2019; Ward et al., 2018), but among those who did practice at home, adherence was good, with participants completing the majority of the weekly prescription (ranging 66-93%) (Cheung et al., 2014; Cheung et al., 2017; Innes et al., 2020; Pandya, 2019; Ward et al., 2018; Zacharia et al., 2018) .

Discussion

There is moderate evidence from individual studies (shown in Table 1.6) that yoga can be effective for pain and physical function for some of the age-related musculoskeletal conditions present in this review: Yoga was found statistically significantly effective ($P=\leq 0.05$) for pain in knee, lower limb, and hand OA and in neck pain populations. Statistically significant results for physical function were seen in knee and lower limb OA and sarcopenia. The consistency found among the OA populations allows for a conservative recommendation of yoga for this condition. Of note, three of the five OA studies (Cheung et al., 2014; Cheung et al., 2017; Zacharia et al., 2018) used the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which consistently captured statistically significant changes, recommending its use in future studies for this condition and population. The present review agrees in this respect with a systematic review of yoga for knee OA, which found that yoga had positive effects on pain and mobility (effects were captured on the WOMAC in five studies, VAS/NRS in four studies), but that effects on quality of life were unclear. (Kan et al., 2016).

Notably, significant results for pain exceeded those for physical function. This perhaps reflects yoga's origins as a mediative practice with the use of focused breath to influence neurobiological effects on stress reactivity, including with improved regulation of the sympathetic nervous system and hypothalamic-pituitary-adrenal system (Pascoe, Thompson, & Ski, 2017).

A broad range of physical function measurements were used, with no clearly discernible pattern in the results. However, where physical function results were captured, it was with tools specific to the condition or population, such as the OA tools WOMAC (in Cheung et al., 2017; Kuntz et al., 2018), KOOS (in Zacharia et al., 2018), and the Senior Fitness Test in the sarcopenia population (Pandya, 2019), indicating population-specific measuring tools can be recommended as they are shown to be sensitive to change.

Of interest was the absence of significant effects overall for health-related quality of life compared to controls despite five different measures being used (Table 1.5). The existing literature on yoga's effects on quality of life is unclear. Existing systematic reviews of yoga for knee osteoarthritis (Lu et al., 2024) and back pain (Cramer at al., 2013; Wieland et al., 2017) similarly reported a lack of evidence for significant quality of life effects (Cramer et al., 2013; Lu et al., 2024; Wieland et al., 2017). Yet these findings are not reflected in existing research using slightly different populations, including older but without musculoskeletal conditions (Patel et al., 2012; Sivaramakrishnan et al., 2019), or those with chronic conditions but not recruited by age (Sieczkowska et al., 2019; Telles et al., 2019). Possibly, depending on the population of study, the assessment of exercise interventions that have nuanced psychosocial outcomes can in some cases be limited by solely using quantitative outcomes, and more phenomenological studies could be needed. In Teut et al., (2016), the participants of both interventions nonetheless gave high scores on a numerical rating scale for satisfaction, credibility, and likelihood of recommending the intervention, despite their not having reduced pain, or improved function or quality of life. The researchers suggest that for older adults, patient-centred outcomes are particularly important in designing meaningful interventions. The length of the intervention may also play a role. An existing systematic review and meta-analysis examining yoga and health-related quality of life for older adults suggests that medium-term interventions of 24 weeks may be more effective

(Sivaramakrishnan et al., 2019). The present review contained no long-term studies that measured quality of life and these may be needed to capture results.

Another interesting finding was that no significant results for any outcome were found in the one study of low back pain, at odds with existing trials that were not centred on older adults (Kuvačić, et al., 2018; Tilbrook et al., 2011). Again, this could be a function of more specificity in the outcome measures used – the Oswestry Low Back Pain Disability Questionnaire in addition to a numerical pain scale (Kuvačić, et al., 2018) and the Roland Morris Disability Index (Tilbrook et al., 2011), versus Teut's FRI, VAS and Hanover Functional Ability Questionnaire. Teut's study was the only study retrieved of yoga for back pain specifically in the older population (65+, mean 73). One theory posited by the Teut, et al. (2016) is that the lack of effects measured could be due to the way older people process and perceive pain. However, the fact that other studies on older adults with other MSK conditions in this review (Cheung et al., 2014; Cheung et al., 2017; Dunleavy et al., 2016; Garfinkel et al., 1994; Kuntz et al., 2018; Zacharia et al., 2018) did show significant pain reduction calls this into question. Differences in geography and ethnicity of study populations perhaps also play a part in how participants respond to self-reported outcome measures. Teut et al. (2016) also suggested the intervention length of three months was possibly not long enough to address the chronic nature of the back pain in their sample (mean duration 18-20 years). While it is not possible to generalise conclusions based on a single study and beyond the remit of this review to provide an exhaustive assessment of yoga for back pain specifically, this trial highlights gaps in knowledge. These could be addressed by further mixed-methods trials of yoga for back pain on older adults, potentially of medium and long-term duration, study of the effects of yoga on a younger versus older population, and study of the intervention's effects in relation to the duration of the back pain.

Although there was some variety of intervention durations and practice frequencies used across a range of conditions, some trends in dosage were observed. In the majority of effective short-term (8-12 week) trials (Cheung et al., 2014; Cheung et al., 2017; Garfinkel et al., 1994; Innes et al., 2020; Zacharia et al., 2018) 60 minutes was the prevalent length of group classes coupled with an approximate prescribed average of four 30-minute sessions of home practice. For OA there is evidence of pain effects after eight weeks (Cheung et al., 2014; Cheung et al., 2017; Garfinkel et al., 1994). Weekly frequency of practice emerged as the most elusive variable, as some 8 and 12-week studies using only one hour of yoga per week saw significant pain effects (Garfinkel et al., 1994; Dunleavy et al., 2016). Existing literature is similarly conflicted regarding practice frequency: In a previous dosage study, no difference was found in reduction of moderate to severe low back pain between one yoga session versus two per week over 12 weeks (Saper et al., 2013). In contrast, these findings disagree with a more recent survey finding practice frequency (either with or without the teacher) to be the strongest predictor of self-reported positive results (Cartwright et al., 2020; Wiese et al., 2019a). These conflicting conclusions make it difficult to determined precisely how critical a variable weekly practice hours and frequency are in determining quantitative results in a clinical setting. These may depend on the population, and further studies are needed. However, taking the OA studies in isolation (Cheung et al., 2014; Cheung et al., 2017; Garfinkel et al., 1994; Kuntz et al., 2018; Zacharia et al., 2018), one 60-minute group class with additional classes or home practice two or more times per week, for eight weeks minimum, can be recommended for OA pain.

Yoga was in some studies more effective than other rehabilitative exercise, and on balance at least on a par (Cheung et al., 2017; Dunleavy et al., 2016; Kuntz et al., 2018; Pandya, 2019). Compared to walking, yoga was found superior for functional fitness for sarcopenia (Pandya, 2019). Against aerobic and strengthening exercises for OA patients, one study (Cheung et al., 2017) found yoga more effective while in another (Kuntz et al., 2018) it was equally effective. Both yoga and Pilates were effective for neck pain (Dunleavy et al., 2016). Parity here suggests that exercise referral should be partly based on patient preference (Foster et al., 2018). This review finds evidence of good adherence in the predominantly female populations, which in existing research has been credited for its effects on female patients with OA (Zhang et al., 2019).

In the five studies that included home yoga exercise (Cheung et al., 2014; Cheung et al., 2017; Innes et al., 2019; Pandya, 2020; Ward et al., 2018) all but one (Innes et al.,2019) found adherence to group exercise to be higher than for home exercise. Therefore, for effective results and greater satisfaction, yoga therapists should encourage face-to-face instruction. Where this is not possible, the goal of the therapist may shift to facilitation and motivation for home practice.

The present review agrees with existing research on the low injury risk and safety of yoga (Cramer et al., 2015; Wiese et al., 2019b), noting more adverse effects in yoga compared with non-physical interventions, but finding that yoga is as safe as exercise comparators (Cramer et al., 2015). However, in several cases (Cheung et al., 2017, Dunleavy et al., 2016; Garfinkel et al., 1994; Innes et al., 2020; Pandya, 2019; Teut et al., 2016) the interventions were customised and delivered by instructors who had received special training to work with older adults or those with specific health conditions. This finding concurs with Wieland et al. (2017), and while this is recommended as a key consideration for optimum results and safety, it is an important consideration for exercise referral that results are not generalised across all approaches to yoga including more physically demanding or athletic styles.

Strengths

Nine of the included studies were published within the last five years at the time of writing. Studies' methodologies were well reported according to CONSORT guidelines (Schulz et al., 2010) facilitating the quality assessment, which was conducted by two reviewers to reduce bias. The review follows PRISMA reporting guidelines (Moher et al., 2009; Moher et al., 2015) ensuring transparency of protocols, searches, and results, reducing sources of error. The review was published in *Musculoskeletal Care* (Denham-Jones et al., 2022b) strengthening the validity of findings through peer review.

Limitations

Due to a paucity of studies on yoga for chronic musculoskeletal conditions in adults over 50 years exclusively, inclusion criteria instead allowed for studies with age-associated musculoskeletal conditions with a *mean* age over 50. While findings can be applied to populations over 50, the presence of younger participants in the overall sample somewhat reduces the reliability of findings when making recommendations specifically for adults 50 and over.

Some of the studies used small samples and did not include power calculations (Cheung et al., 2014; Garfinkel et al., 1994; Ward et al., 2018), which can lead to exaggerated estimates of the effect sizes. Only three studies (Greendale et al., 2009; Pandya, 2019; Teut et al., 2016) had more than 100 participants.

Nine studies measured only short-term results. Although the large long-term study (Pandya, 2019, a 10 year study) showed excellent retention and significant results, it was the only one of its scale in the review. Therefore, the review is unable to generalised on the long-term retention of results of yoga and this is an area of research to be explored.

Several issues of heterogeneity reduced the ability to generalise results: A broad interpretation of physical function was used, taking into account a variety of measures for this outcome. Zacharia et al., (2018) was anomalous in design as it assessed the impact of an additional home practice versus none, hence did not have a non-yoga control group so any effects cannot be assessed against non-treatment. Variety in statistical methodology limited the number of studies included in data pooling to five or less, thereby reducing certainty of the forest plots.

Methodological quality was varied. Yoga trials do not by nature allow for blinding of participants, leaving open the possibility of placebo effects. Additionally, three trials (Dunleavy et al., 2016; Garfinkel et al., 1994; Ward et al., 2018) did not use intention-to-treat analysis. This potentially biases the treatment affect as drop-outs related to the interventions may be caused by lack of effectiveness and adverse effects which are then not quantified in results. It also biases the assignment effects which indicate the effects of prescribing exercise in clinical practice, with adherence or attrition an intrinsic part of the outcome (Hollis & Campbell, 1999; Vlad & LaValley, 2008).

This review reflects some of the limitations of yoga clinical trials noted in previously cited reviews of yoga and concurs with them that evidence presented should be viewed conservatively due the issues of inherent risk of bias due to sample size (Patel, et al., 2012), trial duration (Wieland et al., 2017), non-blinding and heterogeneity, and methodological quality (Hill, 2013; Chobe et al., 2020; Chang et al., 2016; Posadzki & Ernst, 2011a; Wieland et al., 2017).

Future trials should utilise robust methodology and reporting protocols, and international yoga reporting guidelines have now been published to facilitate this (Moonaz et al., 2021).

As fewer than five studies included enough data for a funnel plot, an assessment for publication bias was not possible as too few studies mean that the power of the test is too low to distinguish chance from real asymmetry (Higgins et al., 2023).

Conclusion

This review found evidence that postural yoga is a safe and adaptable form of exercise with good adherence for older adults with arthritis, neck and back pain, hyperkyphosis, RLS, and sarcopenia. Sub-group analysis indicates pain and physical function benefits particular to OA patients over 50 years. Although based on only four studies, these results agree with existing research of yoga for OA, and cautiously can be generalised.

As yoga was at least as effective as other strengthening and aerobic exercise for pain and functioning outcomes, prescription and uptake of yoga as therapy therefore may depend on accessibility, motivation, and preference. Findings support the use of adaptable styles of hatha yoga, such as Iyengar and Viniyoga, with props and modifications to address age-related physical limitations. One 60-minute group class per week over at least eight weeks is recommended at minimum, with additional classes or home practice two or three times per week evidencing effects for OA pain, with no adverse events.

Yoga did not evidence statistically significant effects for any outcome in an older back pain population, and further studies are needed to better understand its effects on this group. Health-related quality of life effects were not in evidence for any population represented in this review, suggesting that different measuring tools may be needed, and phenomenological studies may provide further insight into the qualitative aspects and lived experiences of older adults practising yoga.

Chapter Two
A Systematic Review of the Effectiveness of Pilates on Pain, Disability, Physical Function, and Quality of Life in Older Adults with Chronic Musculoskeletal Conditions

Introduction

As shown in the preceding narrative review, Pilates is particularly appropriate as a form of rehabilitative exercise for those with physical limitations due to its low impact nature and adaptability. Pilates is known to improve muscle endurance, flexibility, and dynamic balance (Cruz-Ferreira et al., 2011; Kamioka et al., 2016). Studies of have shown improvements in pain (Aladro-Gonzalvo et al., 2013; La Touche et al., 2008; Lim et al., 2011; Lin et al., 2016; Miyamoto et al., 2013; Mizarchi & Kafri, 2017; Patti et al., 2015; Posadzki et al., 2011b; Vasconcellos et al., 2014; Wells et al., 2014b), disability (Aladro-Gonzalvo et al., 2013; Miyamoto et al., 2013; Yamato et al., 2016), and physical function (La Touche at al., 2008; Lin et al., 2016; Wells et al., 2014b) for back pain. There is also evidence that Pilates improves balance (Barker et al., 2015; Casonatto & Yamacita, 2020; Moreno-Segura et al., 2018), fitness, function, and well-being (Bueno de Souza et al., 2018; Bullo et al., 2015; de Oliveira Francisco et al., 2015; Engers et al., 2016) in older adults. In addition, Pilates has been shown to facilitate continuing participation in other activities such as work and physical activity (Gaskell & Williams, 2018).

Justification for the Review

A literature search was conducted to locate existing systematic reviews and establish research gaps. Three systematic reviews of Pilates were retrieved for general adult populations but without specific age or condition criteria. Two agreed on the general fitness benefits of flexibility, dynamic balance, and muscle endurance, (Cruz-Ferreira et al., 2011; Kamioka et al., 2016) and one reported positive mental health outcomes (Fleming &

Herring, 2018).

There were 12 reviews retrieved on Pilates for chronic low back pain (CLBP) irrespective of age, offering evidence that Pilates improved pain (Aladro-Gonzalvo et al., 2013; La Touche et al., 2008; Lim et al., 2011; Lin et al., 2016; Miyamoto et al., 2013; Mizarchi & Kafri, 2017; Patti et al., 2015; Posadzki et al., 2011b; Vasconcellos et al., 2014; Wells et al., 2014b) disability (Aladro-Gonzalvo et a., 2013; Miyamoto et al., 2013; Yamato et al., 2016), and physical function (La Touche at al., 2008; Lin et al., 2016; Wells et al., 2014b). Only one review found no evidence for the effectiveness of Pilates for low back pain even over non-exercise control groups (Pereira et al., 2012). Several reviews focused on Pilates for older adults, without any specific health condition as inclusion criteria for participants. Three of these focused on balance (Barker et al., 2015; Casonatto & Yamacita, 2020; Moreno-Segura et al., 2018), another four on physical fitness, function and well-being (Bueno de Souza et al., 2018; Bullo et al., 2015; de Oliveira Francisco et al., 2015; Engers et al., 2016). All found evidence that Pilates statistically improved these outcomes.

This above-cited Pilates research tends to focus either on the healthy population, back pain, or older adults not defined by any health condition. Less is known about how and why Pilates should be delivered from middle-age onwards, taking into consideration both the ageing process from its onset, age-related musculoskeletal conditions, and the need or desire to stay active. This review therefore considers the effects of Pilates on middle-aged and older adults, using a sample with a mean age over 50 with chronic musculoskeletal conditions. This population merits further study for a number of reasons. It is known that the incidence of people in this group becoming less active is compounded by a combination of their condition and their age (Hoy et al., 2014), yet at the same time their health can benefit from exercise (Prince et al., 2015). As outlined in the preceding narrative review, the health and well-being of an ageing population is important on an individual and societal level as adults may be required to stay in work for longer in their later years.

Aims and Objectives

- To assess the musculoskeletal health benefits of Pilates in a population with a mean age over 50 years
- To assess the effectiveness of Pilates on pain, physical function, and quality of life
- To inform design of a future randomised comparative trial that assesses effects and experiences of Pilates compared with yoga including:
  - to gain understanding of effective Pilates practices for the over-50 population
  - to determine optimum feasible intervention length, duration, and frequency
  - to identify appropriate outcome measurement tools to capture the effects of Pilates
  - to assess and understand perception of and adherence to Pilates

Methodology

This systematic review methodology followed PRISMA guidelines incorporating the PRISMA-P checklist for systematic review protocols (Moher et al., 2009; Moher et al., 2015). The question was constructed according to the PICO model (population, intervention, comparison, outcome the currently recommended paradigm for evidence-based clinical research, the currently recommended paradigm for evidence-based clinical research (Moher et al., 2015).

Research Question

How does Pilates affect pain, disability, physical function, and quality of life in adults of a mean age over 50 years with chronic musculoskeletal conditions?

Sub-Topics.

For adults over 50 years with chronic musculoskeletal conditions, was Pilates effective for pain, disability, physical function, and quality of life, and for which conditions?

For middle-aged and older adults, what are the optimum session length, frequency, intervention duration and outcome measures for capturing statically significant results?

How well was Pilates adhered to among various populations?

Search Strategy

A literature search was undertaken using Cochrane Controlled Register of Trials (CENTRAL), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Google Scholar, PsycInfo, Pubmed, SCOPUS, and Web of Science (Core Collection). To ensure against publication bias, Opengrey and Worldcat were searched for unpublished material (Siddaway et al., 2019). Search terms are shown in Table 2.1, with MeSH terms sourced from the U.S. National Library of Medicine, selected shown in column four. The search strategy and terms applied to Cochrane CENTRAL are also presented. Articles were screened using the inclusion and exclusion criteria show in Table 2.2. Rationales for database choices are presented in Tables A2.1 and A2.2 in Appendix III. Full text assessment was performed by two reviewers to mitigate bias.

Table 2.1 *Database Search Words*

Key Terms	Terms Used	Alternative Terms	MeSH terms
Population	Aging Ageing	Mature Senior Elderly "Old*" "Older adult" "Middle age*"	Aging -Physiology (PH) Middle Aged -Physiology (PH) Aged - physiology (PH) psychology (PX)
Intervention	Pilates	"Pilates Training" "Pilates-Based Exercise" "Pilates Based Exercises" "Pilates-Based"	Exercise Movement Techniques
Outcome	Pain Disability Physical Function "Quality of Life"	Ache QOL HRQOL GQOL "Health-Related Quality of Life" "Life Quality"	Pain -pathology (PA) -physiopathology (PP) -prevention & control (PC) -psychology (PX) -back pain -chronic pain -musculoskeletal pain -neck pain Physiology Quality of Life
Condition	Musculoskeletal	Arthritis "Back Pain" Chronic	Arthritis -pathology (PA) -physiopathology (PP) -prevention & control (PC) -psychology (PX) -therapy (TH)
Design	"Randomised Controlled Trial" "Cohort study" "Observational study"	RCT	Randomised Controlled Trial Cohort Studies

Search Terms as Applied to CENTRAL Database.

Search Name: Pilates SR
Last Saved: 26/07/2019 13:25:25
Comment: Same as Yoga SR but line 9 changed to Pilates

ID Search
#1 ag?ing in Trials
#2 MeSH descriptor: [Aged] explode all trees
#3 mature in Trials
#4 senior in Trials
#5 elderly in Trials
#6 old* in Trials
#7 "older adult" in Trials
#8 MeSH descriptor: [Middle Aged] explode all trees
#9 Pilates
#10 MeSH descriptor: [Pain] explode all trees
#11 MeSH descriptor: [Pain] explode all trees and with qualifier(s): [pathology - PA, physiopathology - PP, prevention & control - PC, psychology - PX]
#12 disability in Trials
#13 "physical functioning" in Trials
#14 "quality of life" in Trials
#15 ache in Trials
#16 QOL in Trials
#17 HRQOL in Trials
#18 GQOL in Trials
#19 "health-related quality of life" in Trials
#20 "life quality" in Trials
#21 MeSH descriptor: [Physiology] explode all trees
#22 MeSH descriptor: [Quality of Life] explode all trees
#23 musculoskeletal in Trials
#24 MeSH descriptor: [Musculoskeletal Diseases] explode all trees
#25 MeSH descriptor: [Arthritis] explode all trees
#26 MeSH descriptor: [Back Pain] explode all trees
#27 MeSH descriptor: [Arthritis] explode all trees and with qualifier(s): [pathology - PA, physiopathology - PP, prevention & control - PC, psychology - PX, therapy - TH]
#28 MeSH descriptor: [Randomized Controlled Trial] explode all trees
#29 MeSH descriptor: [Cohort Studies] 3 tree(s) exploded
#30 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8) AND #9 AND (#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27)

Table 2.2 *Inclusion and Exclusion Criteria*

Selection criteria	Inclusion Criteria	Exclusion criteria	Rationale
Population	Older adults, aged over 50, or mean age or 50 AND with chronic MSK conditions	General adult population Adults under age 50 Older Adults without chronic MSK conditions Adults over age 70 Frail elderly adults	Topic is Pilates for MSK conditions in an ageing population MSK conditions more likely in older population Established need for older adults to remain active and working, therefore aim is to capture older, working adults 50-70 years
Condition	Chronic musculoskeletal conditions	Acute conditions Conditions caused by trauma Co-morbidities of other pathologies	Target population for future intervention and measurement
Intervention	Pilates mat exercises Pilates-based exercise Classical Pilates Contemporary Pilates Clinical Pilates Pilates with portable equipment (e.g. ball, band, foam roller)	Pilates studio apparatus sessions (using large non-portable equipment, e.g., Reformer, Cadillac, Wunda Chair) Hybrids (e.g. yoga-Pilates fusion)	Further research will be based on the Pilates mat repertoire rather than exercises on the apparatus which are more costly to implement and less conducive to workplace delivery
Comparison	Any control group	None	RCTs with any type of control group will be included for maximum recall. Trials and cohort studies without controls to be included if not enough RCT meet selection criteria
Outcome	<u>Primary Outcomes</u> Pain Disability Physical Function Quality of Life <u>Secondary Outcomes</u> Core Strength Flexibility Balance Adverse effects Adherence	Studies whose main focus is not on the effectiveness of the intervention or assignment to intervention on the individual. For example, Economic or socio-economic studies.	The research aims to assess the therapy and its effect on the individual. Focus is on clinical research.
Design	Randomised controlled trials (Cohort Studies)	Cohort Studies Case-control Studies Case reports Cross-sectional reviews Dissertations, unless incorporating RCT or cohort study	Randomised controlled trials generally considered among the most appropriate study design to accurately assess the clinical efficacy of therapy interventions (Greenhalgh, 1997). Cohort studies included if <6 RCTs meet selection criteria Other studies eliminated to reduce volume and increase quality/specificity of the SR
Language	Available in English	Not available in English	No available budget for translation

Quality Assessment

Methodological quality and risk of bias was assessed by two reviewers using the Cochrane Collaboration's tool for assessing risk of bias in randomised trials (Higgins et al., 2011). This tool was selected for its comprehensiveness and detailed user guidelines. It focuses on internal validity and trial conduct as well as reported characteristics, on which judgments of risk of bias are made. The tool allows users to assess bias related to randomisation, deviations from the intended intervention, missing outcome data, outcome measurement, and selection of the reported result (Table A2.3).

Where disagreement was found between the researcher and the second assessor (the research supervisor) the assessment became an iterative process whereby the researcher re-evaluated the paper against the guidelines for the Cochrane risk-of-bias tool (Sterne et al., 2018) for any domains that had resulted in differing evaluations. In clear cases or error, these were corrected. Where discrepancies remained following the researcher's second pass of evaluation against the criteria, these were resolved by a discussion between the two assessors, a decision was mutually agreed upon, and the bias assessment either revised or maintained.

Data Extraction

As Pilates includes a diverse repertoire of exercises, the Template for Intervention Description and Replication (TIDieR) checklist was used to gain an understanding of the Pilates intervention used in each trial in order to make comparisons and differentiations when analysing results. The TIDieR checklist itemises aspects of the intervention's rationale, administration, setting, duration, frequency, cost, planning, modification, and delivery (Hoffmann et al., 2014).

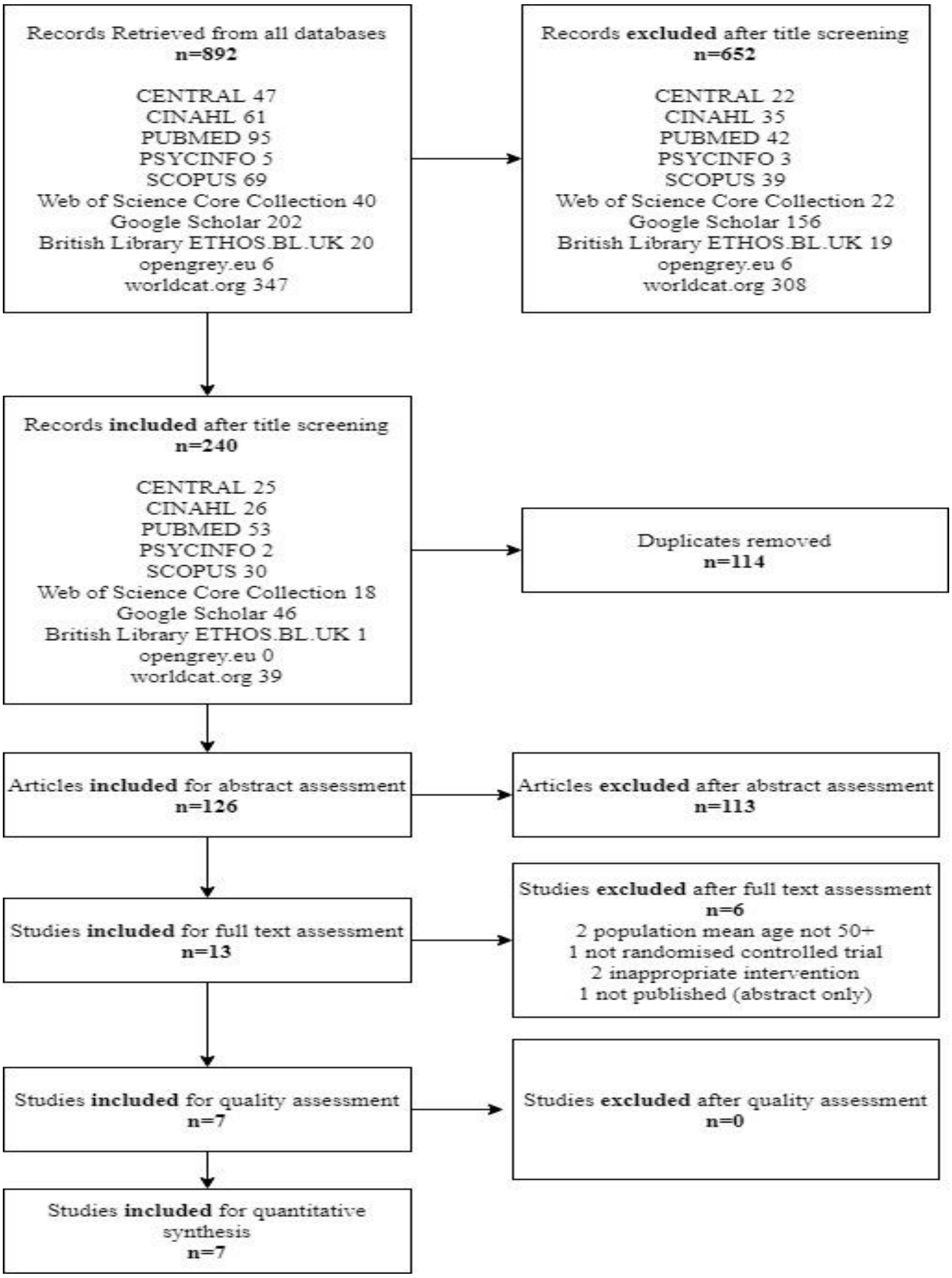
Data Analysis

Information from the data extraction form for each study was uploaded into Review Manager software (Revman Version 5.1, The Nordic Cochrane Centre, Copenhagen) to calculate the interventions' effects. Heterogeneity of studies was assessed using an I^2 test ($I^2 = 100\% \times (Q\text{-}df)/Q$) which calculates the percentage of variation in the studies deriving from heterogeneity rather than chance and is not inherently dependent on the number of studies considered (Higgins and Thompson, 2002; Higgins et al., 2003). Due to heterogeneity (I^2>50%), a random effects model was used. Forest plots were used to illustrate the effect size and 95% confidence intervals and provide a visual aid to efficiently view and interpret the evidence (Verhagen and Ferreira, 2014). The meta-analysis was carried out using Revman software utilising a random effects inverse variance method, measuring continuous data for standardised mean differences. In the inverse-variance method the weighting for each study is the inverse of the variance of the effect estimate (i.e., 1 over the square of its standard error). Larger studies, with smaller standard errors, are given more weight than smaller studies with larger standard errors so as to minimizes the imprecision (uncertainty) of the pooled effect estimate (Higgins et al., 2023)

Results

The literature search retrieved 600 articles, of which seven articles fulfilled the inclusion criteria for the systematic review (Figure 2.1).

Figure 2.1 *Literature Search PRISMA Flow Chart*



Study Populations

Three studies included back pain populations (Cruz-Díaz et al., 2015; Donzelli et al., 2006; Notarnicola et al., 2014), two were of participants with osteoporosis (Küçükçakir et al., 2013; Oksuz & Unal, 2017), and one each were of chronic mechanical neck pain (Dunleavy et al., 2016) and knee osteoarthritis (Mazloum et al., 2018). The mean age of participants across the seven studies was 56.68 years. Sample size ranged from 40 to 103 with a mean of 57. The overall sample size of all studies combined was 397 and 73% of total participants were female. The high proportion of female participants reflects the fact that three studies recruited only women (Cruz-Díaz et al., 2015; Küçükçakir et al., 2013; Oksuz & Unal, 2017), the higher prevalence in older women of chronic musculoskeletal conditions (Gran, 2003; Wijnhoven, et al., 2006), and possibly a greater tendency for more women than men to volunteer for a Pilates-based intervention (Table 2.3).

Table 2.3 *Characteristics of Included Studies – Population*

Study	Location	Population Age	Female/Male %	Population Characteristics	Sample Size Randomised	Sample analysed per group - Pilates/non-exercise control/exercise comparator (total)
Cruz-Díaz et al., 2015	Spain	65+, mean 71.1	100.00%	Chronic low back pain≥3 months	103	47/50 (97)
Donzelli et al., 2006	Italy	20-65, mean 50.08	NR	Chronic low back pain≥3 months	43	21/22 (43)
Dunleavy et al., 2016	USA	mean 55.6	87%/13%	Chronic Mechanical Neck Pain > 3 months	88	19/17/20 (56)
Küçükçakir et al., 2013	Turkey	45-65, mean 55.5	100.00%	Postmenopausal osteoporosis	70	30/30 (60)
Mazloum et al., 2018	Iran	40+ mean 52.1	40%/60%	Knee OA	49	14/14/13 (41)
Notarnicola et al., 2014	Italy	30+, mean 51.2	55%/45%	Chronic low back pain>6 months	60	30/30 (60)
Oksuz & Unal, 2017	Turkey	50-75, mean 60	100.00%	Osteoporosis	40	20/20 (40)

Key to Abbreviations: NR=Not reported; ≥=equal to or more than; >=more than

Characteristics of Interventions

The length of each Pilates or exercise session was 60 minutes in all cases. Frequency of supervised sessions ranged from one to five times per week. Duration of the supervised intervention ranged from 10 days to one year. Four (Cruz-Díaz et al., 2015; Oksuz & Unal, 2017; Dunleavy et al., 2016; Mazloum et al., 2018) were short-term (6-12 weeks), two (Donzelli et al., 2006; Notarnicola et al., 2014) were medium-term (six months), and one (Küçükçakir et al., 2013) was one year. The mean number of supervised sessions in all studies included was 43, ranging from 10 to 120. Five studies used non-Pilates exercise in addition to non-exercise controls, including physiotherapy with transcutaneous electrical nerve stimulation (TENS), massage and low back stretching (Cruz-Díaz et al., 2015), Back School (Donzelli et al., 2006), yoga (Dunleavy et al., 2016), home exercise comprising of thoracic extensions in a sitting position (Küçükçakir et al., 2013), and conventional therapeutic exercises (non-Pilates exercise therapy) (Mazloum et al., 2018) (Table 2.4). Outcome measures for each study appear in Table 2.5. A summary of results is shown in Table 2.6.

Table 2.4 *Characteristics of Included Studies - Interventions*

Study Name/ Population	Intervention (60-minute session)	Intervention Frequency	Exercise Control (60-minute session)	Exercise Control Frequency	Duration	Non-Exercise Control	Data Collection & Follow-Up Points
Cruz-Díaz et al., 2015 Chronic Low Back Pain (women 65+)	Pilates + physiotherapy including transcutaneous electrical nerve stimulation (TENS), massage and low back stretching	2/week	Physiotherapy including transcutaneous electrical nerve stimulation (TENS), massage and low back stretching	2/week	6 weeks	None	6 weeks
Donzelli et al., 2006 Chronic low back pain	Pilates Cova Technique	Daily for 10 days + unreported amount of home practice for 6 months	Back School	Daily for 10 days + unreported amount of home practice for 6 months	10 days/6 months	None	1, 3 & 6 months
Dunleavy et al., 2016 Chronic Mechanical Neck Pain	Pilates	1/week	Yoga	1/week	12 weeks	Meditation	Baseline, 6, 12 & 18 week follow-up
Küçükçakir et al., 2013 Postmenopausal Osteoporosis	Pilates	2/week	Home exercises (thoracic extensions in sitting position)	NI	1 year	None	1 year
Mazloum et al., 2018 Knee Osteoarthritis	Pilates	3/week (24 sessions over 8 weeks)	Conventional therapeutic exercises	3/week (24 sessions over 8 weeks)	8 weeks	No treatment (Usual activities)	8 weeks
Notarnicola et al., 2014 Chronic low back pain	Pilates	5/week	NA	NA	6 months	No treatment ("Inactivity")	6 months
Oksuz & Unal, 2017 Osteoporosis (women)	Pilates	3/week	NA	NA	6 weeks	Usual activities	6 weeks

Key to Abbreviations: NA=Not applicable, NI=No information

Table 2.5 *Characteristics of Studies – Outcome Measures*

Study	Primary Outcome Measures 1. Pain 2. Disability 3. Physical Function 4. QOL	Secondary Outcome Measures 1. Strength 2. Flexibility 3. Balance
Cruz-Díaz et al., 2015	1. NRS 2. NA 3. TUG 4. NA	1. NA 2. NA 3. TUG
Donzelli et al., 2006	1. VAS 2. OLBPDQ 3. NA 4. NA	1. NA 2. NA 3. NA
Dunleavy et al., 2016	1. NDI 2. NDI 3. NA 4. NA	1. NA 2. NA 3. NA
Küçükçakir et al., 2013	1. VAS, SF-36 2. NA 3. Six-minute walk test; sit-to-stand test, SF-36 4. Qualeffo-41, SF-36	1. NA 2. NA 3. NA
Mazloum et al., 2018	1. Lequesne Index 2. Lequesne Index 3. Timed walk, sit-to-stand test, stairs; target knee angle reproduction using Biodex system 3 4. NA	1. NA 2. NA 3. NA
Notarnicola et al., 2014	1. OLBPDQ, SF-36 2. OLBPDQ, RMDQ 3.SF-36, SFS 4. SF-36	1. NA 2. NA 3. NA
Oksuz & Unal, 2017	1. VAS, SF-McGill, PDI, Qualeffo-41 2. ODI 3. CSRT, CSST, TUG, HAQ, Qualeffo-41 4. HADS, SLS,Qualeffo-41	1. CSST 2. CSRT, Back Scratch Test 3. Berg Balance Test

Key to Abbreviations: BBT=Berg Balance Test, CSRT=Chair Sit and Reach Test, CSST=Chair Sit and Stand Test, HADS=Hospital Anxiety and Depression Scale, HAQ-DH=Health Assessment Questionnaire Disability Index, NA=Not Applicable, NDI=Neck disability index, NRS=Numerical Rating Scale, ODI=Oswestry Disability Questionnaire, OLBPDQ=Oswestry Low Back Pain Disability Questionnaire, PDI=Pain Disability Questionnaire, Qualeffo-41=Questionnaire of the European Foundation of Osteoporosis, RMDQ=Roland Morris Disability Questionnaire, SF 36=Quality of Life Short Form 36, SFS=Spinal Functioning Sort Questionnaire, SLS= Satisfaction with Life Survey, SF McGill=Short Form McGill Pain Questionnaire, TUG=Timed Up and Go Test, VAS= Visual Analogue Scale

Table 2.6 *Results Summary*

Study	Condition	Measured ?	Outcome Measure	Effective vs Control ? (P=<0.05)	Effective vs Exercise? (P=<0.05)
Pain					
Cruz-Díaz et al., 2015	CLBP	Y	NRS	-	Y
Donzelli et al., 2006	CLBP	Y	VAS	- (no P value)	N (no P value)
Dunleavy et al., 2016	Neck Pain	Y	NDI	Y	N (both effective)
Küçükçakir et al., 2013	Osteoporosis	Y	VAS, SF-36	-	Y
Mazloum et al., 2018	Knee OA	Y	Lequesne Index	Y	Y
Notarnicola et al., 2014	CLBP	Y	OLBPDQ, SF-36	Y	-
Oksuz & Unal, 2017	Osteoporosis	Y	VAS, SF-McGill, PDI, Qualeffo-41	Y	-
Disability					
Cruz-Díaz et al., 2015	CLBP	N	-	-	-
Donzelli et al., 2006	CLBP	Y	OLBPDQ	- (no P value)	N (no P value)
Dunleavy et al., 2016	Neck Pain	Y	NDI	Y	N
Küçükçakir et al., 2013	Osteoporosis	N	-	-	-
Mazloum et al., 2018	Knee OA	Y	Lequesne Index	Y	Y
Notarnicola et al., 2014	CLBP	Y	OLBPD, RMDQ	Y	-
Oksuz & Unal, 2017	Osteoporosis	Y	ODI	Y	-
Physical Function					
Cruz-Díaz et al., 2015	CLBP	Y	TUB	-	Y
Donzelli et al., 2006	CLBP	N		-	-
Dunleavy et al., 2016	Neck Pain	N		-	-
Küçükçakir et al., 2013	Osteoporosis	Y	6-min walk test, sit-to-stand test, SF-36	-	Y
Mazloum et al., 2018	Knee OA	Y	Timed walk, sit-to-stand test, stairs, Biodex system 3	Y	N
Notarnicola et al., 2014	CLBP	Y	SF-36, SFS	N (y baseline)	-
Oksuz & Unal, 2017	Osteoporosis	Y	CSRT, CSST, TUG, HAQ, Qualeffo-41	Y	-
QOL					
Cruz-Díaz et al., 2015	CLBP	N		-	-
Donzelli et al., 2006	CLBP	N		-	-
Dunleavy et al., 2016	Neck Pain	N		-	-
Küçükçakir et al., 2013	Osteoporosis	Y	Qualeffo-41, SF-36	-	Y
Mazloum et al., 2018	Knee OA	N		-	-
Notarnicola et al., 2014	CLBP	Y	SF-36	Y	-
Oksuz & Unal, 2017	Osteoporosis	Y	HADS, SLS, Qualeffo-41	Y	-

All short-term follow-up (8-12 weeks) unless indicated: 6 months (medium), 1 year (long)

Key to Abbreviations: BBT=Berg Balance Test, CSRT=Chair Sit and Reach Test, CSST=Chair Sit and Stand Test, HADS=Hospital Anxiety and Depression Scale, HAQ-DH=Health Assessment Questionnaire Disability Index, NA=Not Applicable, NDI=Neck disability index, NRS=Numerical Rating Scale, ODI=Oswestry Disability Questionnaire, OLBPDQ=Oswestry Low Back Pain Disability Questionnaire, PDI=Pain Disability Questionnaire, Qualeffo-41=Questionnaire of the European Foundation of Osteoporosis, RMDQ=Roland Morris Disability Questionnaire, SF 36=Quality of Life Short Form 36, SFS=Spinal Functioning Sort Questionnaire, SLS= Satisfaction with Life Survey, SF McGill=Short Form McGill Pain Questionnaire, TUG=Timed Up and Go Test, VAS= Visual Analogue Scale

Pain.

All studies measured this outcome and captured statistically significant results (statistically significant at *P*=0.05) for Pilates versus control across CLBP, osteoporosis, neck pain and knee OA populations. (Donzelli et al., 2006 did not report *P* values).

Disability.

Five studies (Donzelli et al. 2006; Notarnicola et al., 2014; Oksuz & Unal, 2017; Dunleavy et al., 2016; Mazloum et al., 2018) measured disability and four (Notarnicola et al., 2014; Oksuz & Unal, 2017; Dunleavy et al., 2016; Mazloum et al., 2018) captured significant results for Pilates versus control across CLBP, osteoporosis, neck pain, and knee OA populations. (Donzelli et al., 2006 did not report *P* values).

Physical Function.

Five studies (Cruz-Díaz et al., 2015; Notarnicola et al., 2014; Küçükçakir et al., 2013; Oksuz & Unal, 2017; Mazloum et al., 2018) measured physical function and four (Cruz-Díaz et al., 2015; Küçükçakir et al., 2013; Oksuz & Unal, 2017; Mazloum et al., 2018) captured significant results for Pilates versus control across CLBP, osteoporosis, neck pain, and knee OA populations. One CLBP study (Notarnicola et al., 2014) captured a significant change versus baseline, but not versus control.

Quality of Life.

Three studies (Notarnicola et al., 2014; Küçükçakir, 2013; Oksuz & Unal, 2017) measured quality of life and all captured significant results for Pilates versus control across CLBP and osteoporosis populations.

Summary of Results for Secondary Outcomes

Strength, Flexibility, and Balance.

Oskuz & Unal (2017) measured strength, flexibility, and balance and found significant results for Pilates versus control for osteoporosis. Cruz-Díaz, et al. (2015) also measured balance, with significant results for CLBP.

Pilates versus Other Exercise

Five studies used exercise controls solely (Cruz-Díaz et al., 2015; Donzelli et al., 2006; Küçükçakir et al., 2013), or in addition to non-exercise controls (Dunleavy et al., 2016; Mazloum et al., 2018). All measured pain and three reported significant results: Cruz-Díaz et al. (2015) for CLBP using Pilates in addition to a therapy of Transcutaneous Electrical Nerve Stimulation (TENS), massage and low back stretching, versus those receiving the therapy only; Küçükçakir et al. (2013) for osteoporosis using Pilates versus thoracic extension exercises; and Mazloum et al. (2018) for knee OA using Pilates versus conventional therapeutic exercises.

Three studies (Donzelli et al., 2006; Dunleavy et al., 2016; Mazloum et al., 2018) measured disability, but only Mazloum et al., (2018) (knee OA) found Pilates significantly superior. Pilates was found as effective as yoga for pain and disability in Dunleavy et al., (2016) for neck pain (versus yoga), and in Donzelli et al. (2006) for CLBP (versus Back School).

Three studies (Cruz-Díaz et al., 2015; Küçükçakir et al., 2013; Mazloum et al., 2018) measured physical function with significant results for in Cruz-Díaz et al. (2015) for CLBP and in Küçükçakir et al. (2013) for osteoporosis. Mazloum et al. (2018) found Pilates equal to therapeutic exercises for knee OA. Cruz-Díaz et al. (2015) also captured significant balance results, and Küçükçakir et al. (2013) effects for quality of life, compared to their exercise controls.

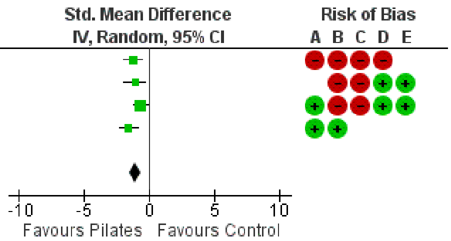
A summary table of results of individual studies are presented in Table A2.5 in Appendix III.

Forest plots were created for studies with common outcomes and sufficient data. (Figures 2.2,2.3, 2.4). An analysis of four studies (Dunleavy et al., 2016; Mazloum et al., 2018; Notarnicola et al., 2014; Oksuz & Unal, 2017;) indicated statistical significance of Pilates for pain and disability (versus non-exercise controls). Pooling of three studies using exercise controls showed no significant effectiveness in pain outcomes for Pilates over other exercise. A random effects model was used due to heterogeneity (I^2= 82% and 92% respectively). Random effects models do not presume that there is only one true effect size but allow for variance in methodologies and effect sizes between studies (DerSimonian & Laird, 2015).

Figure 2.2 *Forest Plot Comparison: Pilates vs. Non-Exercise Control (Outcome: Pain)*

Study or Subgroup	Pilates Mean	Pilates SD	Pilates Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dunleavy 2016	1.9	1.6	20	3.9	1.6	17	23.4%	-1.22 [-1.93, -0.51]
Mazloum 2018	8.4	1.9	14	10.5	1.8	13	19.1%	-1.10 [-1.92, -0.28]
Notarnicola 2014	10.8	10.1	30	21.9	20.8	30	34.5%	-0.67 [-1.19, -0.15]
Oksuz 2017	-5.35	4.79	20	0.2	0.62	20	23.0%	-1.59 [-2.31, -0.87]
Total (95% CI)			**84**			**80**	**100.0%**	**-1.09 [-1.51, -0.68]**

Heterogeneity: Tau² = 0.06; Chi² = 4.46, df = 3 (P = 0.22); I² = 33%
Test for overall effect: Z = 5.18 (P < 0.00001)

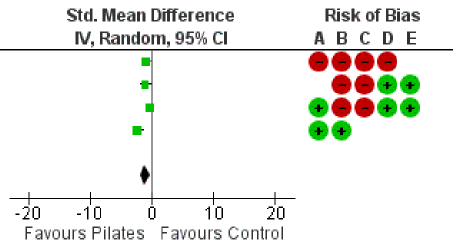


Risk of bias legend
(A) Bias arising from radomisation process
(B) Bias due to deviations from intended intervention
(C) Bias due to missing outcome data
(D) Bias in measurement of outcome
(E) Bias in selection of reporting result

Figure 2.3 *Forest Plot Comparison: Pilates vs. Non-Exercise Control (Outcome: Disability)*

Study or Subgroup	Pilates Mean	Pilates SD	Pilates Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dunleavy 2016	6.8	4.3	20	12.5	6.8	17	25.3%	-1.00 [-1.69, -0.31]
Mazloum 2018	8.4	1.9	14	10.5	1.8	13	23.6%	-1.10 [-1.92, -0.28]
Notarnicola 2014	5.1	4.8	30	6.6	5.4	30	27.5%	-0.29 [-0.80, 0.22]
Oksuz 2017	-7.6	5.05	20	1.6	2.3	20	23.6%	-2.30 [-3.11, -1.48]
Total (95% CI)			**84**			**80**	**100.0%**	**-1.13 [-1.96, -0.31]**

Heterogeneity: Tau² = 0.58; Chi² = 17.09, df = 3 (P = 0.0007); I² = 82%
Test for overall effect: Z = 2.69 (P = 0.007)

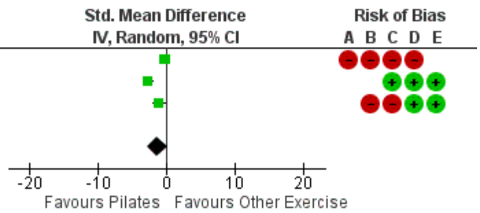


Risk of bias legend
(A) Bias arising from radomisation process
(B) Bias due to deviations from intended intervention
(C) Bias due to missing outcome data
(D) Bias in measurement of outcome
(E) Bias in selection of reporting result

Figure 2.4 *Forest Plot Comparison: Pilates vs. Exercise Control (Outcome: Pain)*

Study or Subgroup	Pilates Mean	Pilates SD	Pilates Total	Other Exercise Mean	Other Exercise SD	Other Exercise Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dunleavy 2016	1.9	1.6	20	2.3	1.6	19	34.0%	-0.24 [-0.88, 0.39]
Kucukcakir 2013	0.4	0.7	30	3.1	1.2	30	33.4%	-2.71 [-3.43, -2.00]
Mazloum 2018	8.4	1.9	14	10.5	1.8	13	32.6%	-1.10 [-1.92, -0.28]
Total (95% CI)			**64**			**62**	**100.0%**	**-1.35 [-2.84, 0.15]**

Heterogeneity: Tau² = 1.61; Chi² = 26.06, df = 2 (P < 0.00001); I² = 92%
Test for overall effect: Z = 1.77 (P = 0.08)



Risk of bias legend
(A) Bias arising from radomisation process
(B) Bias due to deviations from intended intervention
(C) Bias due to missing outcome data
(D) Bias in measurement of outcome
(E) Bias in selection of reporting result

Sub-group analysis

Pilates for Back and Neck Pain.

All of the low back pain studies (Cruz- Díaz 2015; Donzelli et al., 2006; Notarnicola et al., 2014) and the one neck pain study (Dunleavy et al., 2016) showed significantly favourable results for Pilates in all outcomes versus non-exercise controls (except Notarnicola et al., 2014 for physical function outcomes, as noted). When compared to other exercise interventions, Cruz-Díaz et al. (2015) found that additional Pilates enhanced the TENS, physical therapy, and stretching programme, but Pilates was found equal to a Back School programme and yoga for neck pain and CLBP respectively in Donzelli et al., 2006 and Dunleavy et al., 2016.

Pilates Interventions

Content.

Küçükçakir et al. (2013) (osteoporosis population) and Donzelli et al. (2006) (low back pain population) referred in broad terms to a programme of postural education, finding a neutral position, antalgic stretching, proprioception, and breathing exercises, without referencing specific Pilates repertoire, although Donzelli et al. (2006) mentioned mobilisation of the lumbar spine and scapula-humeral joint in treating the back pain population. Three of the studies (Notarnicola et al., 2014; Oksuz & Unal, 2017; Mazloum et al., 2018) included a Pilates class involving core stability, back extensor strength, and pelvic stability which were effective across knee OA, low back pain, and osteoporosis populations. One study (Dunleavy et al., 2016) provided more details of exercises not found in the other studies, clearly targeted to the mechanical neck pain population, including more emphasis on thoracic flexibility exercises, spinal extensor and posterior muscle strength, spinal rotation stability, scapular stability, and cervical postural exercise. However, it also included traditional abdominal and anterior muscle-focused repertoire, pelvic stability and hip abduction, and rotation exercises to improve general conditioning.

Perception.

Although quality of life was measured in only three studies (Notarnicola et al., 2014; Küçükçakir et al., 2013; Oksuz & Unal, 2017), several more of the studies reported narratively on the pyschosocial benefits of the group Pilates intervention and its influence on subjective status and adherence: Donzelli et al. (2006) reported that in a subjective status questionnaire, 71.43% of Pilates versus 36.36% of Back School participants self-reported that their symptoms had improved. The researchers speculated that their satisfaction with the treatment led to better patient compliance and that the greater involvement of the therapist, more personalised treatment even within the group delivery, and more variety and originality in the Pilates exercises resulted in a more proactive and trusting attitude towards the treatment compared to the Back School protocol. Dunleavy et al. (2016) also noted the importance of group exercise for effective delivery, suggesting that home exercises could be performed incorrectly and reinforce maladaptive movement, and that good cueing and instruction were needed to establish efficient patterns over an extended period. Group exercise also engendered inclusivity, as similar impairments and limitations within the group allowed participants to learn from corrections for everyone in the group, as well as enabling visual reinforcement and motivation in observing peers. In Küçükçakir et al. (2013) the excellent compliance in a year-long study and the beneficial effects of Pilates were attributed to participants' volunteering for a "fun" gym programme, with further motivation provided by gradual improvements and an absence of adverse effects. Motivation was also acknowledged as a mediator of results by Notarnicola et al. (2014), noting that the Pilates group were more motivated than the self-selecting inactive control group, and acknowledging that this may even have led to a placebo effect in outcomes. Mazloum et al. (2018) suggested that the social aspects of group Pilates compared to individual therapeutic exercises (which were well-targeted to knee OA patients, including exercises to strengthen the quadriceps and gluteals and to stretch hamstrings to address quadriceps to hamstring strength ratio), may have had a psychological impact resulting in better self-reported pain and disability scores. Similarly, Oksuz & Unal (2017) reported that anxiety and depression were reduced, suggesting that biopsychosocial modes of exercise have positive effects on mood state.

Adverse Events.

No adverse effects were noted in any study. Four studies reported that Pilates was "safe" (Dunleavy et al., 2016; Küçükçakir et al., 2013; Mazloum et al., 2018; Oksuz & Unal, 2017), with one (Dunleavy et al., 2016) specifically referring to an absence of adverse effects. The remaining studies did not report on this outcome (Cruz-Díaz et al., 2015; Donzelli et al., 2006; Notarnicola et al., 2014).

Adherence.

An average of 81% adherence was reported across all studies. One study, Donzelli et al. (2006), reported in detail about compliance for the home exercise prescription that followed the group Pilates and Back School interventions. For home exercise, 45.45% of Back School and 28.57% of Pilates group (26.06% of total) complied with their prescription. Of the Back School group 4.5% and of the Pilates group 9.5% (6.97% of total) practised on a regular basis. Of the Back School group 50% and of the Pilates group 61% (62.8% of total) practised only when pain worsened.

Discussion

Pilates mat work uses a versatile repertoire incorporating different levels that can be used to treat age-related conditions in middle-age and older adults, including CLBP, knee OA, and osteoporosis. This collection of studies shows that Pilates was consistently effective with significant results for all outcomes measured and all populations studied when compared to non-exercise controls. In Donzelli et al. (2006) for which *P* values were not reported and could not be calculated, Pilates reduced back pain and disability only on a par with Back School on the VAS and OLBPDQ, although subjective responses and perceptions of the results were better for Pilates, indicating potential for better long-term adherence in a real-world setting.

All studies measured pain, with most also assessing disability (Donzelli et al., 2006; Notarnicola et al., 2014; Oksuz & Unal, 2017; Dunleavy et al., 2016; Mazloum et al., 2018) and physical function (Cruz-Díaz et al., 2015; Notarnicola et al., 2014; Küçükçakir et al., 2013; Oksuz & Unal, 2017; Mazloum et al., 2018) with a focus on strength. A wide range of valid and reliable outcome measures was used. (Table 2.5). Chair Sit-to-Stand and Timed Up and Go tests emerged as successful measures for capturing significant results for physical function and associated aspects of strength of lower extremities, balance, and mobility. These measures were used in over half the studies (Cruz-Díaz et al., 2015; Küçükçakir et al., 2013; Oksuz & Unal, 2017; Mazloum et al., 2018) for a range of populations – CLBP, knee OA, and osteoporosis. The findings concur with the large body of existing literature on CLBP which found that Pilates can improve symptoms of pain (Aladro-Gonzalvo et al., 2013; La Touche et al., 2008; Lim et al., 2011; Lin et al., 2016; Miyamoto et al., 2013; Mizrachi & Kafri, 2017; Patti et al., 2015; Posadzki et al., 2011b; Vasconcellos et al., 2014; Wells et al., 2014b), disability (Aladro-Gonzalvo, et al., 2013; Miyamoto et al., 2013; Yamato et al., 2016), and physical function (La Touche et al., 2008; Lin et al., 2016; Wells et al., 2014b).

No overall evidence was found that Pilates effects exceeded those of other exercise. Results in favour of Pilates compared with other exercise in individual studies may be due to a disparity between comparators. Cruz-Díaz et al. (2015) compared a group receiving physical therapy involving Transcutaneous Electrical Nerve Stimulation (TENS), massage, and low back stretching to a group receiving the physical therapy with additional Pilates as an adjunct. As such, this study design does not represent a straightforward assessment of Pilates versus a comparable exercise alternative. The inclusion of physical exercise in addition to the more passive physical therapy favours the experimental group for functional and balance outcomes and measures such as the Timed Up and Go test, as reflected in the results. In Küçükçakir et al. (2013) the comparator was a home exercise programme of thoracic extension exercises performed in a sitting position, with compliance not reported. In contrast, the Pilates intervention was a varied programme, including postural education, breathing, sitting, antalgic and stretching exercises, proprioceptive training, and use of exercise band and balls, more likely to favour the walking test and sit-to-stand functional outcomes. Mazloum et al. (2018), on the other hand, described a Pilates intervention designed for core strength and pelvic stability and a comparable conventional exercise therapy protocol with exercises to strengthen quadriceps, gluteals and hamstrings suitable for a knee OA population, providing a comparison with greater parity aligned to the outcomes. This study found Pilates on a par with the exercise comparator.

Due to the outcome bias inherent in two out of the three exercise comparators which were not sufficiently comparable to Pilates, the present review therefore agrees with previous research that Pilates is not significantly more effective than other exercise (Wong et al., 2022), which included yoga (Dunleavy et al., 2016), traditional stabilisation exercises (Lim et al., 2011; Pereira et al., 2012; Vasconcellos et al., 2014; Wells et al., 2014b) Back School exercises (Patti et al., 2015; Vasconcellos et al., 2014), or physical therapy (Lim et al., 2011). Similar findings of non-superiority of Pilates to other forms of exercise were found in another systematic review of Pilates for chronic back pain (Wong et al., 2023).

Strength, balance, and flexibility emerged as secondary outcomes of interest. Strength was referred to in only one study (Oksuz & Unal, 2017) in relation to the osteoporosis population performing the Chair Sit-to-Stand test, for which the Pilates group gained significant improvements compared to the no-treatment control group. Although "core strength" was not referred to as a discrete outcome, Cruz-Díaz et al., (2015) suggested that results in other outcomes such as pain, functional mobility, and balance may have been due to increased core strength in the form of pelvic and trunk stability. Low back pain has been linked to diminished muscle activation of deep trunk muscles (Curnow et al., 2009). An increase in trunk muscle and lower limb strength in Pilates could reduce self-reported back pain (Leveille et al., 1999), as well as improving balance, function, and fear of movement in an older lower back pain population. The significant results for back pain in the present review support the concept of "core" and general strengthening as an important function of Pilates.

For balance outcomes, the kinesiophobia study by Oskuz & Unal (2017) found significant improvement for the Berg Balance Test as well as the Timed Up and Go test, for which Cruz-Díaz et al. (2015) also reported significant results for the Pilates group. This perhaps illustrates balance working in combination with strength and flexibility to improve components of physical function. Significant results were also achieved in the Pilates group for upper and lower limb flexibility measured on the Sit and Reach Test and the Back Scratch

Test. This study used a combination of abdominal exercises, pelvic stabilisation exercises and trunk, hamstring, and back extensor strengthening. The resultant lower extremity strength, lower extremity flexibility, and upper extremity flexibility showed a positive effect on static and dynamic balance. This reflects findings in previous studies of balance training on older adults (Bird et al., 2012) and older women with osteoporosis (Madureira et al., 2010). It also agrees with several other systematic reviews of Pilates for older adults (Barker et al., 2015; Bueno de Souza et al., 2018; Bullo et al., 2015; de Oliveira Francisco et al., 2015; Casonatto & Yamacita, 2020; Engers et al., 2016; Moreno-Segura et al., 2018) and demonstrates that Pilates's effects on flexibility, strength, and balance work in synergy to allow better functional movement.

As all studies reported significant results, the session frequency and duration suggest that different intervention time scales can produce positive results. Most studies (Cruz-Díaz et al., 2015; Oksuz & Unal, 2017; Dunleavy et al., 2016; Mazloum et al., 2018) were short-term (6-12 weeks). The shorter of these studies (Cruz-Díaz et al., 2015; Oksuz & Unal, 2017; Mazloum et al., 2018) (6-8 weeks) used two to three sessions a week, while the 12-week study (Dunleavy et al., 2016) used only one. This tentatively suggests that frequency can be increased if total duration is shorter and can be decreased when duration is longer, and efficacy achieved in either case. This applied to a range of conditions, as these studies spanned the included populations: back pain, neck pain, knee OA, and osteoporosis. Results broadly align with Lin et al. (2016) who recommend, for CLBP, two to three hours of Pilates per week for a total of 20 hours training (Lin et al., 2016). Yet due to heterogeneity in dose and populations, the present review agrees with other reviews of Pilates (for CLBP) (Miyamoto et al., 2013; Wells et al., 2014b) that further dosage studies of homogenous populations are needed to increase certainty.

The remaining studies were medium-term (Donzelli et al., 2006; Notarnicola et al., 2014) and long-term studies (Küçükçakir et al., 2013). These studies provide additional evidence of the long-term effects of Pilates. For CLBP, Donzelli et al. (2006) noted that initial improvements following a daily ten-day Pilates or Back School intervention were at least maintained even after the participants began to exercise less regularly at home, and that both methods were similarly effective in both the short-term (one month) and long-term (six month) outcomes. Dunleavy et al. (2016) also noted that improvements to neck pain in the Pilates and yoga groups were comparable at the end of the 12-week study and maintained at an 18-week follow-up point. Notarnicola et al. (2014) and Küçükçakir et al. (2013) provide further evidence of the long-term effects of group Pilates, such as significant effects for quality of life and good adherence.

Adherence was high overall with ≥81% of participants on average completing the trial (Cruz-Díaz et al., 2015; Donzelli et al., 2006; Küçükçakir et al., 2013; Dunleavy et al., 2016; Mazloum et al., 2018). However, the evidence in Donzelli et al. (2006) was that overall adherence to home exercise was poor, particularly in the Pilates group. Although both groups experienced an improvement in symptoms following the initial ten day group intervention, improvements to back pain and disability plateaued in the ensuing six months of home practice, a possible indication of the superior efficacy and practicability of group exercise.

Pilates exercises were found to be safe and effective for different populations whether or not they were explicitly customised to target specific conditions. Only three studies (Donzelli et al., 2006; Mazloum et al., 2018; Oksuz & Unal, 2017) reported that the Pilates classes were delivered by physiotherapists, but since significant results were found across all seven studies, effectiveness does not appear to be contingent on this. All of the studies referred to postural education either generally, in terms of technique (e.g., isometrically contracting the transverse abdominals, pelvic floor, and multifidus muscles while exhaling (in Notarnicola et al., 2014), Pilates principals (centring, control, precision, concentration, breath, and flow) in Mazloum et al. (2018), or in relation to daily living. Dunleavy et al., 2016 refers to movement education on topics such as sitting posture for computer work, lifting techniques to avoid neck stress, and how to reach overhead with or without weight. This additional movement education may have added value and positively influenced participants' functioning in daily life. It illustrates how Pilates can be used to emphasis movement, educating and demonstrating to patients how to move free of pain. In focusing specifically on individuals with age-related musculoskeletal limitations, the present review adds to the existing evidence base by suggesting that such conditions do not limit the efficacy of Pilates or restrict its delivery and there are no contraindications for recommending Pilates to this population.

Strengths

PRISMA reporting (Moher et al., 2009; Moher et al., 2015) was followed for transparency ensuring transparency of protocols, searches and results, reducing sources of error. Studies' methodologies were well reported according to CONSORT guidelines (Schulz et al., 2010) facilitating the risk of bias analysis. To reduce bias, two reviewers, the author/student and PhD supervisor, performed the full text study selection after abstract screening and undertook the quality assessments of selected studies. One of the main strengths of this review is the use of contemporary studies. Four out of the seven studies were published in the past five years. Studies were conducted in five different countries across Europe, North America, and the Middle East providing evidence that heterogeneous populations with potentially different lifestyles and cultural attitudes towards exercise similarly benefited from the intervention. The review was published in *Musculoskeletal Care* (Denham-Jones et al., 2022a) strengthening the validity of findings through peer review.

Limitations

Due to a paucity of studies on Pilates for chronic musculoskeletal conditions in adults over 50 years exclusively, inclusion criteria instead allowed for studies with age-associated musculoskeletal conditions with a *mean* age over 50. While findings can be applied to populations over 50, the presence of younger participants in the overall sample somewhat reduces the reliability of findings when making recommendations specifically for adults 50 and over. Even with this concession in the literature search, a low number of studies met the inclusion criteria and there was heterogeneity among them. This heterogeneity also reduced the number of studies for which results could be pooled into forest plots, reducing certainty of pooled results. With fewer than ten studies, analysis of publication bias was not feasible. Four of the seven studies were of high risk of bias (Cruz-Díaz et al., 2015; Notarnicola et al., 2014; Dunleavy et al., 2016; Mazloum et al., 2018). Although blinding of participants is not feasible in the types of trials included, there were several other sources of bias regarding the methodology. Two were quasi-randomised (Notarnicola et al., 2014; Dunleavy et al., 2016) and five were biased by a lack of an intention-to-treat analysis (Cruz-Díaz et al., 2015; Donzelli et al., 2006; Küçükçakir et al., 2013; Dunleavy et al., 2016; Mazloum et al., 2018) including three in which there were drop-outs which may have been related to a lack of effectiveness of the intervention or adverse effects (Cruz-Díaz et al., 2015; Dunleavy et al., 2016; Mazloum et al., 2018). This also biases the assignment effect which indicates the effects of prescribing exercise in clinical practice, with adherence or attrition an intrinsic part of the outcome (Hollis & Campbell 1999; Vlad & LaValley 2008).

Conclusion

Pilates mat exercises with a qualified instructor, or Pilates-qualified physiotherapist, can be recommended to treat the symptoms of chronic back and neck pain, knee OA and osteoporosis in all adults including older populations. The range of exercises in Pilates targeting the trunk and upper and lower limbs including all major muscle groups facilitates this.

Pilates was consistently shown to improve functional mobility outcomes including sitting to standing transition, walking speed, and stair climbing, and encourages sustained participation in group exercise by social interaction and motivation especially within a group setting. Advantages may arise when participants are taught in a group of a similar age or condition as each can benefit from collective instructions, postural and movement education, and modifications targeted to their population for optimum results.

The present review shows tentative evidence that results manifest in the short term (6-12 weeks) with two or three sessions, across back pain, neck pain, knee OA, and osteoporosis populations. With only seven studies reviewed this could not be determined with certainty, nor whether optimum delivery differs according to the musculoskeletal health condition.

Mat Pilates is an accessible form of group exercise that can be offered at some workplaces and as one of many exercises choices in private and public sector gyms. As Pilates showed results comparable to other forms of exercise, there is scope for more rigourously designed research comparing Pilates to other empirically supported therapies, particularly with regard to exercise preference in relation to age, sex, and chronic conditions. Given the psychosocial benefits of Pilates cited in the present review, future studies should include quality of life and related mental health, anxiety, and depression outcomes. Sound methodology should be used, including randomised controlled trials with non-exercise as well as exercise control groups and intention-to-treat analysis. Future studies with more detailed reporting of the interventions themselves, including rationale for the choice of exercise or emphasis, might also provide further insight into how Pilates could help alleviate the symptoms of other musculoskeletal conditions not covered in the present review. This would also inform the targeted delivery of Pilates for functional benefits such as continued participation in work, specific sports, and fitness activities during retirement years, and long-term effects on fall risk and rehabilitation. Research in these areas would support the continued development of clinical reasoning-based Pilates protocols tailored for specific conditions and functional goals relevant in later life.

Chapter Three
Discussion of Systematic Review Results for Yoga and Pilates

A summary and discussion of both systematic reviews was undertaken in order to inform the next phase of research.

Aims and Objectives

- To provide a side-by-side summary of key findings of the two preceding systematic reviews (see Table 3.1)
- To consolidate findings of both systematic reviews and discuss them in the context of further developing the research
- To identify research gaps

Taking the reviews together, Knee osteoarthritis (Cheung et al., 2014; Cheung et al., 2017; Kunz et al., 2018; Mazloum et al., 2018) and chronic low back pain studies (Cruz-Diaz et al., 2015; Donzelli et al., 2006; Notarnicola et al., 2014; Teut et al., 2016) were the most prevalent. For knee osteoarthritis pain, both yoga and Pilates were shown to be clinically effective in all four studies, using both physical and non-physical activity comparators – a wait list, education, and traditional exercise in the yoga studies (Cheung et al., 2014; Cheung et al., 2017; Kunz et al., 2018) and conventional therapeutic exercise in the Pilates study (Mazloum et al., 2018). Three of the studies, two yoga (Cheung et al., 2017; Kunz et al., 2018) and one the Pilates study (Mazloum 2018) also showed significant results for physical function.

For neck pain (Dunleavy et al., 2016) both yoga and Pilates were shown to be clinically effective for pain outcomes. For chronic low back pain Pilates was effective for pain in all three studies (Cruz-Diaz et al., 2015; Donzelli et al., 2006; Notarnicola 2014) but no significant results were found for yoga (Teut et al., 2016). While two of the Pilates studies

(Donzelli et al., 2006; Notarnicola 2014) were medium-term (5-7 sessions per week for 6 months) compared to the 12-week/twice weekly yoga intervention (Teut et al., 2016), results were also seen in the 6-week (two times a week) Pilates study (Cruz-Diaz et al., 2015). Based on this it is appears it was the yoga intervention rather than the dosage that accounts for this finding in this particular study of adults over 65.

Yoga significantly improved pain symptoms in hand OA (Garfinkel, 1994) and lower limb OA populations (Zacharia et al., 2018), led to postural change in patients with hyperkyphosis (Greendale et al., 2009), improved physical function for women with sarcopenia, and improved quality of life compared to baseline measurements for those with restless leg syndrome (Pandya, 2019) At the time of writing there were no Pilates studies of older adults for these populations, indicating a gap in research. Pilates significantly improved pain, physical function, and quality of life in osteoporosis patients in two studies (Küçükçakir et al., 2013; Oksuz & Unal 2017) but there were no yoga studies of older adults with these conditions, indicating another gap.

None of the seven yoga studies that measured quality of life captured significant results compared to control groups (knee OA, hyperkyphosis, restless leg syndrome, chronic low back pain, and rheumatoid arthritis) (Cheung et al., 2014; Cheung et al., 2017; Greendale et al., 2009; Innes et al., 2020; Kunz et al., 2018; Teut et al., 2016; Ward et al., 2018) whereas all of the Pilates studies (one back pain and two osteoporosis) (Notarnicola et al., 2014; Oksuz & Unal 2017; Notarnicola et al., 2014) captured significant results for this outcome. It is an interesting finding that the yoga studies in this review failed to capture any statistically significant changes to quality of life, even when the yoga interventions significantly reduced pain as they did in the case of the three knee osteoarthritis studies (Cheung et al., 2014; Cheung et al., 2017; Kuntz et al., 2018) or were notably well-received and enjoyed (Teut et al., 2014), and despite the range of measures used, including the SF-12, SF-36. EuroQol EQ-SD-3 and the four-item knee related QOL subscale of the KOOS. This potentially supports the idea of using mixed-methods and adding the use of thematic, qualitative research as another dimension through which to explore narratives and themes related to individual experiences and their impact on quality of life amongst yoga participants.

All studies in both yoga and Pilates used on average 60-minute group sessions, indicating that this is a feasible and acceptable length for group sessions, although the uniformity of session lengths across studies means it cannot be determined whether similar results could have been achieved using shorter sessions. The low adherence rate to home exercise was evident for both interventions indicating the need for, and appeal of, group exercise regardless of the exercise type.

Neither yoga nor Pilates was found significantly superior to other exercise comparators in any individual study. Only one study compared yoga with Pilates versus a meditation control (Dunleavy et al., 2016, for neck pain) with no significant group differences between the two exercise groups. This suggests that despite the acknowledged mind-body component in pain management (Lumley et al., 2011; Morone & Greco, 2007), interventions including physical exercise may have greater benefit.

The two present systematic reviews indicated that although both interventions were safe and effective for chronic age-related conditions, Pilates interventions had a broader range of benefits than the specially modified yoga interventions, including better results for function and quality of life for back pain and knee OA. Table 3.1 shows that the Pilates studies founds statistically significant results for all outcomes measured, while the yoga studies collectively show ten instances (marked by the zeros and patterned squared in Table

3.1) where an outcome was measured with no statistically significant effects evident. Overall, all 7 Pilates studies were clinically significant against 9 of the 11 yoga studies. Due to the presence of only two long-term studies, Pandya (2019) for yoga and Küçükçakir et al. (2013) for Pilates, the duration of effects could not be assessed and compare. Although the generalisability of both systematic reviews is limited by the low number of studies in each, the present comparison concurs with a 2019 study by Lim and Park into the effects of yoga and Pilates on functional movement and health related quality of life. For a population of adults aged 30 to 40 years that study found Pilates significantly superior to yoga on the Rand-36 Health Survey (SF-36) and Functional Movement Screen (FMS) (Lim & Park, 2019).

Pilates and yoga are growing areas of clinical interest and the literature reviews conducted by this researcher found that the majority of studies were published since 2010, but with few originating in the United Kingdom. Following these reviews there remained scope for further research into exercise preferences and experiences in order to understand whether the most effective yoga or Pilates interventions are being accessed in the "real world" by those who may best benefit and how well they meet the needs of older populations and those with age-related pain or impairments, without and with particular modifications. A survey and randomised controlled trial were prepared as outlined in the next chapters, further exploring participation in these interventions, how they may be optimised for positive musculoskeletal health outcomes, and to assess the relative benefits and any contraindications associated with practising Pilates and yoga in later life.

Table 3.1 *Summary of Yoga and Pilates Systematic Review Outcomes*

Significant Result (*P*=0.05) ---------------- Population	**Yoga Studies**	**Pain**	**Physical Function**	**Quality of Life**	**Pilates Studies**	**Pain**	**Physical Function**	**Quality of Life**	**Significant studies per population**
Back pain	1	0	0	0	3	3	1 (of 2)	1 (of 1)	**3 (Pilates)**
Neck pain	1	1	NA	NA	1	1	NA	NA	**1 (yoga, Pilates)**
Knee OA	3	3	2	0	1	1	1	NA	**4 (3 yoga, 1 Pilates)**
Hand OA	1	1	0	NA	--	--	--	--	**1 (yoga)**
Lower Limb OA	1	1	1	NA	--	--	--	--	**1 (yoga)**
RA	1	0	0	0	--	-	-	--	**0**
Osteoporosis	--	--	--	--	2	2	2	2	**2 (Pilates)**
Hyperkyphosis	1	NA	0	0	--	--	--	--	**1* (yoga)**
Rest Leg Synd.	1	NA	NA	1 vs baseline	--	--	--	--	**1 (yoga)**
Sarcopenia	1	NA	1	NA	--	--	--	--	**1 (yoga_**
TOTAL	**11**	**6**	**4**	**1**	**7**	**7**	**4**	**3**	*hyperkyphosis

NA=Not measured -- = no study

Chapter Four
A Community Survey of Yoga and Pilates Participation in Adults Aged Over 50: Attendance, Motivators, Barriers, and Preferences

As seen in the preceding chapters, yoga and Pilates are both low impact, scalable interventions, specifically recommended for low back pain by the NHS (NHS, 2020; NHS Royal Berkshire Foundation Trust, 2022). However, it is important to explore factors impacting accessibility and participation to gauge whether an intervention is truly efficacious when implemented.

Both the systematic reviews and previous research of Pilates and yoga for chronic musculoskeletal conditions in older adults have shown that adherence to group exercise was better than for home exercise (Cox et al., 2021; Denham-Jones et al., 2022a; Denham-Jones et al., 2022b), indicating the importance of group exercise and justifying further study of group exercise in a community setting. Topics identified for further exploration, within and beyond the context of this study, included the effect of yoga on quality of life and how best to capture qualitative effects, and whether the interventions are as safe and effective when they are not specifically designed for trial purposes. These questions will now be addressed through a survey designed to assess how group yoga and Pilates classes are perceived, accessed, and experienced in practice, and how well they meet the needs of the ageing population. The yoga studies reviewed (Denham-Jones et al., 2022b) notably used little qualitative research and evidenced no statistically significant quality of life improvements in any population, although numerous qualitative benefits were cited in the Pilates studies. Hence for comparison the present study has a qualitative emphasis across both interventions.

Pilates exercises had better results for physical function and quality of life than yoga without having to be specifically modified. The survey data will also test this theory to inform exercise prescription and provide insight into how yoga can be best modified and taught to positively affect these outcomes. An understanding of perception of an intervention is thought to improve recruitment, teaching, and retention (Sohl et al., 2011) and may help to assess to what degree preferences and beliefs, exercise delivery, and repertoire aid or hinder access to interventions that are most beneficial for specific populations and conditions. For example, Sohl's study reports that older people held more positive beliefs about yoga, yet yoga practice declines with age (Sohl et al., 2011) suggesting a potential issue of accessibility to yoga in older adults.

The cohort represented in both systematic reviews was over 70% female (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b). This is reflected in the "real world", where yoga and Pilates are especially popular with women. In the United Kingdom, 78% of group exercise participants are women, and yoga and Pilates have been the top two most popular class formats in recent years, as reported by The Exercise Movement & Dance Partnership U.K. (EMD U.K., 2018). U.K.-based studies indicate that participation in both is >85% female (Cartwright, et al., 2020; Taylor et al., 2020). As women are known to have a higher prevalence of chronic musculoskeletal conditions with age (Gran, 2003; Wijnhoven, et al., 2006) this is a group that can particularly benefit if good adherence is maintained in later life.

The study presented is a survey of yoga and Pilates participants over 50 years old, exploring habits, perceived benefits, preferences, motivators, and barriers in accessing these interventions. The survey results will inform a hypothesis-driven comparative trial of the two interventions to test best practice by first establishing how intervention design and delivery can be modified and maximised through a practical understanding of exercise preference and habits and the physical and time limitations of older adults who may still be working.

The sample was not limited to those with chronic musculoskeletal conditions, so as to facilitate adequate sample size, to capture data from those who may be using the practices for prophylactic reasons, as well as to identify any risks from the practices to healthy older adults.

The literature search and the implementation of search alerts conducted at the time of the narrative and systematic reviews allowed existing related surveys and qualitative literature to be sourced. At the time of writing, yoga survey literature included several national surveys of participation. Four existed of prevalence, motivators, and characteristics in yoga practitioners among adults in the U.S. (Birdee et al., 2008; Cramer et al., 2016; Park et al., 2016; Saper et al., 2004), one of motivators, benefits, and behaviours of U.K. practitioners (Cartwright et al., 2020), and one of yoga in Australia (Penman et al., 2012). While not specifically of older adults, the existing surveys allowed for contextualisation and comparison of findings in the subsequent discussion. Other research related to older adults practising yoga in real-world settings included several qualitative studies focussing on experience and perceptions. Cox et al. (2021) conducted a gender-specific study exploring the experiences of middle-aged women through interpretative phenomenological analysis of interviews (Cox et al., 2021). Sivaramakrishnan et al., (2017) used thematic analysis to explore perceptions of yoga in practising and non-practising older adults in Scotland (Sivaramakrishnan et al., 2017). Wertman et al., (2016) compared the experiences of middle-aged and older adults through a mixed-methods approach using quantitative and qualitative data from a survey and interviews with a subset of participants (Wertman et al., 2016). Findings include yoga participants’ appreciation of a supportive environment (Cox et al., 2021; Sivaramakrishnan et al., 2017), their sense of mindfulness, and improvements to body confidence and self-care habits (Cox et al., 2021), feelings of social connection (Wertman et al., 2016), and a call for delivery to account for physical limitations and experience levels (Sivaramakrishnan et al., 2017). The studies provided opportunities for comparison in later discussion of findings related to yoga in the present study. At the time the present research was conducted, the researcher was unable to source any Pilates participation surveys, or qualitative studies of Pilates experiences and perceptions in non-controlled, participant-selected community settings, and there were no survey or qualitative studies that compared and contrasted the two practices. In respect to these areas of research, the current study fills a gap.

Aims and Objectives

- To explore experiences of adults over 50 years in a real-world setting by consulting target population through use of a survey
- To assess whether safety and efficacy, as identified in systematic reviews, are experienced when yoga and Pilates are delivered outside of a controlled trial environment
- To consult target population on exercise habits, perceptions, motivators, and barriers so as to inform population wants and needs, and develop protocols for later testing in comparative trial of yoga and Pilates

Methods

Study Design

The study and reporting of the results were guided by CHERRIES, the Checklist for Reporting Internet E-Surveys, chosen over the CROSS checklist (a consensus-based checklist for reporting of survey studies) (Sharma et al., 2021), for its specificity for internet surveys (Eysenbach, 2004). The survey tool was a cross-sectional open survey in the form of a self-administered online questionnaire consisting of multiple choice, check box and open text questions related to age, work and health status, exercise habits, motivators, perceived benefits, barriers, and preferences.

Research Questions

1. What is the employment and health status of adults of over 50 years accessing yoga and/or Pilates?

2. What is the regularity, frequency, and duration of yoga and Pilates practices?

3. What are the perceived benefits of participating in yoga and/or Pilates?

4. What are the motivators and barriers involved in the preference of either intervention?

Ethics Approval

Ethics approval was granted by the University of Salford ethics committee upon the provision of the overall benefit and risk for the project to reflect the ethical concept of risk minimisation. Ethics approval documentation (ethics application HSR1920-06) is provided in Appendix V.

Recruitment

A convenience sample was taken from two private fitness clubs and a yoga/Pilates studio in London. Convenience sampling was chosen for feasibility and the potential to recruit from the same community for subsequent stages of the research. Information sheets (see Appendix V) with a link to the survey were made available at the reception desks and common spaces at these sites. Participation was voluntary and no incentives were offered.

At the time of data collection, the venues hosted 36 yoga and 12 Pilates classes per week collectively, with an approximate attendance of 10-20 per class, for potentially a pool of more than 400 people. (This number may have been lower than normal due to the caution and uncertainty related to the Covid-19 pandemic which affected class attendance during this period). A sample size of 30 was decided to be both feasible and to account for exclusion due to ineligibility or incompletion. This number also aligns with the approximate number in a fully booked class any of the venues, therefore broadly representing a cross-section of a single class cohort. Recruitment took place from August 10 to October 10, 2020.

Survey Information

The survey comprised of a 37-item online questionnaire. The design of the questionnaire was informed by a peer reviewed literature series published in the *British Medical Journal* sourced for its comprehensive coverage of survey research from design and development, (including issues of diversity and accessibility) through to administration, analysis, and reporting (Boynton, 2004; Boynton & Greenhalgh, 2004; Boynton et al., 2004). Open text boxes were included to reduce questioning bias where a list of multiple choices was presented, as well as to increase scope and add detail. Survey questions are shown in Table 4.1 and detailed rationale for the survey questions is shown in Table 4.2. Participants provided informed consent and no identifying data was be taken from respondents. The full survey tool is included in Appendix IV.

Table 4.1 *Survey Questions*

Question Number (*=required)	**Question**
1*	I have read and understood the participant information sheet (v1.0 13/1/20
2*	I have had the opportunity to consider the information and have no questions or have had any questions answered satisfactorily.
3*	I understand that my participation in completing this survey questionnaire is voluntary.
4*	I understand that the survey questionnaire is completed anonymously and that no identifying data will be taken.
5*	I understand that once I have completed the questionnaire I cannot withdraw my responses.
6*	I understand that my answers will be used to support other research in the future, and may be shared anonymously with other researchers, including in published form.
7*	I understand that there is no compensation or payment for provided for taking part in this survey.
8*	I agree to take part in this study
9*	What is your date of birth?
10*	Are you? male/female/other gender identity
11*	Which of the following categories best describes your employment status? Employed/working full-time Employed/working part-time/ Not employed, looking for work/ Not employed, NOT looking for work/Retired/Disabled, not able to work
12*	Do you have any of the following chronic* conditions (*lasting 3 months or more)? Back pain/ Neck pain/Rheumatoid Arthritis/Osteoporosis/Knee osteoarthritis/Other osteoarthritis - please specify in comment box below/Other musculoskeletal (muscle, bone or joint) condition(s) - please specify in comment box below/None
13*	How often do you currently attend yoga classes? Once a week/Twice a week/More than twice a week/Twice a month or less/Never (please go to question 22
14	When did you first start attending yoga classes? Less than one month ago/6-12 months ago/1-2 years ago/3-5 years ago/Over 5 years ago/ Over 10 years ago
15	What time of day do you attend yoga class? (check all that apply) Before 9am/Morning after 9am/Midday Afternoon/Evening Monday-Friday/Weekends
16	What factors influence which yoga class or classes you attend ? (check all that apply) The teacher/The style of the class/The level of the class/The time of the class/Other (please specify below)
17	What are your reasons for attending yoga class? (check all that apply) Stress reduction/To develop muscular tone and strength/To improve flexibility/To improve balance/To socialise /Yoga helps relieve the symptoms of a health condition/Other (please provide details below)
18	If yoga helps relieve the symptoms of a health condition, please provide details below.

Table 4.1 *Survey Questions (continued)*

Question Number (*=required)	**Question**
19	Have you ever sustained an injury during a yoga class? No/Yes/Not sure
20	Do you feel that group yoga classes cater to your needs? Always/Sometimes/Rarely/Never
21	How could group yoga classes better accommodate the needs of adults over 50 years? (check all that apply) Not applicable - my needs are met/Provision of classes specifically for older adults/More modifications offered by the teacher/More classes led by older teachers/Smaller class sizes/ Slower paced classes/Other (please specify below)
22	If you do NOT attend yoga classes, what is the reason? (check all that apply) Cost/Class time/Class location/Class teacher/Yoga is too physically difficult for me/Yoga is too physically easy for me/Yoga is painful for me/I have a health condition that makes yoga unsuitable/Other (please specify below)
23	If you have health condition that makes yoga unsuitable, please provide details below.
24*	How often do you currently attend Pilates classes? Once a week/Twice a week/More than twice a week/Twice a month or less/Never (please go to question 33)
25	When did you first start attending Pilates classes? Less than one month ago/6-12 months ago/1-2 years ago/3-5 years ago/Over 5 years ago/Over 10 years ago
26	What time of day do you attend Pilates class? (check all that apply) Before 9am/Morning after 9am/Midday Afternoon/Evening Monday-Friday/Weekends
27	What factors influence which Pilates class or classes you attend ? (check all that apply) The teacher/The style of the class/The level of the class/The time of the class/Other (please specify below)
28	What are your reasons for attending Pilates class? (check all that apply) Stress reduction/To develop muscular tone and strength/To improve flexibility/To improve balance/To socialise / Pilates helps relieve the symptoms of a health condition/Other (please provide details below)
29	If Pilates helps relieve the symptoms of a health condition, please provide details below.
30	Have you ever sustained an injury during a Pilates class? No/Yes/Not sure
31	Do you feel that group Pilates classes cater to your needs? Always/Sometimes/Rarely/Never
32	How could group Pilates classes better accommodate the needs of adults over 50 years? (check all that apply) Not applicable - my needs are met/Provision of classes specifically for older adults/More modifications offered by the teacher/More classes led by older teachers/Smaller class sizes/ Slower paced classes/Other (please specify below)
33	If you do NOT attend Pilates classes, what is the reason? (check all that apply) Cost/Class time/Class location/Class teacher/Yoga is too physically difficult for me/ Pilates is too physically easy for me/ Pilates is painful for me/I have a health condition that makes Pilates unsuitable/Other (please specify below)
34	If you have health condition that makes Pilates unsuitable, please provide details below.
35*	Which do you prefer? Yoga/Pilates/No preference (Please state reasons for your answer)
36*	What other exercise do you participate in at least twice per month? (check all that apply) Gym group exercise other than yoga or Pilates/Cycling or indoor cycling/Running/Swimming/ Football/Martial arts/Walking or hiking/Dance class/Racquet sport (e.g. tennis/badminton/squash)/No other exercise/Other (please specify)

Table 4.2 *Rationale for Survey Questions*

Question Numbers/Topic (*=required)	**Rationale**
Q 1-8 *	These questions follow the information for participants. Participant provides informed consent.
Q 9-12* Age, gender, work, and MSK health status	To identify population of study, verify respondents meet inclusion criteria
Q13*-14 Frequency and duration of attendance	To assess correlation between dosage and perceived benefits. Systematic review by researcher found correlation between significant functional outcomes and class frequency and qualitative outcomes over time.
Q15 and 16 Time of attendance and reason for class time	Understanding of habits and hypothetical answer choices for motivators. "Other" open text box available for motivators.
Q17 Reasons for attending yoga	Hypothetical answer choices based on benefits of yoga found in researchers' literature reviews. "Other" open text box available.
Q18 Health-related benefits	Open text box for health-related benefits and potentially to collect data on other health benefits unrelated to MSK health.
Q19 Injuries sustained	Literature indicates safety of yoga (per researcher's and others' systematic review (Cramer et al., 2015). Question addresses whether safety is reflected outside of controlled trial when intervention may not be modified for specific conditions. Open text box available for details.
Q20 Wants and needs	To determine how well these are met for this population. "Other" open text box available.
Q21 Call for suggestions for improvement in delivery	Answer choices based on researchers' hypotheses, based on teaching experience. "Other" open text box available.
Q22 Barriers to participation	Hypothetical answer choices. "Other" open text box available.
Q23 Health-related barriers	Open text box for health-related barriers as health status is central to the research.
Questions 24-34 mirror 13-23 but pertain to Pilates.	Participants will answer questions on either or both interventions.
Q 35 Yoga/Pilates preferences*	Understanding perceptions. All questions regarding motivation, barriers, and preferences may contribute to improving participation, delivery and adherence. (Sohl et al., 2011). "Other" open text box available.
Q36 Other exercise*	Answer choices based on common exercise found on gym timetable and popular sports. "Other" open text box available. To assess activity levels of respondents. Perceived benefits of yoga/Pilates are potentially attributable to other exercise.

Data was collected from October 14 to November 28, 2020.

Data Analysis

Quantitative data is expressed numerically, using percentages to illustrate proportion.

Answers to the open text questions were analysed using thematic coding and thematic analysis. This method was chosen for its flexibility and suitability for a sole researcher to identify themes (Braun & Clarke, 2014), providing insight to quantitative outcomes, and giving participants a more nuanced voice in their participation. Braun & Clarke (2006) suggest this approach aligns with a constructivist paradigm, so therefore it is a tool appropriate to the ontological position stated in this research (Braun & Clarke, 2006). Provision of a qualitative perspective has been shown to enrich health and well-being research (Braun & Clarke, 2014), and is particularly recommended in the pre-trial stage (O'Cathain et al., 2013).

The first step in exploring the data from open-ended questions was to review the raw responses. The data were copied from the survey into a Microsoft Word (2016) document and read twice for familiarity. This step was followed by data coding using open coding and inductive codes generated by the data. Number codes were used, with a short text summary attached to each number. This process was completed in Microsoft Word (2016) using the comments function. As the coding progressed, the initial codes were grouped into categories then modified and similar codes were consolidated. Patterns in the coded data were then actively interpreted by the researcher and a theme identified where those patterns were determined by the researcher to convey meaningful insights and help address research questions. The themes were reviewed by the researcher.

In this phase the following questions were addressed (Braun & Clarke, 2012, p.65):

- Is this a theme (it could be just a code)?
- If it is a theme, what is the quality of this theme (does it tell me something useful about the data set and my research question)?
- What are the boundaries of this theme (what does it include and exclude)?
- Are there enough (meaningful) data to support this theme (is the theme thin or thick)?
- Are the data too diverse and wide ranging (does the theme lack coherence)?

No further modifications to the themes were made at this stage. After the review of themes by the researcher, quotations from participants were pooled to illuminate salient points within themes. The themes were presented in a narrative summary.

Results

The analysis included 35 respondents and 34 of these answered all of the required questions for completeness rate of 97%.

The mean age of participants was 59.9 years, ranging from 50 to 73 years. The majority (77%) were female. Most participants (57%) were still working either full-time or part-time, 31% retired, with 11% not working. (Figure 4.1, Table 4.3).

Figure 4.1 *Age and Work Status of Survey Respondents*
(Key: FT=Employed full-time, PT=Employed part-time)

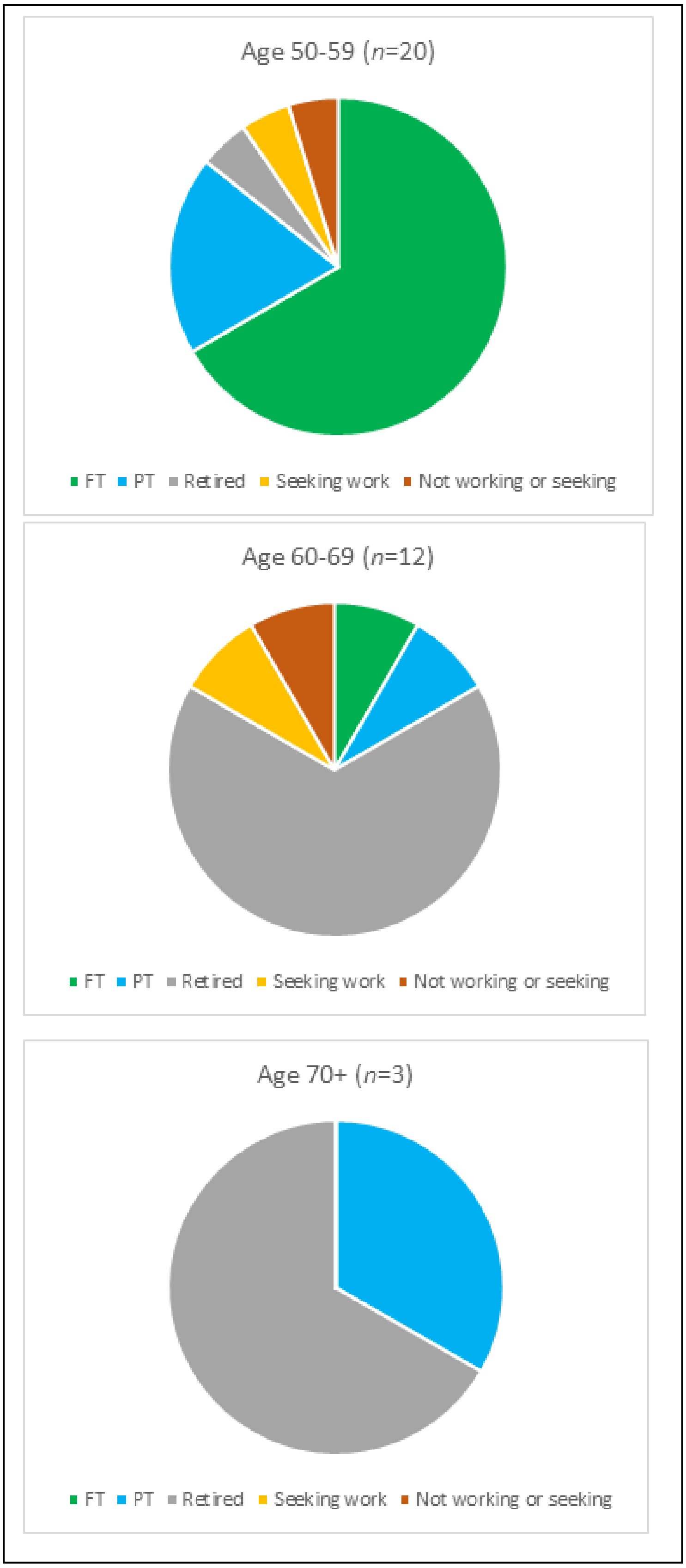


Table 4.3 *Demographic Characteristics of Sample*

Variable	%	*n*=	
Male	22.86	8	
Female	77.15	27	
Working full-time	40.00	14	
Working part-time	17.14	6	
On temporary leave (paid or unpaid)	0.00	0	
Not working, looking for work	5.71	2	
Not employed, not looking for work	5.71	2	
Retired	31.43	11	
Disabled, not able to work	0.00	0	
Work Status by age group (%)	50-59 (*n*=20)	60-69 (*n*=12)	70+ (*n*=3)
Working full-time	**65%**	8%	-
Working part-time	20%	8%	33.3%
On temporary leave (paid or unpaid)	-	-	-
Not working, looking for work	5%	8%	-
Not employed, not looking for work	5%	8%	-
Retired	5%	**66%**	**66.6%**
Disabled, not able to work	-	-	-

The distribution of conditions amongst participants is show in Figure 4.2. At least one musculoskeletal condition was cited by 49% of respondents, with 51% citing none. The most prevalent concern was back pain at (11%), followed by osteoarthritis (OA) (8% total, 6% knee). Of those reporting “other” chronic musculoskeletal conditions (*n*=15), knee (27%) and shoulder (20%) injuries and limitations were the most prevalent. (Table 4.4).

Figure 4.2 *Presence of Chronic Musculoskeletal Conditions Among Survey Respondents*

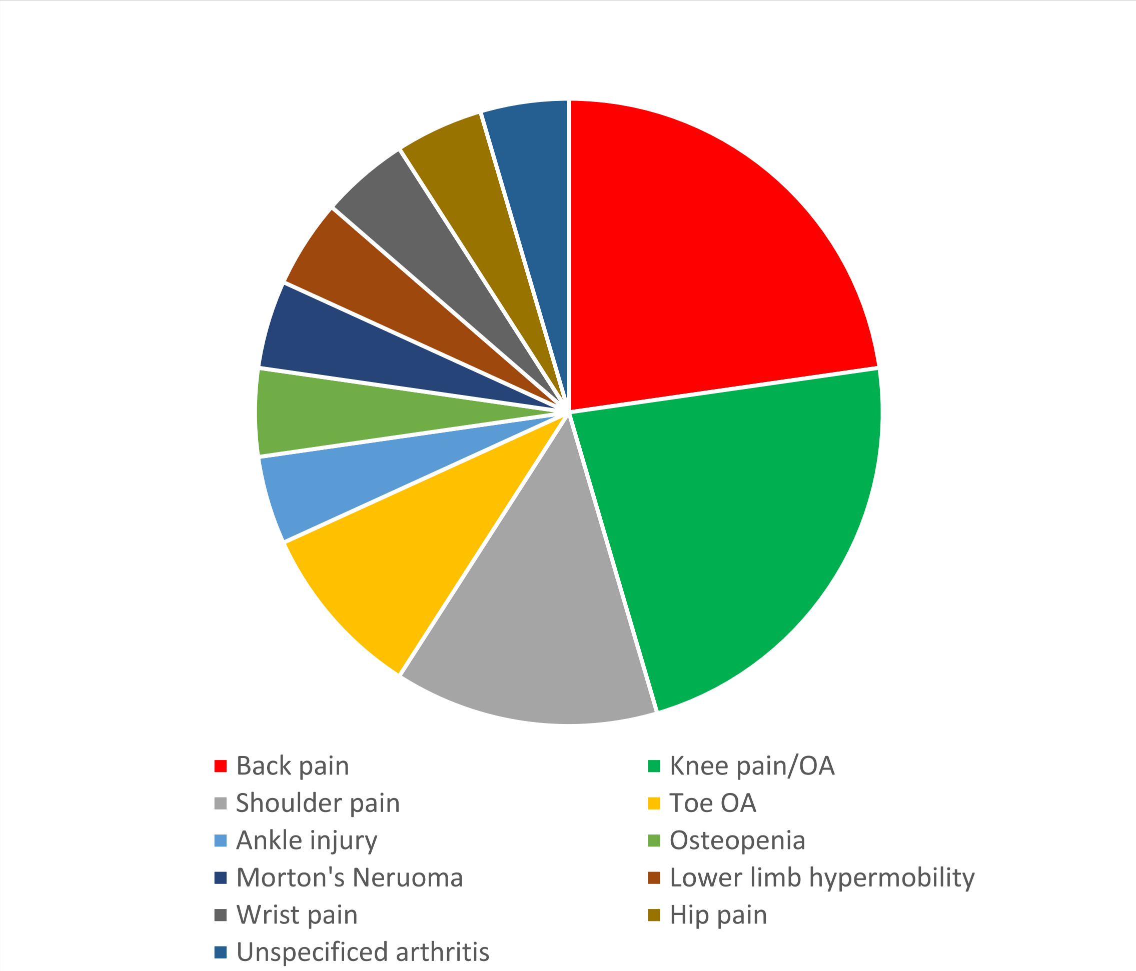


Table 4.4 *Chronic Musculoskeletal Conditions (lasting more than three months)*

Condition	%	*n*=
Back pain	11.43	4
Neck pain	0.00	0
Rheumatoid arthritis	0.00	0
Osteoporosis	0.00	0
Knee osteoarthritis	2.86	1
Other osteoarthritis (see below)	5.71	2
Ankle (injury); toe		*1*
Toe (bunion)		*1*
Other musculoskeletal (muscle, bone or joint) condition(s) +, ++ multiple conditions, same respondent (see below)	31.43	11
Slipped disc diagnosis two years ago		*n=1*
Back pain at night+		*n=1*
Knee pain or injuries+		*n=4*
"Frozen" shoulder or shoulder pain		*n=3*
Osteopenia++		*n=1*
Morton's neuroma ++		*n=1*
Hypermobility in feet, ankle and knees++		*n=1*
Limited cutaneous systemic sclerosis (scleroderma)		*n=1*
Wrist pain when weight-bearing		*n=1*
Hip pain		*n=1*
"Stiffness"		*n=1*
None	51.43	18

There was similar participation in yoga (67.7%) and Pilates (71.5%), with 37.% practising both. Of those practising yoga, 56% also practised Pilates, while 52% of Pilates participants also practised yoga. Most participants (68%) expressed a preference for one practice over the other, with 44% preferring yoga to 24% Pilates and 32% expressing no preference. (Figure 4.3 and 4.4). Of yoga participants 21% were men, for Pilates 28%. Of male respondents 62% participated in yoga and 87% in Pilates.

Figure 4.3 *Respondents Practising yoga/Pilates/both, at any Point in Time*

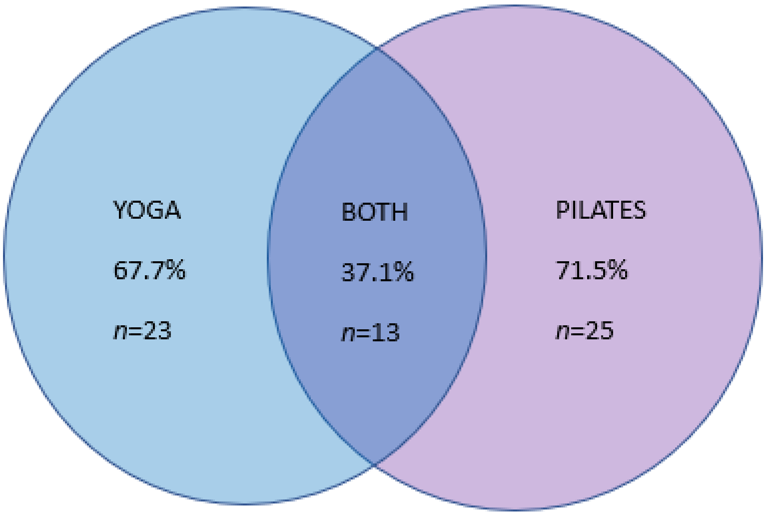
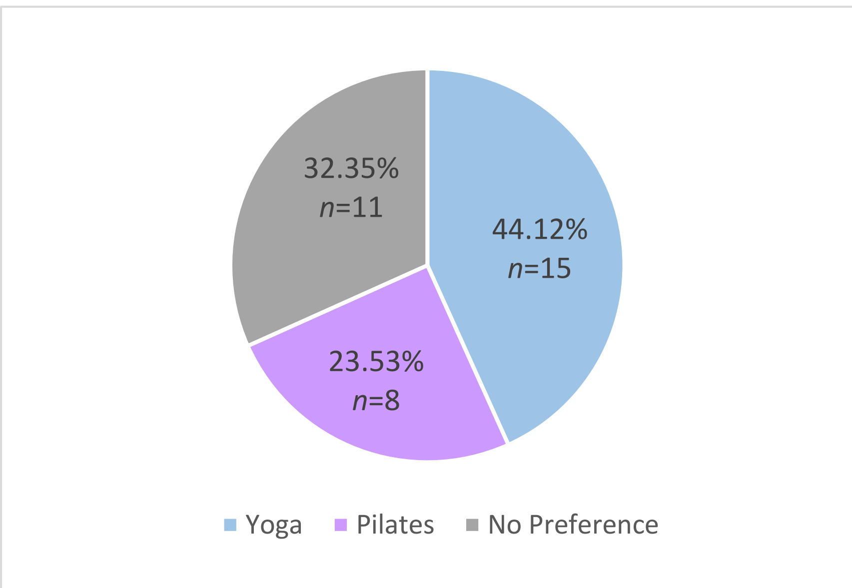


Figure 4.4 *Preferences (1 respondent out of 35 provided no answer)*



There was one explicit question related to preference (Figure 4.4). Other data concerning preferences were identified through open text box comments. Comments were divided into discrete references to yoga and discrete references to Pilates. Dominant reasons for yoga preference were general and mental well-being (25% of all yoga references), and the focus on flexibility (16% of all yoga references). The dominant reason for Pilates preference was the focus on abdominal muscles and back (12% of all Pilates references). The dominant reasons for disinclination towards yoga were related to the teacher, teaching style or teachings (25% of all yoga references) and for Pilates the lack of classes at a suitable time (16% of all Pilates references).

References were coded as negative, positive or neutral. For yoga, 64% were categorised as positive, 24% as negative, and 12% as neutral. For Pilates, 33% were categorised as positive, 17% as negative, and 50% as neutral. (Table 4.5).

Table 4.5 *Factors Influencing the Formation of Preferences*

Factor	About Yoga	About Pilates	Pos/Neg/Neutral
Previous experience	1	1	NL
Lack of previous experience	1	1	NL
Focus on flexibility	4		P
Focus on balance	1		P
Focus on stamina	1		P
Focus on back/core		3	P
Focus on breath	1		P
Well-being/mental well-being	5		P
Functional		1	P
Injury concern or pain issue	1	1	N
Ease of extra home practice	1		P
Teacher/teachings (positive)	3		P
Teacher/teachings (negative)	5	1	N
Class time (positive)	1	1	NL
Class time (negative)		3	N

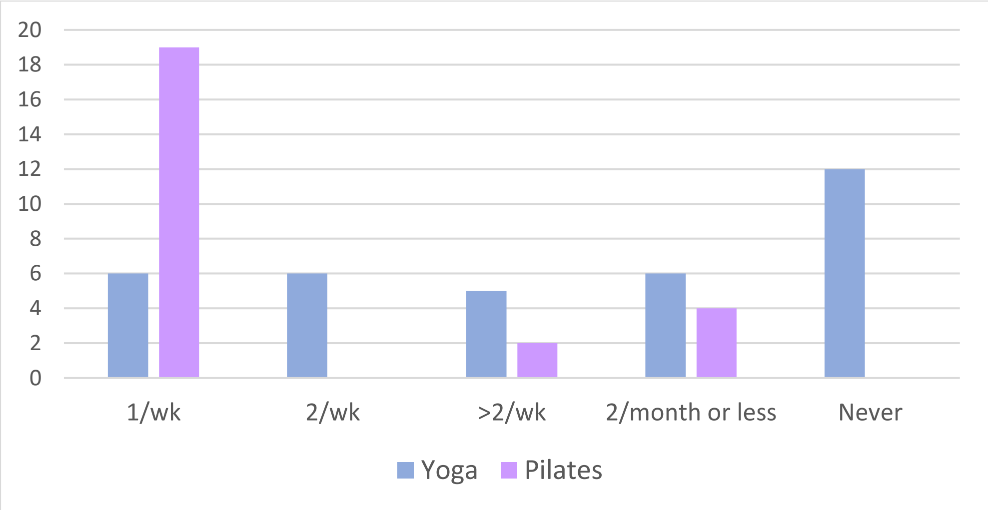
All respondents indicated participation in other exercise, the most prevalent being cardiovascular type exercise – running (68%), walking or hiking (65%), and cycling (29%) (Table 4.6).

Table 4.6 *Participation in Other Exercise*

Exercise	**%**	***n*=**	***n*= Yoga/Pilates Participant**
Running	67.65	23	14/15
Walking or hiking	64.71	22	16/16
Cycling/Indoor cycling	29.41	10	9/8
Gym group exercise other than yoga or Pilates	26.47	9	8/8
Swimming	14.71	5	4/4
Dance class	8.82	3	2/2
Racquet sport	2.94	1	1/0
Other (see below)	32.35	11	7/6
Weights/strength		*4*	*2/4*
Athletic training/HIIT		*2*	*0/2*
Gardening		*2*	*1/1*
Swimming		*2*	*2/1*
Aerobic dance teaching		*1*	*0/1*
Rowing and sailing		*1*	*1/1*
Playing piano as professional musician		*1*	*1/1*
Unspecified		*1*	*1/1*

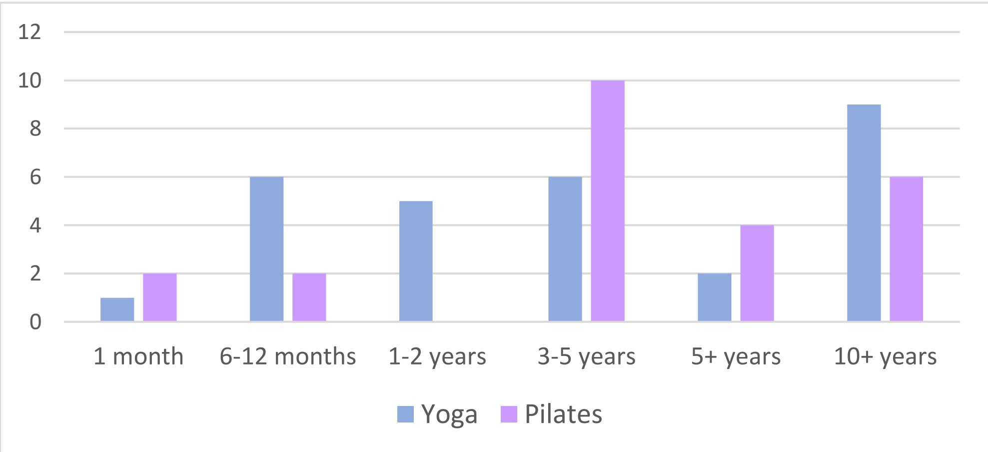
Most Pilates participants (54%) attended only once a week, whereas 57% of yoga participants practised between one and two or more times weekly (17% once a week, and 31% twice or more). (Figure 4.5).

Figure 4.5 *Frequency of Group Class Attendance*



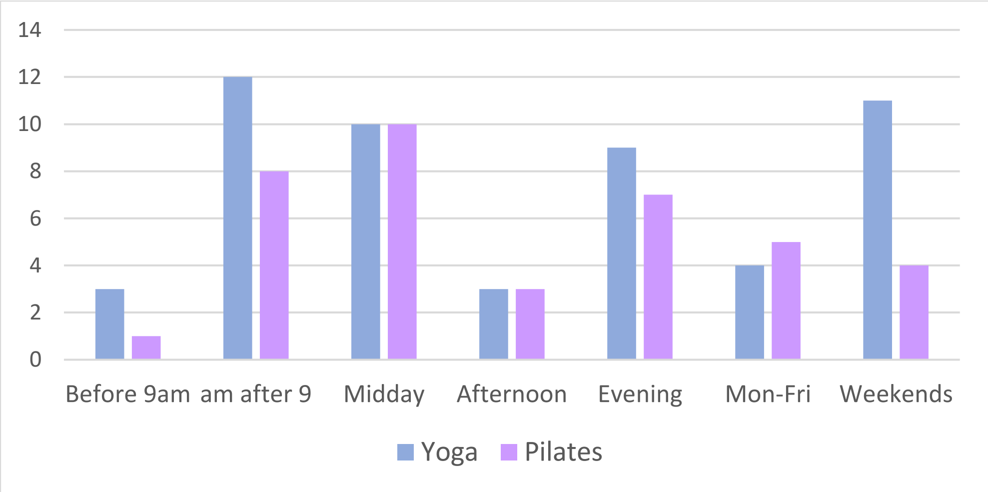
Most respondents for both yoga (78%) and Pilates (84%) said they had practised for more than two years, and 37.5% of yoga participants and 25% of Pilates practitioners said they had practised for over ten years. (Figure 4.6).

Figure 4.6 *Duration of Group Class Attendance*



Class attendance was spread over a range of times. Midday was the most popular class time when accounting for both groups (42% in both yoga and Pilates respondents) and before 9am the least popular overall (12.5% for yoga and 4.17% for Pilates). (Figure 4.7).

Figure 4.7 *Time of Day, Group Class Attendance*



Class teacher was the most cited reason to influence the choice of specific class attended (75% yoga, 58% Pilates) and class level the least (42% yoga, 33% Pilates). (Figure 4.8 and Table 4.7). Flexibility was the strongest motivator for attending yoga and the second strongest for Pilates (100% yoga, 75% Pilates). Muscle tone or strength was the strongest motivator for attending Pilates (79%) and second strongest for yoga (66%). (Figure 4.9 and Table 4.8).

Figure 4.8 *Factors Influencing Class Attendance*

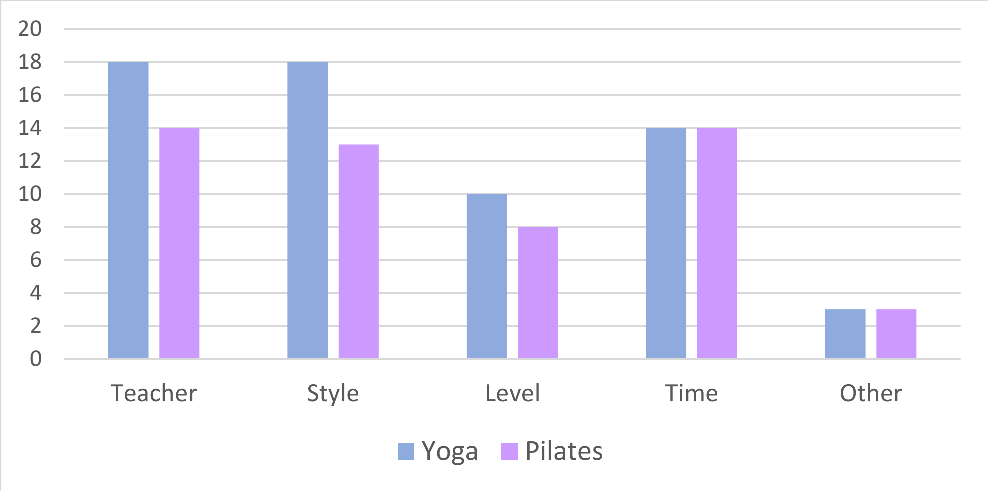


Table 4.7 *Factors Influencing Class Attendance: %, (n)*

Factor	**Yoga *n*=24**	**Pilates *n*=24**
Teacher	75.00 (18)	58.33 (14
Style	75.00 (18)	54.17 (13)
Level	41.67 (10)	33.33 (8)
Time	58.33 (14)	58.33 (14)
Other (see below)	12.50 (3)	25.00 (6)
Attended with family member	*(1)*	*(2)*
Convenient location (including online n=1)	*(2)*	*(2)*
Free class	-	*(1)*

Figure 4.9 *Motivations for Practising Yoga or Pilates*

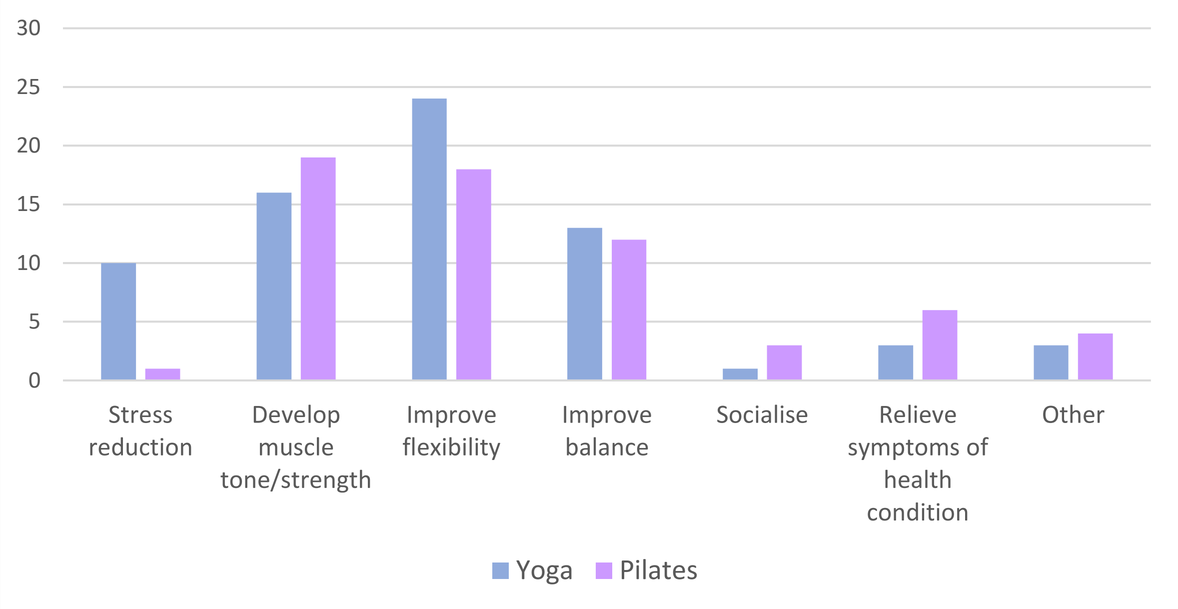


Table 4.8 *Motivations for Practising Yoga or Pilates: %, (n)*

Motivator	**Yoga *n*=24**	**Pilates *n*=24**
Stress reduction	41.67 (10)	4.17 (1)
Develop muscle tone/strength	66.67 (16)	79.17 (19)
Improve flexibility	100.00 (24)	75.00 (18)
Improve balance	54.17 (13)	50.00 (12)
Socialise	4.17 (1)	16.67 (4)
Relieve symptoms of health condition (see below)	12.50 (3)	25.00 (6)
Back	*(2)*	*(4)*
Hip pain	*(1)*	*(1)*
Scleroderma	*(1)*	*(1)*
Shoulder (not specified)	*(2)*	*(2)*
Arthritis, big toe	-	*1*
Other (see below)	12.50 (3)	16.67 (4)
Stiff hips and scoliosis (not chronic)	*(1)*	-
Delay symptoms of scelroderma	*(1)*	*(1)*
Injury prevention for running initially	*(1)*	*(2)*
Trapped nerve/Sciatica	-	*(1)*
Posture	-	*(1)*
Mindfulness, meditation	*(1)*	-
Core strength/reduce back pain following childbirth	-	*(1)*

Respondents' barriers to practising yoga were spread evenly across cost, time, location, and teacher for yoga (all 8%). For Pilates, classes time was the most cited barrier (30%), and one respondent cited pain. Most respondents also cited a variety of "other" barriers to practice than those suggested in the survey question (75% for yoga, 80% for Pilates). Of these, for those not practising yoga, the most cited reason (55% of comments) was that their focus was on Pilates instead. For "other" obstacles to Pilates, respondents further mentioned time and accessibility, as well as a range of reasons spread across issues such as injury or enjoyment. (Figure 4.10 and Table 4.9).

Figure 4.10 *Barriers to Practice*

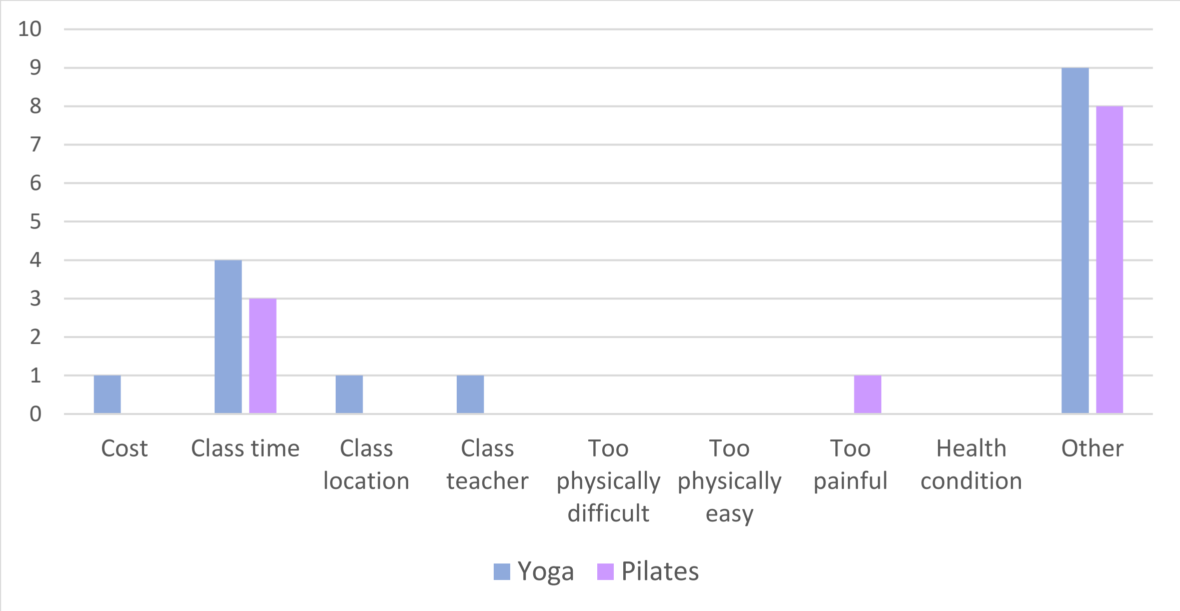


Table 4.9 *Barriers to Practising Yoga or Pilates: %, (n)*

Barrier	**Yoga *n*=12**	**Pilates *n*=10**
Cost	8.33 (1)	0.00 (0)
Class time	3.33 (4)	30.00 (3)
Class location	8.33 (1)	0.00 (0)
Class teacher	8.33 (1)	0.00 (0)
Too physically difficult	0.00 (0)	0.00 (0)
Too physically easy	0.00 (0)	0.00 (0)
Too painful	0.00 (0)	10.00 (1)
Health condition	0.00 (0)	0.00 (0)
Other (see below)	75.00(9)	80.00 (8)
Felt too inflexible; "humiliating"	*(1)*	-
Teacher/teaching style	*(3)*	-
Use online class	*(3)*	-
Focus is on Pilates instead	*(5)*	-
Prefers core work	*(1)*	-
Never tried	*(1)*	*(1)*
No available local class	-	*(2)*
Knee injury	-	*(1)*
"Not on radar"	-	*(1)*
Don't enjoy	-	*(1)*
Class time clash	-	*(1)*
Self practice at home (Pilates teacher)	-	*(1)*
Prefer meditative aspects of yoga	-	*(1)*
Tried once, neck hurt	-	*(1)*
Knee injury	*(2)*	*(1)*

Injury prevalence was higher for yoga with 12% of participants having sustained an injury in yoga (21% not sure, 67% declaring no injuries) versus 9% for Pilates injuries (91% declaring none). (Figure 4.11 and Table 4.10).

The surveyed population indicated that their needs were more fully met by Pilates (64%) than yoga (27%). (Figure 4.12 and Table 4.11) . "More modifications offered by the teacher" was the most selected solution (41% yoga, 18% Pilates). Smaller classes sizes, and classes aimed at older adults were both favoured by 9% for both yoga and Pilates. There was disparity in views on slower paced classes, 14% in favour for yoga, and 5% for Pilates. There was greater disparity between views on classes led by older teachers, 23% indicating that this would help their needs to be better met in yoga versus 5% for Pilates. (Figure 4.13 and Table 4.11).

Figure 4.11 *Injury sustained in a Yoga or Pilates Class*

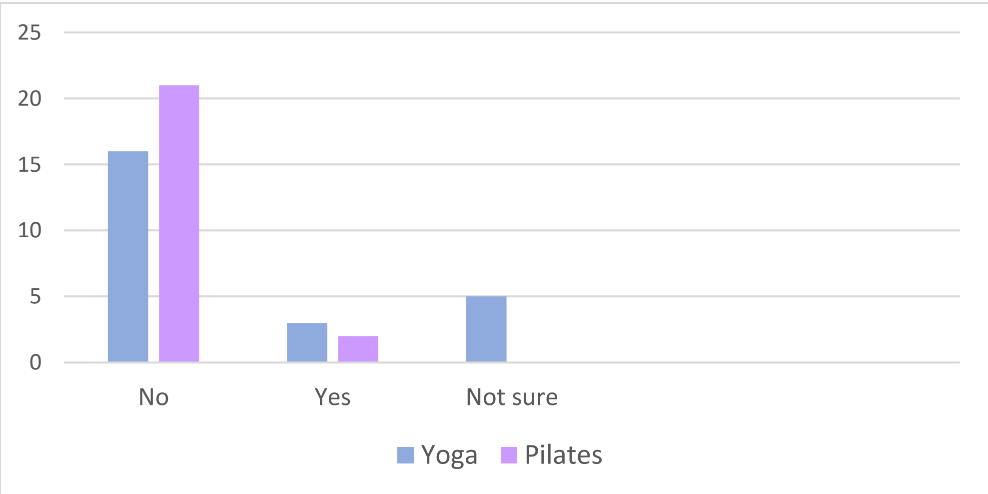


Table 4.10 *Injury Sustained in a Yoga or Pilates Class*

Response	Yoga *n*=24	Pilates *n*=23
No	66.67 (16)	91.30 (21)
Yes	12.50 (3)	8.70 (2)
Not Sure	20.83 (5)	0.00 (0)

Figure 4.12 *Does Yoga or Pilates Cater to the Needs of the Demographic Surveyed?*

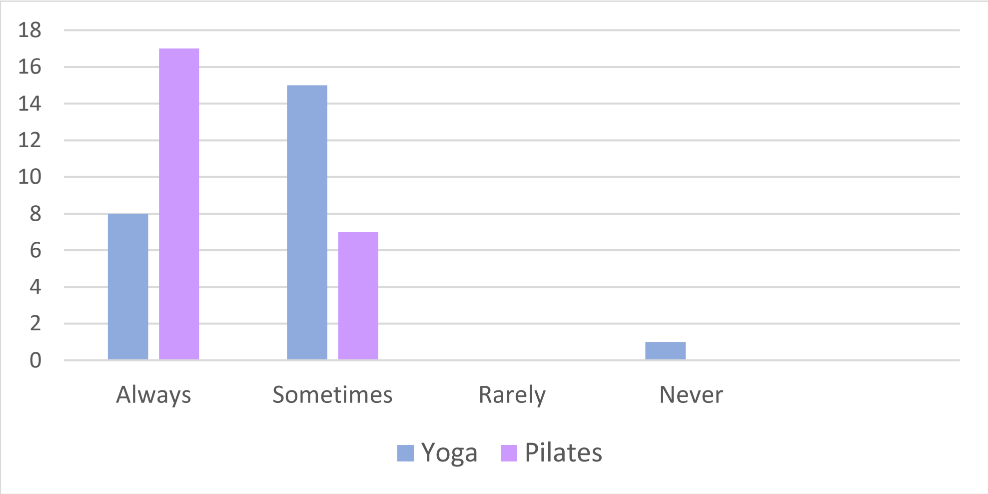
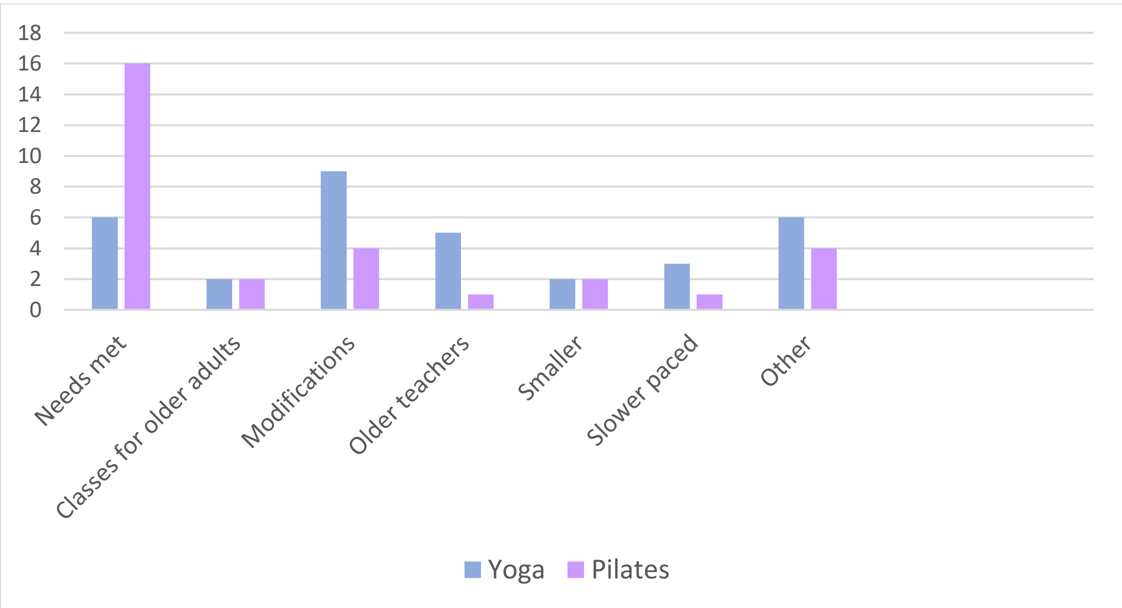


Table 4.11 *Does Yoga or Pilates Cater to the Needs of the Demographic Surveyed?*

Response	Yoga *n*=24	Pilates *n*=24
Always	33.33 (8)	70.83 (17)
Sometimes	62.50 (15)	29.17 (7)
Rarely	0.00 (0)	0.00 (0)
Never	4.17 (1)	0 (0)

Figure 4.13 *How could group Yoga or Pilates classes better accommodate the needs of adults over 50 years?*



Thematic Analysis of Open-Text Questions

The thematic analysis was small in scale and scope due to the small sample and thinness of data. As such, it served a supplementary purpose in the illumination of aspects of the quantitative data of the survey. Two themes were identified.

Theme One: Appeal of Well-being in Yoga versus Physical Fitness in Pilates.

Several yoga practitioners indicated that their attraction to the practice was related to the emphasis on the mind-body connection, mental health, and overall well-being. One commented specifically, “My interest is in the mental/meditative side of yoga”. In some cases, this was contrasted to the physical fitness benefits of Pilates, which were also acknowledged. One participant commented, “I am better at Pilates because have done it for many years but find yoga better for my well-being.” Another said, “I like the breathing in yoga for stress reduction and relaxation. Pilates is better for my core strength and back issue.” There was also a perception with one respondent that yoga presented a greater diversity of benefits, addressing a broader range of physical as well as mental outcomes: “Pilates increases core strength, but yoga increases whole body strength, flexibility, and stamina and has a spiritual and mindful dimension which is hugely beneficial. I believe it counteracts the effects of the ageing process in the body such as stiffness and muscle weakness, and also counteracts inflexibility of the mind.”

Yet some of the themes that account for yoga’s appeal appear to be a polarising factor as they were dominant in some Pilates practitioners’ dislike of yoga, with those preferring Pilates more likely to be focussed on physical function outcomes. This was evidenced in the second subtheme which was the converse of the first.

Subtheme Two: Dislike of Yoga Teaching Approaches Versus Appeal of Pilates Pragmatism.

There were several instances of open text evidence from those who preferred Pilates or practised both disciplines that the teachings of yoga, which included its philosophies as well as the poses, were off-putting or inaccessible, respectively. One respondent commented, “I am not interested in the spiritual side of yoga. Also, Pilates supports my back and strengthens my core, whereas yoga can cause you to bend too much or too far.” Another responded said, “I worry that yoga is associated with odd mysticisms…however admirable the yoga poses look, at nearly 70 they are going to be totally unattainable for me.” Another did not mention the accessibility or otherwise of the poses but suggested a preference for a secular approach to yoga, stating, “I would have said Pilates until quite recently - I found some of the mindset behind some yoga off-putting, but the Adrienne [youtube teacher] sessions mostly avoid that.” Conversely, one participant did not mention the “spiritual” aspects as a deterrent but expressed a lack of knowledge about the functional aspects of the practice in comparison to Pilates, stating, “Sometimes I'm not sure what the purpose is of certain yoga positions! Pilates feels more like physiotherapy with a particular purpose. I'm a runner so I want to make sure what I’m doing isn't going to result in an injury.”

The thematic data revealed that the mind-body aspects that were appreciated by some of the yoga practitioners also served as a divisive factor in that they acted as deterrents to others and were dominant in some Pilates practitioners’ dislike of yoga, with those preferring Pilates more likely to be focused on physical function outcomes.

Discussion

Population

A comparison of the demographic data with existing evidence reveals that the sample is representative of the wider population in several respects. For work status, survey results found that 80% of those aged 50-59 and 20% of those over 60 years were working. These numbers are similar to 2020 U.K. employment figures of 73% for age 50-64 and 12% for the over 65s (Centre for Ageing Better, 2020). Most respondents were female (77.15% versus 22.86% male). This aligns closely with national norms for those accessing group exercise in general, at 78.4% female and 21.6% male (EMD U.K., 2018). The proportion of participants citing at least one chronic musculoskeletal condition (49%) is very closely aligned with global norms for chronic musculoskeletal conditions, present in 48.3% of adults 55-74 (Global Burden of Diseases 2017 Disease and Injury Incidence and Prevalence Collaborators, 2018), and national norms for chronic pain, present in 46% of the same age bracket (Public Health England, 2017). However, the prevalence of the most-cited conditions, back pain (11%) and OA (8% total, 6% knee,) were both lower than the national estimate of 16.9% for back pain in all adults (Versus Arthritis, 2019), and 33% for all OA (Jordan et al., 2007; Jordan et al., 2010), and lower than the estimated 18% for knee OA in adults over 45 (Versus Arthritis, 2019). While it is not within the scope of the present cross-sectional study to establish whether yoga and Pilates participation has prevented these conditions, or whether these conditions prohibit participation in yoga and Pilates for some sufferers, both possibilities present areas for further research.

Respondents were closely split between those who had practised yoga (67.7%) and Pilates (71.5%) at any point in time, with 37.1% of these having practised both. Despite slightly more Pilates practitioners in the sample, where a preference was expressed, yoga was preferred by 44.12% versus 23.53% for Pilates (with 32.35% expressing no preference). This reflects current exercise trends showing yoga and Pilates as the top two group exercise choices in England, and yoga's popularity exceeding Pilates, with 1,285,000 attending yoga classes "in the preceding four weeks", to 887,000 for Pilates (EMD U.K., 2018). This is perhaps accounted for by yoga's popularity among women, who comprise the majority of group exercise populations in England (EMD U.K., 2018). While it is possible that more people access yoga due to more timetabling of yoga classes, studio coordinators are encouraged to create group exercise schedules based on attendance and feedback (EMD U.K., 2018) so it is more likely that timetables reflect class popularity and demand rather than drive it. The high proportion of women yoga participants is also reflected in a survey of yoga the United Kingdom citing 87% female participants (Cartwright et al., 2020), as well as in yoga participation studies conducted in the United States (Atkinson & Permuth-Levine, 2009; Birdee et al., 2008; Cramer et al., 2016; Park et al., 2016; Quilty et al., 2013; Saper et al., 2004) and Australia (Cagas et al., 2020b; Penman et al., 2012). Similarly, in a study of older Pilates participants taken in 2020 in England, 85% were women (Taylor et al., 2020).

The present survey found that male participation was higher for Pilates, at 28% versus 21% for yoga, with 85.5% of male respondents having participated in Pilates, compared with 62.5% for yoga. Cagas et al. (2020b) found that low yoga uptake among men in Australia was driven by preference for other forms of exercise and gender perceptions and pressures, with yoga viewed by men as non-competitive and feminine (Cagas et al., 2020b). A U.S. study cites men's self-consciousness about lack of flexibility and ability to do the poses compared to women (Atkinson & Permuth-Levine, 2009). Further qualitative research would be needed to establish whether similar issues exist for men and Pilates as a research gap was identified in this area.

Preferences

Data on the formation of preferences (Table 4.6) indicates that respondents expressed stronger opinions about yoga than Pilates. For references related to yoga, there were almost three times as many positive as negative comments, with only 12% neutral. In contrast, for Pilates negative and positive comments received almost equal weighting and half of all comments were neutral. The qualitative data revealed that preferences were as much driven by personal taste as functional outcomes. The components that attracted participants to yoga were primarily related to the emphasis on the mind-body connection, overall and mental well-being, and spirituality, a finding reflected in several qualitative studies of middle-aged and older yoga participants (Sivaramakrishnan et al., 2017) and particularly of older women (Cox et al., 2021; Wertman et al., 2016), while those preferring Pilates were more likely to be desiring of physical function outcomes. Wertman et al. (2016) noted a similar dichotomy in relation to female and male participants within yoga (Wertman et al., 2016) with women inclined to emphasise the mind-body benefits and men the physical benefits of the practice, and while this was not a feature in the present study, it did find more men chose to practice Pilates than yoga.

For those that had tried both disciplines, the physical functional aspects driving Pilates preference were also embraced by yoga practitioners. Yet the spiritual aspects driving yoga preference sometimes served as a deterrent for those Pilates practitioners seeking a predominantly physical mode of exercise. This position is reflected in a qualitative study by Atkinson & Permuth-Levine (2009) who found that barriers to starting and to continuing yoga included the perception that yoga practitioners were involved “alternative lifestyles”, yoga teachers to be “judgmental” or push participants beyond their abilities unsafely, concerns about getting injured, and yoga not providing the aerobic benefits of other exercise, such as running (Atkinson & Permuth-Levine, 2009). Notably similarly findings are reflected in the qualitative study of older adults' perceptions of yoga which found that both practitioners and non-practitioners expressed an awareness of a stigma around yoga's spiritual and religious associations, with male yoga participants expressing concerns that yoga did not provide an aerobic or muscular workout and that the flexibility required in some of the poses went beyond the requirements of daily function (Sivaramakrishnan et al., 2017). Cagas, et al. (2020a), suggest that both positive benefits, such as "mind-body spiritual benefits", and negative impressions of yoga involve additional features not found for other exercise (Cagas et al., 2020a).

Exercise Attendance and Habits

Yoga practitioners were more likely to practice more than once a week than those practising Pilates, and while there was a high incidence of practice longevity for more than two years for both, yoga practitioners were more likely to have practised for ten years or more (yoga 37.5%, Pilates 25%.). For yoga this is slightly above the norms for group exercise as a whole, in which 26% said they had attended for more than five years (EMD U.K., 2018). These figures again align with data on yoga practice in the United Kingdom, which found the mean number of classes per week for non-teachers was 2.5 and years practised was 10.5 (Cartwright et al., 2020). This could reflect encouragement of regular practice by yoga teachers, as well as enjoyment, perceived benefits, and the adoption of yoga as a long-term lifestyle choice benefitting a range of outcomes beyond physical fitness, such as psychological well-being and spirituality (Cartwright et al., 2020). For adults over 50, the previous systematic reviews of yoga and Pilates concluded that benefits to chronic musculoskeletal conditions were more likely based on two to four sessions per week

(Denham-Jones et al., 2022a; Denham-Jones et al., 2022b). Existing yoga survey literature also suggests that frequency of practice is the strongest predictor of positive self-reported results (Cartwright et al., 2020; Wiese et al., 2019a). Although musculoskeletal health was not a major motivator for yoga practice in this survey at only 12%, Cartwright et al., (2020) found that over 87% of participants found yoga helpful for musculoskeletal conditions. Pain prevention therefore provides an additional incentive for yoga class attendance more than once weekly for symptom prevention in musculoskeletal patients. For chronic low back pain Lin et al. (2016) recommend two to three hours of Pilates per week, while Silva et al. (2020) found that different weekly frequencies of Pilates mat and apparatus protocol did not accelerate pain improvement (Lin et al., 2016; Silva et al., 2020). Further research may yet be needed to determine Pilates dosages for various outcomes in specific populations, for example statistical analyses of existing studies using scatter plots to determine relationships between practised hours and pain scores.

Participants most often cited cardiovascular and outdoor exercise such as running, walking or hiking as “other exercise” in which they were engaged and these should be added to the questionnaire for future use. This was true of both yoga and Pilates participants and is perhaps a reflection of the recruitment from gyms, and the yoga studio having provided occasional classes specifically for runners. Pilates participants were twice as likely to take part in weight, strength, and high intensity interval training, consistent with the emphasis on functional fitness benefits common both to Pilates and these forms of exercise. There is scope to analyse quantitively the effect of co-intervention in future research.

For factors influencing specific class attendance, yoga and Pilates participants ranked teacher, style, time, and level in the same order, from most to least important (for yoga, teacher and style received equal rating). This agrees with Estabrooks et al. (2004) who identify the instructor as the primary determinant in group exercise participation in older adults (Estabrooks et al., 2004). In contrast, national norms for group exercise ranked time followed by instructor as the top two influencers for group exercise attendance (EMD U.K., 2018). This perhaps indicates that the teacher is either a more important factor for older adults than younger groups, or for yoga and Pilates than in the other forms of exercise included on the EMD survey (indoor cycling, circuits, Zumba, aerobics, body condition, body pump, core stability, and aqua aerobics) (EMD U.K., 2018). It could also indicate that there are fewer time constraints on the over 50 population, potentially due to retirement (31%), part-time work (17%) in this sample, or more autonomy with work patterns. It would be reasonable to infer this for the survey sample, 60% of whom were not in full-time employment.

Motivators

The strongest motivator for practising yoga was flexibility, cited by 100% of yoga practitioners, with other benefits ranked from most to least important being muscle tone/strength, balance, stress reduction, health conditions/other, and social aspects. Physical fitness benefits out-ranked mental health benefits, and although this is true for exercise in general, the importance given to psychosocial benefits for yoga in this survey falls below national norms even for group exercise in general. For yoga, “stress reduction” was cited as a motivator by only 41.67%, compared to 50% for this motivator for group exercise nationally (EMD U.K., 2018). Given the fact that most participants in the present survey were long-term practitioners, this is also at odds with other literature from the United Kingdom, United States, and Australia which found that initial yoga motivators included general wellness, fitness, and flexibility, but stress and mental health outcomes became more important than these over time (Cartwright et al., 2020; Park et al., 2016; Penman et al., 2012). It is again possible that this is due to the small sample potentially skewed towards gym-goers (rather than yoga studio members) whose motivations are more fitness-orientated. Mental benefits nonetheless emerged strongly within this survey's qualitative themes for the formation of yoga preferences, where comments about yoga improving general and mental well-being exceeded references to yoga's focus on flexibility. This is in line with the findings of Cartwright et al. (2020) who found that although 91.6% of responds said that yoga improved their flexibility, this was only an initial motivator for 8.5% of respondents, with general wellness (39%) being the top motivator (Cartwright et al., 2020). Similarly, Park et al. (2016) found that while flexibility was an initial reason for adopting yoga, this shifted over time towards more holistic and spiritual motivations (Cartwright et al. 2020; Park et al., 2016), so the predominance of general well-being motivators in the qualitative data could be a reflection of the longevity of the practice in this sample.

Social aspects also ranked low among yoga participants as a motivator (4.17%). This is at odds with group exercise nationally. For group exercise in general, 28% acknowledged classes as a social activity to do with friends and 25% were motivated by "meeting people", with these responses ranked 7th and 8th out of a possible 13 choices, respectively (EMD U.K., 2018). Qualitative evidence of yoga participants benefitting from a sense of community and belonging and enjoying social aspects was also found in one study of supervised yoga and home practice (Fleming et al., 2022) and others of perceptions and experiences of older adults (Sivaramakrishnan et al., 2017; Wertman et al., 2016). However, the response of the participants in the present survey was in line with Cartwright et al. (2020) who found that only 6% of yoga participants cited social interaction (Cartwright et al., 2020). Similarly, a US-based survey placed social interaction at 16% but ranked 10th of 11 motivators (Quilty et al., 2013). This is perhaps due to the introspective nature of yoga compared to other group exercise, and while yoga can offer a sense of community this may not be ranked as highly as other benefits in quantitative analyses. Other yoga surveys (Birdee at al., 2008; Cramer et al., 2016; Park et al., 2016; Penman et al., 2012; Saper et al., 2004) focused on health outcomes excluding social aspects, preventing comparison.

Relief from symptoms of a health condition was ranked a joint sixth out of the seven yoga motivators (cited by 12.5%). Similarly, Cartwright et al. (2020), found that only 9.5% of yoga practitioners cited physical health conditions as a motivator for starting yoga initially, and this reduced over time. Additionally, only 8% of general gym goers said that group exercise was recommended to them by a doctor or health professional (EMD U.K., 2018). The relatively low importance of the relationship between yoga and health conditions in the present survey is again perhaps an indication that gym and yoga studio attendees enjoy a good level of health and that those with health conditions are less likely to attend. However, it could represent a lack of awareness among health practitioners and exercise participants of the benefits of yoga for specific conditions. For those that did mention health conditions benefitting from yoga, back, and shoulder pain were the most commonly cited, as was the case in larger samples taken in other yoga surveys. (Cartwright et al., 2020; Cramer et al., 2016; Penman et al., 2012; Saper et al., 2004). Knee pain was not improved with yoga in the present survey, despite evidence from randomised controlled trials that it can help improve pain symptoms for knee osteoarthritis in middle-aged and older adults. This is perhaps an indication that to benefit knee conditions yoga needs to be carefully adapted, as was the case in these trials (Cheung et al., 2017; Cheung,et al., 2014; Kuntz et al., 2018).

For Pilates, strength, flexibility, and balance were the most cited motivators. There was more weight placed on health conditions (25% of participants citing this motivator) with back and knee pain the most prevalent. There were some disparities between Pilates and yoga motivators. Social aspects were cited by a higher percentage for Pilates (16.67% versus 4.17% for yoga). This finding is reflected by Taylor et al., (2020) in a survey of live and video Pilates participation before and during the 2020 Covid-19 restrictions in England, where the social aspects of live attendance, and the partial replication of these benefits in video delivery, were highlighted (Taylor et al., 2020). More striking, only 4.17% of Pilates participants cited stress reduction as a motivator, compared to 41.67% for yoga and 50% in the wider population for group exercise nationally (EMD U.K., 2018). This again may reflect the functional fitness emphasis in Pilates benefits (Wells, et al., 2012), influencing the way it is delivered and experienced.

Barriers

Barriers to the practice of both yoga and Pilates were centred around pragmatic concerns. For yoga these were spread evenly across cost, time, and location, with the teacher given the same weighting. In contrast, for Pilates, class time emerged as the most cited barrier (30%), which speaks to the fact that nationally yoga participants outnumber Pilates participants by an estimated 25% (EMD U.K., 2018) creating an issue of supply and demand that could result in less class scheduling for smaller niche groups in facilities offering more than one class type. This may lead to a self-perpetuating vicious cycle. The qualitative data on yoga and Pilates preference in this survey reveals that a lack of Pilates availability contributed to the “preference” for yoga. For group exercise in general, inconvenient class times were cited as the top barrier to participation, with work commitments third, and timetable swaps or workplace exercise delivery recommended as possible solutions (EMD U.K., 2018).

Safety and Suitability

There was some disparity between the injury rate in yoga and Pilates with 9% of participants saying they had experienced a Pilates-related injury and 12% for yoga (with 20.83% for yoga "not sure" for a total 33% possibly having sustained a yoga injury). The yoga injury rate is similar to national statistics, with 67.6% of practitioners reporting no injuries and 20.7% as least one, as is the data regarding site of injury, with back, knee, shoulder, and wrist among the most common (Cartwright et al., 2020). This data broadly corresponds with a U.S. study of yoga injuries that found a lifetime prevalence of injuries of 35.4% (Cramer et al., 2015), although conflicts with another U.S. study in which only 45% reported no injury in the time they had practised (Wiese, et al., 2019b). Comparable literature for Pilates injuries in a real-world setting is not available for comparison. Although the incidence of adverse events from yoga was similarly found to be non-significant compared to usual care and other exercise in a systematic review (Cramer et al., 2015) this may be a reflection of trial ethics and more carefully designed protocols (Wieland et al., 2017). In a study of real-world yoga practice by middle-aged women, Cox et al. (2021) note their desire for yoga pose options and alternatives, clear instruction and accepting, non-judgemental teachers (Cox et al., 2021). The higher rate of injuries in yoga compared with Pilates in this survey could be attributed to the superior safety of Pilates in real-world practice but could also be related to number of years practised, which was higher for yoga: Wiese et al. (2019b) found that the strongest predictors for increased probability of reporting an injury over a lifetime of yoga practice was greater number of years of practice (P= < .0001) (Wiese et al., 2019b). In the present survey, of those who had practised for 10 years or more, the percentage reporting no yoga injuries dropped to 55.56% with 22.22% not sure. Although it is unknown whether this due to the accumulation of time and opportunity for injury to occur, or the advanced age of participants, this could cautiously be interpreted as an indication that the yoga practices need to be more carefully modified with age. The findings here agree with Sivaramakrishnan et al., (2017) whose interviews of older adults revealed the need for more alternative yoga postures to be offered when participants were concerned about yoga practice safety and personal limitations (Sivaramakrishnan et al., 2017).

Pilates also performed slightly better than yoga for meeting the needs of the over-50 population when participants were asked this question and indicated by its lower injury rate. In addition, the suggestion of slower classes and older teachers scored high for yoga but low for Pilates. Again, this suggests that yoga for this population needs more adaptation, both in general and for older adults, and compared to Pilates. Referrals in health care settings should suggest that participants choose a class suitable for their level of fitness and ability and that those with health conditions consult both a medical general practitioner and the teacher to ensure that the movements in the class will be suitable.

Strengths

The study was designed to address questions pertaining to a cross section of a particular population and to inform the protocol of a future trial to be recruited from the same or similar locations. As such it aligns with the notion in the CHERRIES guidelines that web surveys are useful for generating hypotheses to be confirmed in a more controlled environment (Eysenbach, 2004). A new yoga and Pilates participation survey instrument was created, informed by past work, as none existed at the time of implementation. Although data was self-reported, there is indication that the sample is representative of the wider population when compared to available existing literature, suggesting that results are reasonably informative and useful for this purpose. A balance of yoga and Pilates participants was captured.

Limitations

The sample was self-selected, limited to one geographical area and two types of facility (gym and yoga centre). Although the sample was found to be somewhat representative when placed in the context of existing literature, the data does not include the views of inactive older adults, those in rural areas, or those in a lower income socio-economic position. One purpose of the study was to consult a target population ahead of the design, development, and testing of protocols using participants from the same community. Appropriate data collection methods and reporting ensured the internal validity and quality of the study for this purpose. The study design and low target sample size were not chosen with a view to determining data saturation point, establish statistical significance, or the ability to make inductive generalisations from the findings or draw causal inferences. However, it is acknowledged that the data has not been re-tested with a different and larger sample of yoga and Pilates participants thus it cannot be concluded that findings are transferrable. While the findings can be used in conjunction with those gathered in the two systematic reviews presented in Chapters One and Two, this should be done in the context of contrast, as well as comparison, with acknowledgment of their different respective populations of study: Those in the reviews were of a mean age of over 50 years with specific musculoskeletal conditions, whereas the survey participants were aged over 50 but chronic pain or conditions were not a selection criterium. As two of the three facilities offered unlimited and various classes for a membership fee, the cost of classes could not be assessed and economic barriers to participation were not explored. While comparative national data was available for group exercise and yoga, there was a paucity of similar data available for Pilates practice. The low number of respondents over age 70 (n=3) also limits the application of the findings for yoga and Pilates practitioners aged

70 and above. The scope of this study did not include piloting of the survey instrument or the piloting and standardisation of the qualitative element of the post-trial survey, and reliability related to the interpretation and the reproduction of results under the similar conditions were not established (Boynton & Greenhalgh, 2004).

Conclusion

Yoga and Pilates participants followed normal patterns of employment and musculoskeletal health status, with slightly superior musculoskeletal health related to back pain, OA generally and knee OA specifically, underscoring the potential for these interventions to help mitigate the painful progression of these conditions. Participants were predominantly female, in line with group exercise participants in general and previous yoga surveys. Male survey respondents were more likely to take part in Pilates than yoga. The longevity of practice evident in both groups is possibly both a reflection of participants' age and the benefits experienced from these practices which continued to motivate participation. Motivations for practice slightly differed, with flexibility the top motivator for yoga, and strength and other functional benefits driving Pilates participation. Qualitative analysis revealed that yoga practitioners also enjoyed the mind-body and mental elements, while aspects of these teachings appeared to be a deterrent to some of the Pilates participants. Neither group was primarily motivated by chronic musculoskeletal conditions, and while knee injuries emerged as a possible barrier to yoga practice, musculoskeletal conditions in general were not a major barrier to either discipline. Barriers were centred on pragmatic concerns around class delivery rather than outcomes, with class time a greater obstacle to Pilates. Further study on the relationship between class scheduling and uptake could establish causation and help to identify whether accessibility drives uptake or demand drives accessibility, assessing the effect on health outcomes.

Despite the higher rate of injury and slightly lower rating for meeting needs of this population, yoga practice shower greater participation longevity and popularity than Pilates. This suggests that the importance of those elements unique to yoga, such as the focus on the mind-body connection and emphasis on overall well-being, outweigh the physical outcomes. Nonetheless, better practice might involve the development of age and condition-related yoga modifications to optimise physical benefits and reduce injuries. An inclusive and practical approach could widen accessibility and appeal. Pilates emerged as a suitable functional form of exercise for this population. The lower level of demand might be addressed with more timetabling of classes to enhance choice of class time, as this was the primary barrier to participation. Pilates teaching should maintain its pragmatic approach whilst incorporating the mind-body elements of the original Pilates principles such as breathing, centring, concentration, and flow, similar to those enjoyed by those participating in yoga. This could enhance appeal while maintaining accessibility. The present survey also identified crossover in yoga and Pilates participation and motivation, suggesting potential for evidence-based development of a yoga-Pilates fusion format with assessment of reception and outcomes, as there is a gap in research around this concept.

In comparison with yoga, less is known about Pilates participation due to a lack of survey data both nationally and internationally. While this research sourced eight peer reviewed surveys of yoga participation covering several countries, none were found for Pilates. It is therefore more difficult to place this survey’s findings about Pilates in a wider context. The evidence base would benefit from further survey tool development and a nationwide Pilates participation survey covering demographics, motivators, barriers, and perceived benefits for Pilates mat classes specifically, providing a demographic context for future comparative research.

Chapter Five
Eight-week Yoga and Pilates Trial Interventions for Adults Over 50 Years: Design and Rationale

The aim of this section of research was to develop an eight-week yoga and an eight-week Pilates intervention suitable for the over-50 population. The intervention was for use in a randomised comparative feasibility trial of yoga and Pilates measuring pain, physical function, and quality of life and analysing the qualitative experiences of the age-targeted exercise intervention, thereby testing the effectiveness, appropriateness, and acceptability of the protocols using a mixed-methods approach. The trial protocol, methodology, and results are discussed in subsequent chapters.

The protocols were developed using quantitative and qualitative findings from the two previous systematic reviews of yoga for chronic musculoskeletal conditions in adults over 50 years (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b), the survey conducted by the researchers exploring attendance, preferences, motivations, and barriers, and other extant literature on the delivery of yoga. A mixed-methods approach has been advocated in prior Pilates research into rationale for exercises utilised within Pilates group exercise programmes for people with chronic musculoskeletal conditions, and this may also be applied to the yoga intervention, ensuring a consideration for clinical reasoning, evidence, and individual participant preference and experiences for optimal effectiveness of exercises (Gaskell et al., 2019).

Rationale for Age-targeted Protocol

Although a “Gentle Years” yoga programme for older adults has already been developed (Tew et al., 2017), this is a largely chair-based programme and arguably aimed at “elderly” patients, defined for the purposes of the present study as over 75 (Orimo et al., 2006), rather than middle-aged and older people below retirement age. This study used interventions designed for those in "middle years" – those over 50 but not yet elderly, who may have self-reported but undiagnosed chronic conditions. This age group may still be in work or have dependent children, necessitating continued mobility and functional fitness. There is evidence to suggest that people like to exercise with others of a similar age (Beauchamp et al., 2007). However, a recent survey of yoga in the United Kingdom found the ages of participants spanned from 18 to 92 years, with a mean age of 48.7, suggesting that the majority of people in yoga classes are under 50 and that participation declines with age (Cartwright et al., 2020). This is also true of exercise in general (Garcia & Archer, 2014). We know that Pilates and yoga can benefit older adults in a trial situation (Denham-Jones et al., 2021a; Denham-Jones et al., 2021b), particularly when the yoga is modified for specific conditions (Denham-Jones et al., 2021b), so this raises the question as to whether yoga and Pilates classes in the wider community generally cater for the specific needs of the ageing population well enough to maintain engagement into later life. Results of the trial of these interventions may inform how best to modify the delivery of yoga and Pilates exercises to an older cohort, potentially in the light of age-related musculoskeletal issues, in a way that is sustainable, engaging, and enjoyable.

Aims and Objectives

- To develop an eight-week yoga and an eight-week Pilates intervention suitable for the over-50 population for use in a randomised comparative feasibility trial of yoga and Pilates
- To develop evidence-based yoga and Pilates interventions for testing using:
    - the findings of the two systematic reviews (Chapters One, Two and Three)
    - the yoga and Pilates participation survey (Chapter Four)
    - existing literature on yoga and Pilates safety and participant experience

- To provide evidence-based rationale for exercise choices
- To provide documentation of the eight-week protocols to enable fidelity

Yoga

Selection of Exercises

As the present intervention was designed for a healthy population rather than to address a specific pathology, a broad but balanced spectrum of traditional yoga poses was taken to cover a range of muscle groups and objectives. Exercises and modifications are shown in Table 5.1 and home practice structure in Table 5.2. For traditional yoga postures, names are listed in Sanskrit with English translation. Rationale for each exercise is shown in Table 5.3, including muscle focus (Coulter, 2001; Kaminoff & Matthews, 2012), objectives, and any significant effects on musculoskeletal conditions for the exercise found in the systematic review (Denham-Jones et al., 2022b) .

In the preceding survey, flexibility was the primary motivator for yoga attendance, therefore 28 of 35 yoga poses have a flexibility and mobility emphasis.

Back pain was cited as the most prevalent musculoskeletal condition, and a selection of poses were included to address this based on existing evidence including studies of muscle activation and effectiveness of single, specific yoga poses (Liu et al., 2021; Singh et al., 2021). For shalabhasana pose (locust) a dynamic evaluation of the contractile function of lumbodorsal muscles using ultrasound found the pose exercised the lumbar back muscles, especially the longissimus, which could contribute to lumbar stability (Liu et al., 2021). In addition, a randomised controlled trial specifically on the posture ardha matseyandra (a seated spinal twist) found that it was significantly effective for neck pain using the pain pressure threshold measure (PPT) (Singh et al., 2021).

Vrksasana, or tree pose, was included for its known effects on improving balance, as found in a randomised controlled trial of this specific yoga pose for women with postmenopausal osteoporosis (Solakoglu et al., 2022).

As qualitative data revealed a strong appreciation for the mind-body and well-being elements of yoga, the sequence begins with focused breathing designed to emphasise body awareness and the mind-body connection. Breathing exercises were a feature in all of the studies in the preceding systematic review (Denham-Jones et al., 2022b) and this element of the present intervention is also supported by a qualitative study of middle-aged women's experiences with yoga (Cox et al., 2021) in which participants enjoyed breathing, stress reduction, and mindfulness components. The mind-body connection has also been shown to play a role in pain management (Lumley et al., 2011) and therefore may be useful in the management of symptoms of chronic age-related conditions.

Intervention Dosage

For the present intervention, one hour-long group yoga class was delivered for eight weeks. This was accompanied by a progressive eight-week series of 40-minute pre-recorded home practice videos prescribed twice weekly. Session length, intervention duration, and practice frequency were guided by the preceding survey, in which 57% of yoga participants were accustomed to practising between one and two or more times weekly, as well as the effectiveness of this dosage shown in the systematic review of yoga conducted as part of this research (Denham-Jones et al., 2022b). In the majority of effective short-term (8-12 week) trials reviewed (Cheung, et al., 2014; Cheung et al., 2017; Garfinkel et al., 1994; Innes et al., 2020; Zacharia et al., 2018) 60 minutes was the prevalent length of group classes, coupled with an approximate prescribed average of four 30-minute sessions (120 minutes total) of home practice. For osteoarthritis there was evidence of statistically significant pain reduction effects after eight weeks (Cheung et al., 2014; Cheung et al., 2017). The decision was made to condense the two home practice sessions in the present protocol into two sessions totalling 80 minutes for practicability, as it was noted that participants did not adhere to home practice in the studies that prescribed four session per week either in terms of frequency, duration, or both (Cheung et al., 2014; Cheung et al., 2017). The home practice sessions reiterated what was taught in the group sessions, split into two differing sequences, one prescribed during the first four weeks and one during the last four weeks. Home yoga practice (albeit three to five times per week) has also been positively correlated with levels of self-confidence (Wiese et al., 2019a) and frequency of home yoga practice a positive predictor of well-being (Ross et al., 2012). The qualitative elements in the trial methodology were included to contribute to furthering this understanding of home yoga practice frequency and effects.

Graded Delivery

The intervention began with a set of 15 basic yoga poses, with additional postures, more advanced versions, and dynamic flow sequences linking postures added over the course of the eight weeks, for a repertoire of 35 poses at the end of the class series. For the home practice, the first four weeks included a series of these 15 basic poses. In weeks five to eight, this changed to a slightly different sequence that included the progressions and new poses added in weeks two, three, and four. This incremental approach was described in several of the studies (Cheung et al., 2014; Cheung et al., 2017; Dunleavy et al., 2016; Greendale, et al., 2009; Kuntz et al., 2018) in the preceding systematic review (Denham-Jones et al., 2022b) and was used to reduce the chance of injury and support participants' safety and confidence in their practice.

Adaptation of Yoga for the Over 50 Population

The exclusion and modification of specific yoga poses was informed by literature on yoga injuries, biomechanical studies of yoga, and risk factors in the older population. Back, knee, and shoulder pain, respectively, were the most prevalent sites of pre-existing pain and yoga injury reported in the preceding yoga and Pilates participation survey. The injury data was in agreement with surveys by Wiese et al. (Wiese et al., 2019b) and Cartwright et al. (Cartwright et al., 2020). Other surveys found that injuries were associated most frequently with headstands, shoulder stands, seated positions (in particular lotus position and half lotus position), forward bends, backward bends, and handstands (Cramer et al., 2019; Penman, et al., 2012). Consequently, this targeted protocol avoids certain advanced traditional yoga poses.

Poses involving repetitive or extreme flexion or extension of the spine and hyperextension of the neck found in some backbends were excluded as there is evidence to suggest that these may worsen outcomes. One study of yoga injuries found that 74.2% of people had mechanical myofascial pain due to overuse, resulting most commonly in injuries related to spinal hyperflexion and hyperextension (Lee et al., 2019). Extreme spinal flexion was avoided as a cautionary measure, as for osteoporosis this is contraindicated due to the risk of compression fractures (Lee et al., 2019; Sinaki 2013) and disc degeneration due to the risk of herniation (Le Corroller et al., 2012).

Poses involving extreme hip rotation, flexion or extension were excluded to protect the hip and knee joint. The standing pose trikonasana (triangle) was not included in this protocol due to the large knee extensor and adductor moments observed in a study of biomechanical characteristics on the lower extremity of three yoga poses (the other two being crescent lunge and warrior two, both included in this protocol), which suggested that despite its benefits to hip range of motion, strength, and dynamic stability this pose may be less suitable than others for those with knee osteoarthritis (Whissell et al., 2021). Janu sirsasana, a seated pose involving knee flexion and external rotation of femur, was included with the option of using blanket and cushions to support the knee and hip joint, but the more extreme rotations found in the padmasana (lotus) variations were excluded to reduce the risk of limited hip rotation leading to torque of the knee joint, compression of the medial joint space, and potentially tears of the posterior horn of the medial meniscus (Le Corroller et al., 2012).

A sun salutation was included to create a sense of flow and synchronicity between breath and movement. Evidence has shown that sun salutations can have significant effects on pain, functional disability, and quality of life in sub-acute back pain patients (Arovah et al., 2022). This is possibly due to improvements to back and abdominal muscle strength and flexibility (Bhutkar et al., 2011) leading to better posture and mobility, stimulation of blood flow (Hunter at al., 2013), and associated feelings of relaxation (Malhotra, 2017) influencing the perception of pain (Arovah et al., 2022). However, as Le Corroller (2012) suggests that the sun salutation's feature of weight being on the hands while moving through various shoulder positions can cause rotator cuff impingement, particularly in the supraspinatus (Le Corroller et al., 2012), the version taught involved even distribution of weight between upper and lower limbs (with knees on the floor instead of planks) and avoided multiple repetitions to prevent overloading the upper limbs. Advanced upper extremity weight bearing poses including headstand, shoulder stand, handstand, and advanced arm balances were also avoided as they have been associated with increased risk of injury and discomfort (Campo et al., 2018; Cramer et al., 2019; Penman et al., 2012; Richmond et al., 2021). Non-inverted arm balances such as bakasana (crow) and vashistasana (side plank) were included but did not involve frequent repetition and were modified by keeping the feet and one knee on the floor, respectively, to reduce the amount of weight born by the upper limbs. Campo et al. (2018) found that pain exacerbated by yoga was most prevalent in the wrist and hand (Campo et al., 2018). Attention was therefore paid to the wrist angle, with hyperextension avoided. Licassi (2019) found that continuous longitudinal axis loading of a hyperextended wrist may result in injury. Wrists should maintain a neutral position in kneeling plank and kneeling side plank to reduce joint angle and injury risk (Hawke et al., 2020; Licassi, 2019).

Teaching cues included clear instructions on alignment, a feature in the reviewed studies of yoga for neck pain and arthritis of the hand, knee, and lower limb (Dunleavy et al., 2016; Garfinkel et al., 1994; Kuntz et al., 2018; Zacharia et al., 2018). Props such as a belt and blanket were used to reduce range of motion and facilitate the achievement of some of the poses without strain, as was also the case in several studies (Cheung et al., 2017; Dunleavy et al., 2016; Greendale et al., 2009; Innes et al., 2020; Ward et al., 2018) in the preceding systematic review (Denham-Jones et al., 2022b). Alternative versions of certain poses were indicated in some cases to cater to individual levels of ability. Although Wiese et al. (2019b) did not find that increased age predicted a greater risk of yoga injury (Wiese et al., 2019b), Swain and McGwin (2016) found that over a broader time period (13 years) people over 44 years, and especially those over 65, were at greater risk of injury associated with practising yoga (Swain & McGwin, 2016). As a precaution, modifications are therefore particularly important when working with an older population who may have age-related functional impairments (Gardener et al., 2006; Valdes & Stocks, 2018) such as arthritis, osteoporosis, and low back pain for which exercise should be adapted to the individual (Burr et al., 2012). The importance of this person-centred rather than pose-centred approach is supported by the preceding survey, in which the injury rate was higher for yoga (12%) than

Pilates (9%), with only 27% of the over-50 population indicated that their needs were met by yoga, compared to 64% for Pilates (64%), and for yoga "more modifications offered by the teacher" was the most selected solution (41%).

Teaching Approach

Classes were taught in a way that acknowledged various degrees of ability and allowed participants to work at a comfortable and safe individual level rather than being encouraged to achieve a specific and rigid demonstration of each pose. In this respect the teaching approach was similar in its philosophy to Krucoff and Carson's "Yoga for Seniors" evidence-informed methodology for creating safe and effective posture modifications, which places yoga postures on a continuum of practice, whereby a scaled range of accessible variations is used, each considered equally valid in achieving the purpose of a particular yoga posture (Krucoff & Carson, 2023). The importance of accommodating individuals' capabilities, limitations, and comfort levels was also specifically mentioned in four of the systematically reviewed studies, in relation to knee OA, hyperkyphosis, and sarcopenia populations (Cheung et al., 2014; Cheung et al., 2017; Greendale et al., 2009; Pandya, 2019). Further, Cox et al. (2021) found that middle-aged female yoga participants expressed their appreciation of non-judgemental teachers, a welcoming, non-competitive environment, and clear instructions and modifications. Newcomers were discouraged when a yoga instructor would demonstrate too quickly, neglected to explain a process in insufficient detail or failed to offer adaptations (Cox et al., 2021). Concerns about difficulty levels, motivation, and injury have also been cited as the top three barriers to yoga practice for seniors over age 55 (Perkins et al., 2020). Pacing, breakdown of certain exercises, individual adaptations, acceptance, and encouragement are key in achieving engagement and satisfaction with yoga for this population. Screening for existing health conditions took place before every class, and symptoms were monitored to reduce injury (Lein, Singh, & Kim, 2020).

Pilates

Selection of Exercises

Application of Pilates by physiotherapists places an emphasis on stability for enhanced movement patterns and motor control, posture, global strength, and endurance (Cuddy & Gaskell, 2020; Gaskell et al., 2019; Giannakou & Gaskell, 2020; Wells et al., 2014a). Exercises typically involve both posterior and anterior chain, and upper and lower limbs, and should be aligned with participants' individual function (Gaskell et al., 2019). Among physiotherapists using Pilates, gluteal exercises including bridging and clams were the most frequently cited, followed by transversus abdominis activation, and supine work such as pelvic tilting and scissors (Cuddy & Gaskell, 2020). These muscular focal points are further justified by the survey which showed that strength, including for the back and abdominal muscles, and functional movement were among the primary motivators for Pilates participation, with one participant likening it to physical therapy in terms of serving a functional purpose. As the present intervention was designed for a healthy population rather than to address a specific pathology, a broad but balanced spectrum of exercises was taken to cover this range of muscle groups and objectives.

Exercises, modifications, and progressions are shown in Table 5.4 and home practice structure in Table 5.5.

Rationale for each exercise is shown in Table 5.6, including muscle focus and objectives, (per Body Arts and Science International [BASI] Pilates where applicable) (Body Arts and Science International, 2007b), and any significant effects on musculoskeletal conditions for the exercise found in the systematic review (Denham-Jones et al., 2022a).

Intervention Dosage

One hour-long group Pilates class was delivered for eight weeks. This was accompanied by a progressive eight-week series of 40-minute pre-recorded home practice videos prescribed twice weekly. The home practice sessions in the present protocol reiterated what was taught in the group sessions, split into two differing sequences, one prescribed during the first four weeks and one during the last four weeks. Session length, intervention duration, and practice frequency were based on several factors: This included the systematic review of Pilates for chronic musculoskeletal conditions in adults over 50 conducted as part of this research, in which all studies that measured either pain, physical function or quality of life reported statistically significant effects (Denham-Jones et al., 2022a). Most of the effective studies in the review (Cruz-Díaz et al., 2015; Dunleavy et al., 2016; 2021; Mazloum et al., 2018; Oksuz & Unal, 2017), and other studies (Abdelatief & Fathy, 2021; Karimi et al.; Yang et al., 2021), have been short-term (6-12 weeks) using 60-minute sessions two to three times per week. The home practice sessions in the present protocol provided a practical means of increasing weekly practice frequency. The length of the home practice sessions could not be determined by information from the preceding systematic review (Denham-Jones et al., 2022a) as the one study that used Pilates home practice (Donzelli etc al., 2006) did not include duration and frequency details of the home practice prescription. However, as the preceding yoga systematic review (Denham-Jones et al., 2022b) was used as the basis for determining the yoga home practice prescription, for parity the Pilates home practice was then set to align with this at 40 minutes twice per week. It is known that live video Pilates classes taken by older adults during the 2020 U.K. pandemic-related restrictions were well-received and contributed to feelings of engagement and progress (Taylor et al., 2020). This research tested to some extent whether the same is true of pre-recorded sessions. Dosage also falls within the range suggested in another systematic review (Lin et al., 2016) recommending two to three hours of Pilates per week for a total of 20 hours training in order to capture effects on chronic low back pain. Even without adherence to the home practice sessions, one hour for eight weeks aligns with real-world usage of Pilates for musculoskeletal conditions by private and NHS physiotherapists, where 30-60 minutes once per week for week 6-9 sessions was considered optimal (Cuddy & Gaskell, 2020). This frequency also mirrors real-world participation found in the prior survey of Pilates participants over age 50 conducted as part of this research, in which 54% said they practised once per week.

Graded Delivery

Existing Pilates research indicates the benefits of gradual progression in levels of challenge (Cuddy & Gaskell, 2020; Gaskell et al.,2019; Wells et al., 2014a). The graded, progressive increase in exercise duration, repetition or difficulty level of the exercise was specifically referred to in four of the studies systematically reviewed (Dunleavy et al., 2016; Mazloum et al., 2028; Notarnicola et al., 2014; Oksuz & Unal, 2017). This approach was similarly taken in developing the present protocol, with both weekly expansion of the repertoire, increase in repetitions, and replacement of basic exercises with more advanced ones. For the home practice sessions, the sequence for the first four weeks included a selection of basic exercises taught in week one, while the sequence for the last four weeks included a slightly different selection of exercises that included progressions and advancements taught in weeks two, three, and four. As recommended in the literature, for the weekly group class, progressions were applied and adjusted on a tailored, ad hoc basis according to the limitations and progress of individual participants (Cuddy & Gaskell, 2020; Gaskell et al.,2019; Giannakou & Gaskell, 2020; Wells et al., 2014a).

Adaptation of Pilates for the Over 50 Population

The repertoire, modifications, and scaled progression of the programme acknowledge the evidenced importance of adaptability to participants' abilities, both in order to improve engagement (Gaskell et al., 2019) and to prevent adverse events (Cuddy & Gaskell, 2020; Gaskell et al.,2019; Giannakou & Gaskell, 2020; Wells et al., 2014). This is particularly important when working with an older population who may have age-related functional impairments (Gardener et al., 2018) such as arthritis, osteoporosis, and low back pain for which exercise should be adapted to the individual (Burr et al., 2012). Back, knee, and shoulder pain respectively were the most prevalent injuries reported in the yoga and Pilates participation survey, and consequently this targeted protocol avoids the extreme flexion or extension of the spine found in some traditional, advanced Pilates exercises (e.g. boomerang, crab, control balance, jack knife, neck pull, rollover), those that require superior hamstring flexibility including the use of legs as long levers in a supine position to develop abdominal strength (e.g. corkscrew, teaser), advanced upper body weight bearing (e.g. push ups, planks, and reverse plank or "leg pull back" which includes weight bearing with shoulder joint in extension) (Body Arts and Science International, 2007a). The sequence includes a predominance of floor-based supine and prone exercises, as well as side lying exercises including hip abduction for strengthening gluteus medius (Macadam et al., 2015), a suggested approach in the treatment of low back pain (Cooper et al., 2016), a condition that can limit physical activity with age (Hoy et al., 2014). The initial floor-based exercises allowed participants to work on developing strength and awareness in supported positions, before moving into standing exercises towards the end of the sequence. These included strengthening exercises for balance, which in combination with the floor exercises have the potential to reduce the risk of falls in older adults (Fernández-Rodríguez et al., 2021).

Improvements to balance and functionality were also shown to reduce the fear of falling in the reviewed studies of Pilates for women with chronic low back pain (Cruz-Diaz et al., 2015) and kinesiophobia in women with osteoporosis (Oksuz & Unal, 2017). Excluded were high impact standing exercises which are not typically part of Pilates repertoire but sometimes form part of contemporary approaches such as high intensity interval Pilates (The Australian Physiotherapy & Pilates Institute, n.d.). In the preceding survey of yoga and Pilates participants, all respondents (*N*=35) indicated participation in other exercise, the most prevalent being cardiovascular type exercise – running (68%), walking or hiking (65%), and cycling (29%). The low impact design of the Pilates programme intentionally differentiates it from these forms of physical activity in order to contrast experiences.

Contemporary Teaching Approach

Cuddy & Gaskell (2020) have noted that physiotherapists using Pilates have shifted away from the purist emphasis on core engagement and neutral pelvis, suggesting that these exacerbate tension and pain, instead favouring a focus on facilitating movement under less rigid parameters (Cuddy & Gaskell, 2020). An emphasis on the mind-body connection, body and postural awareness, reduction of stress, and fear-avoidance patterns was also advocated (Cuddy & Gaskell, 2020). This correlates with one of the themes of the yoga and Pilates survey, which found that the mind-body elements of yoga were among reasons that yoga's popularity eclipsed that of Pilates, despite the latter having a lower injury rate among respondents. Expansion of the mindful elements of Pilates was suggested. The original Pilates principles included centring, breathing, and flow (in addition to concentration, control, and precision). BASI Pilates, a contemporary Pilates teaching method in which the intervention instructor/researcher is certified, add to these the principles of awareness, balance, and harmony (Body Arts and Science International, 2007b). In the presented protocol, the exercises are sequenced so as not to involve frequent and repeated changes of set-up position, to create a sense of flow. Breathing, body awareness, and relaxation exercises were included to bring these aspects into focus, and the mind-body-related Pilates principles were referred to in teaching cues. As such, the intervention takes a contemporary approach to Pilates in that it deviates from the classical Pilates mat sequence order and includes both modification of classical Pilates exercises as well as non-classical or modified exercises taught in their own right. In view of the study by Lewitt et al. (2019), "Developing a Teaching Framework to Describe What We Mean When We Say Pilates" the approach taken in this protocol should therefore be termed 'Pilates-based matwork' (Lewitt et al., 2019). Explanation by the instructor of the rationale for each exercise was given where appropriate to contribute to postural education, a feature of some of the studies in the systematic review in addressing back pain (Donzelli et al., 2006), and pain, function, quality of life, and kinesiophobia in women with osteoporosis (Küçükçakir et al., 2013; Oksuz & Unal, 2017).

Reporting of the Interventions

The interventions were delivered by one instructor to ensure fidelity and continuity and reported *post hoc* using the Template for Intervention Description and Replication (TIDieR) checklist and guide (Hoffmann et al., 2014). This was also the tool used to extract intervention content in the preceding systematic reviews (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b). In an assessment of exercise content reporting in randomised controlled trials of Pilates for the management of back pain, Barros et al. (2020) found that description was rated high according to the TIDieR checklist but low according to the CONTENT (Consensus on Therapeutic Exercise Training) scale (Hoogeboom et al., 2012) and CERT (Consensus on Exercise Reporting Template) checklist (Slade et al., 2016). The difference was due the fact that Pilates is a mind-body exercise not including intensive aerobic and strengthening components for which the CONTENT scale and CERT checklists were more appropriate. The TIDierR was developed for general therapeutic interventions, and therefore able to capture more content relevant to Pilates (Barros et al., 2020). Barros et al. (2020) further recommend better attention to reporting of adherence, modifications, and motivation strategies (Barros et al., 2020), so these were reported where applicable.

For the yoga interventions, the TIDieR checklist was supplemented with the CLARIFY checklist (CheckList stAndardising the Reporting of Interventions For Yoga) which was developed by Delphi consensus process to address noted shortcomings in the reporting of yoga trials that limit understanding and replication of the intervention (Moonaz et al., 2021). In agreement with the rationale for the development of CLARIFY checklist, in the yoga systematic review that forms part of the present research (Denham-Jones et al., 2022b) only 4 of the 11 interventions were published in enough detail for individual postures to be extracted. The CLARIFY is a 21-item check list designed to be used as a complement to existing reporting guidelines. It covers the themes of Theory, Activities, Expertise, Delivery, Dose, Home Practices, Protocol Changes, Participant Adherence, Instructor Fidelity, with further sub-categories to account for specific details related to the delivery of yoga. The checklist can be applied to any yoga study design in order to enhance to quality of reporting (Moonaz et al., 2021).

Table 5.1 *Eight-Week Programme of Yoga-based Exercises for Adults over 50 Years*

Week	Exercise	Modifications
1	Abdominal breathing in supta baddha konasana Cat-cow Ragdoll forward fold Standing side bend Virabhardrasana (warrior 2) Parsvakonasana (side angle) on elbow Prasarita padottansana A/C (standing straddle fold) Utkatasana (chair) Bhujangasana (cobra) Balasana (child's pose) Ardha matseyandrasana (seated spinal twist) bottom leg straight Setu bhandasana (bridge) Modified supta padangusthasana (reclining hamstring stretch with belt) Supine twist Savasana (relaxation)	Legs stretched straight out if hip pain Seated spinal flexion and extension if wrist/shoulder pain
2	Adho mukha svanasana (downward dog) after cat-cow Modified parivrrta parsvakonasana (kneeling prayer twist) after prasarita padottanasana	 Palm on floor instead of elbow over thigh
3	Virabhardrasana 2 flow (bend-stretch front leg) Vrksasana (tree) after utkatasana chair Shalabhasana (locust) after cobra	
4	Suryanamaskar (sun salutation) after side bend Parsvakonasana with hand on floor Lunge pulses after modified parivrrta parsvakonasana Dhanurasana (bow) after cobra	 Use block or book Prone quadriceps stretched followed by high cobra
5	Anahatasana (shoulder stretch) after dhanurasana Malasana (squat) after dhanurasana Navasana (boat) after malasana Purvottanasana (reverse plank) with bent knees after boat	 Keep feet on floor/support back of legs with hands Keep hips on floor
6	Plank to modified vashistasana (kneeling side plank) after tree Ustrasana (camel) after anahatasana Anjaneyasana kneeling crescent lunge after camel Janu sirsasana (seated forward fold one leg bent) after reverse plank	 Elevate hips on cushion; use belt to reach feet; cushion under knee
7	Modified pincha myuransana mayurasana (downward facing dog with elbows down) after balasana) Full ardha matseyandrasana Sukhasana (cross legged forward fold) after ardha matseyandrasana Supine figure four after reclining hamstring stretch	Keep knees on floor Continue to keep bottom leg straight
8	Lift back knee on modified parivrrta parsvakonasana Bakasana (crow) after chair pose Paschimottinasana (straight leg seated forward fold)/Upavishta konasana (wide leg seated forward fold) after cross legged forward fold each side Progressive muscle relaxation before savasana	 Lift heels only Elevate hips on cushion; use belt to reach feet

Table 5.2 *Yoga Home Practice Sessions*

	Exercise
Practice A First 4 weeks	Abdominal breathing in supta baddha konasana Cat-cow Ragdoll forward fold Standing side bend Virabhardrasana (warrior 2) Parsvakonasana (side angle) on elbow Prasarita padottansana A/C (standing straddle fold) Utkatasana (chair) Bhujangasana (cobra) Balasana (child's pose) Ardha matseyandrasana (seated spinal twist) bottom leg straight Setu bhandasana (bridge) Modified supta padangusthasana (reclining hamstring stretch with belt) Supine twist Savasana (relaxation)
Practice B Last 4 weeks	Abdominal breathing in supta baddha konasana Adho mukha svanasana (downward dog) Ragdoll forward fold Suryanamaskar (sun salutation) Virabhardrasana 2 flow (bend-stretch front leg) Parsvakonasana with hand on floor Prasarita padottansana A/C (standing straddle fold) Modified parivrrta parsvakonasana (kneeling prayer twist) Lunge pulses Vrksasana (tree) Shalabhasana (locust) Dhanurasana (bow) Balasana (child's pose) Ardha matseyandrasana (seated spinal twist) bottom leg straight Setu bhandasana (bridge) Modified supta padangusthasana (reclining hamstring stretch with belt) Supine twist Savasana (relaxation)

Table 5.3 *Rationale and Evidence for Selected Yoga Exercises*

Exercise	Muscle focus/ Objective	Use in prior RCT -Population	Evidence of effects for prior RCT- Outcomes	Source(s)
Abdominal breathing in supta baddha konasana	Body and breath awareness, relaxation, centring; adductor stretch; external hip rotation	Knee OA	Pain, Physical function	Cheung at al., 2017
Cat-cow	Back extensor activation and stretch; scapula stabilisation	Chronic mechanical neck pain	Pain	Dunleavy et al.,2016
Adho mukha svanasana (downward dog)	Hamstring, calf and spinal muscle stretch; shoulder strength	Chronic mechanical neck pain	Pain	Dunleavy et al.,2016
Ragdoll forward fold	Hamstring and back extension stretch	Chronic mechanical neck pain Knee OA women; Knee OA	Pain Pain; Pain, physical function	Dunleavy et al., 2016 Cheung et al., 2014; Cheung at al., 2017
Standing side bend	Oblique abdominal activation and stretch; quadratus lumborum stretch	Sarcopenia women	Physical function	Pandya, 2019
Suryanamaskar (sun salutation)	Warm-up; breath and movement awareness and coordination; spinal flexor and extensor activation; hamstring and hip flexor stretch; upper body strength	Sarcopenia women	Physical function	Pandya, 2019
Virabhardrasana (warrior 2)	Quadriceps femoris/ vastus lateralis activation of the front limb; gluteal activation	Chronic mechanical neck pain Knee OA women; Knee OA	Pain Pain; Pain, physical function	Dunleavy et al., 2016 Cheung et al., 2014; Cheung at al., 2017
Parsvakonasana (side angle) on elbow	Quadriceps femoris/ vastus lateralis activation of the front limb; gluteal activation; oblique abdominal and quadratus lumborum stretch			
Prasarita padottansana A/C (standing straddle fold)	Hamstring and adductor strtech			
Modified parivrrta parsvakonasana	Oblique abdominal activation; flexor stretch; balance			
Lunge pulses	Hamstring and hip flexor stretch			
Utkatasana (chair)	Quadriceps, hamstring, spinal and shoulder muscle activation; calf stretch	Knee OA women; Knee OA	Pain; Pain, physical function	Cheung et al., 2014; Cheung at al., 2017
Bakasana (crow)	Shoulder strength and stabilisation; balance			
Vrksasana (tree)	Balance; proprioception	Chronic mechanical neck pain Knee OA women; Knee OA Postmenopausal osteoporosis Sarcopenia women	Pain Pain; Pain, physical function Balance Physical function	Dunleavey et al., 2016 Cheung et al., 2014; Cheung at al., 2017 Solakoglu et al., 2022 Pandya, 2019

Table 5.3 *Rationale and Evidence for Selected Yoga Exercises* (continued)

Exercise	Muscle focus/ Objective	Use in prior RCT -Population	Evidence of effects for prior RCT- Outcomes	Source(s)
Plank to modified vashistasana (kneeling side plank)	Shoulder strength and stabilisation; oblique abdominal activation; balance			
Bhujangasana (cobra)	Spinal muscle activation; abdominal muscle stretch; scapula stabilisation	Chronic mechanical neck pain	Pain	Dunleavy et al.,2016
Shalabhasana (locust)	Back extensor activation	Knee OA women; Knee OA	Pain; Pain, Physical function	Cheung et al., 2014; Cheung at al., 2017
Dhanurasana bow	Spinal muscle activation; abdominal muscle stretch; hip flexor and shoulder stretch	Sarcopenia women	Physical function	Pandya, 2019
Anahatasana	Shoulder and back extension			
Ustrasana (camel)	Back and hip extension; abdominal stretch			
Anjaneyasana kneeling crescent lunge	Hip flexor stretch; back extensor activation	Sarcopenia women	Physical function	Pandya, 2019
Modified pincha myuransana mayurasana (downward facing dog with elbows down)	Upper body strength; scapula stabilisation			
Malasana (squat)	Adductor, calf, and low back stretch			
Navasana (boat)	Trunk and psoas strength; balance	Chronic mechanical neck pain	Pain	Dunleavy et al.,2016
Purvottanasana (reverse plank)	Hamstring activation; shoulder extension			
Balasana (child's pose)	Back and gluteal muscle stretch	Chronic mechanical neck pain	Pain	Dunleavy et al.,2016
Ardha matseyandrasana (seated spinal twist) bottom leg straight	Piriformis and gluteal muscle stretched, oblique abdominal and spinal muscle activation	Sarcopenia women	Physical function	Pandya, 2019
Sukhasana (cross legged forward fold)	Activate and stretch hip rotators; stretch hip adductors and back muscles	Knee OA women; Knee OA	Pain; Pain, Physical function	Cheung et al., 2014; Cheung at al., 2017
Paschimottinasana (straight leg seated forward fold)/	Hamstring and back stretch			
Upavishta konasana	Hamstring and adductor stretch	Knee OA women	Pain	Cheung et al., 2014

Table 5.3 *Rationale and Evidence for Selected Yoga Exercises* (continued)

Exercise	Muscle focus/ Objective	Use in prior RCT -Population	Evidence of effects for prior RCT- Outcomes	Source(s)
Janu sirsasana (seated forward fold one leg bent)	Hamstring and adductor stretch; external hip rotation; back and quadratus lumborum stretch	Knee OA	Pain, Physical function	Cheung at al., 2017
Setu bhandasana (bridge)	Gluteus maximus, hamstring activation; shoulder extension	Chronic mechanical neck pain Knee OA women; Knee OA	Pain Pain; Pain, physical function	Dunleavy et al., 2016 Cheung et al., 2014; Cheung at al., 2017
Modified supta padangusthasana (reclining hamstring stretch with belt)	Hamstring stretch; pelvic stability	Sarcopenia women	Physical function	Pandya, 2019
Supine figure four	Piriformis muscle stretch			
Supine twist	Lower back and outer hip stretch	Chronic mechanical neck pain Knee OA women; Knee OA	Pain Pain; Pain, physical function	Dunleavy et al., 2016 Cheung et al., 2014; Cheung at al., 2017
Progressive muscle relaxation	Body and mind awareness, relaxation, stress reduction	Sarcopenia women	Physical function	Pandya, 2019

Table 5.4 *Eight-Week Programme of Pilates-based Exercises for Adults over 50 Years*

Week	Exercise	Reps	Modifications
1	Supine body scan	1	
	Supine diaphragmic breathing	NA	
	Supine lateral breathing in neutral pelvis with		
	TVA engagement on the exhalation	NA	
	Knee fall outs	6	
	Single leg lifts to tabletop	6	
	Chest lift	6	
	Bridge*	4	*Pelvic tilt
	Puppet arms (scapular protraction supine)	4	
	Arms open and close	4	
	Spine twist supine*	4	*Keep feet on floor
	Clams	8	
	Basic back extension	4	
	Quad stretch prone*	1	*Kneeling lunge
	Ankle to knee hip rotator stretch supine*	1	*Keep feet on floor
	Hamstring stretch supine	1	
	Seated Twist*	1	*Supine twist if cross legged sitting not possible
	Waiters (shoulder rotation)	8	
	Scapula stabilisation on all fours	6	
	Supine relaxation	NA	
2	Changes and Additions:		
	Chest lift with rotation* following chest lift	4	*Bring head down between reps
	Hover alternate feet in bridge*	4	*Keep feet down
	Prone leg lifts following basic back extension	6	
	Cat following scapula stabilisation*	6	*In seated position if weight bearing on wrists not possible
3	Changes and Additions:		
	Increase 4 reps to 6 and 6 to 8		
	Toe taps from tabletop following single leg lifts*	6	*Do not bring toes all the way to floor
	Prone leg scissors following prone leg lifts	6	
	Standing rises onto tip toe following cat	6	
	Roll downs following standing rises	4	
4	Changes and Additions:		
	Combine chest lift with alternate leg lift and		
	rotation (modified criss cross exercise)	8	
	Side lying hip abduction following clams	8 each	
5	Changes and Additions:		
	Remove knee drops		
	Chests lift in tabletop replaces leg lifts, taps,	8	
	chest lift/rotation series*	8	*Knees folded into chest instead of tabletop
	Lift alternate leg to tabletop in bridge*	6	*Keep feet on floor or hover
	Supine twist now with legs in tabletop*		*Feet on floor or knees to chest
	Replace basic extension with back extension	8	
	with lat pull down		
	Replace prone leg scissors with prone opposite	8	
	arm and leg raises		
	Remove seated twist		
	Remove waiters		
	Add standing Pilates tree following rises	6 each leg	
6	Changes and Additions:		
	Increase 6 reps to 8 and 8 to 10		
	Add side lying hip adduction after hip abduction	10	
	Add single leg circles following supine hamstring	8 each leg	*Knee bent, bottom leg bent
	stretch*	8	*Seated "cat" (flexion, extension holding back of knees)
	Add seated half roll down following leg circles*		
7	Changes and Additions:		
	Add shoulder extension (reverse table) following		
	seated half roll down*	4	*Hips stay on floor
	Replace all fours scapula stabilisation and cat		*On elbows and knees or standing if upper body weight
	with all fours hip extension (donkey kick)*	10 each leg	bearing not possible)
	Add knee hover all fours following donkey kick*		*Press hands without hovering knees; against wall if all
	Add downward dog after knee hover	4	fours weight bearing not possible
	Replace rises and tree balance with standing	1	
	lunges (static lunge position, both legs bend		
	then stretch) following*	6 each leg	*Standing squat
8	Add standing side bend, quad stretch, standing	1 each stretch,	
	figure 4 and shoulder rolls after lunges	4 shoulder rolls	

Table 5.5 *Home Pilates Practice Sessions*

	Exercise	Reps
Practice A (first 4 weeks)	Supine body scan	NA
	Supine diaphragmic breathing	NA
	Supine lateral breathing in neutral pelvis with TVA engagement on the exhalation	NA
	Knee fall outs	6
	Chest lift	6
	Basic back extension	4
	Quad stretch prone	1
	Hamstring stretch supine	1
	Seated twist	1
	Waiters (shoulder rotation)	8
	Scapula stabilisation on all fours	6
	Supine relaxation	NA
Practice B (last 4 weeks)	Supine lateral breathing in neutral pelvis with TVA engagement on the exhalation	NA
	Single leg lifts to tabletop	8
	Toe taps from tabletop	8
	Chest lift with rotation	8
	Combine chest lift with alternate leg lift and rotation	8
	Bridge hovering alternate feet	6
	Puppet arms (scapula protraction supine)	6
	Arms open and close	6
	Spine twist supine	6
	Clams	8
	Side lying hip abduction	8
	Prone leg lifts	8
	Prone scissors	6
	Ankle to knee hip rotator stretch supine	1
	Hamstring stretch supine	1
	Seated twist	1
	Waiters (shoulder rotation)	8
	Scapula stabilisation on all fours	8
	Cat	8
	Standing rises to tiptoe	6
	Roll downs	6
	Supine relaxation	1

Table 5.6 *Rationale and Evidence for Selected Pilates Exercises*

Exercise	Muscle focus/ Objective	Use in prior RCT -Population	Evidence of effects for prior RCT- Outcomes	Source(s)
Supine body scan	Body awareness; concentration			
Supine diaphragmatic breathing	Breath awareness; relaxation			
Supine lateral breathing in neutral pelvis with TVA engagement on exhalation	Transverse abdominal (TVA) activation	Mechanical neck pain Chronic low back pain (CLBP)	Pain, disability Quality of life (QOL)	Dunleavy et al., 2016 Yang et al., 2021
Knee fall outs	Pelvic lumbar stability (PLS); hip disassociation			
Single leg lifts to tabletop	TVA; PLS, hip disassociation	Mechanical neck pain	Pain, disability	Dunleavy et al., 2016
Toe taps from tabletop	TVA; PLS, hip disassociation			
Chest lift	Abdominal strength; pelvic stability			
Chest lift with rotation	Oblique abdominal strength; pelvic stability			
Chest lift with alternate leg lift and rotation (modified criss cross exercise)	Oblique abdominal strength; pelvic stability	CLBP	Pain, physical function, QOL	Notarnicola et al., 2014
Chest lift in tabletop	Abdominal strength; trunk stability	Osteoporosis	Pain	Abdelatief & Fathy, 2021
Bridge	Abdominal and hamstring and gluteal strength; spinal articulation	CLBP Knee osteoarthritis Osteoporosis	Pain, physical function, QOL	Notarnicola et al., 2014; Yang et al. 2021 Karimi et al., 2021; Mazloum et al., 2018 Abdelatief & Fathy, 2021; Oksuz & Unal., 2017
Puppet arms (scapula protraction supine	Body awareness, shoulder mobility			
Arms open and close	Shoulder mobility	Osteoporosis	Pain, physical function, QOL	Oksuz & Unal, 2017
Spine twist supine	Spinal rotation; PLS; abdominal control with oblique emphasis	CLBP Knee OA Osteoporosis	Pain, physical function, QOL	Notarnicola et al., 2014 Mazloum et al., 2018 Oksuz & Unal, 2017

Table 5.6 *Rationale and Evidence for Selected Pilates Exercises* (continued)

Exercise	**Muscle focus/ Objective**	**Use in prior RCT -Population**	**Evidence of effects for prior RCT- Outcomes**	**Source(s)**
Clams	PLS, hip rotator strength; hip mobility	Knee OA Mechanical neck pain Osteoporosis	Pain, physical function, QOL Pain, disability Pain, physical function, QOL	Mazloum et al., 2018 Dunleavy et al., 2016 Oksuz & Unal, 2017
Side lying hip abduction	Hip abductor strength	CLBP Knee OA Mechanical neck pain Osteoporosis	QOL QOL Pain, disability Pain	Yang et al., 2021 Karimi et al., 2021 Dunleavy et al., 2016 Abdelatief & Fathy, 2021
Basic back extension	Back extensor strength; posture	CLBP	QOL	Yang et al., 2021
Back extension with lat pull down	Back extensor strength; posture			
Prone opposite arm and leg raises	Back and hip extensor strength	CLBP Mechanical neck pain Osteoporosis	Pain, physical function, QOL Pain Pain, physical function, QOL	Notarnicola et al., 2014; Yang et al. 2021 Dunleavy et al., 2016 Oksuz & Unal, 2017
Prone leg lifts	Hip extensor strength	Neck pain	Pain, disability	Dunleavy et al., 2016
Prone leg scissors	Hip extensor and adductor strength			
Quad stretch prone	Hip flexor and quadriceps flexibility			
Ankle to knee hip rotator stretch	Hip mobility			
Hamstring stretch supine	Hamstring flexibility	Knee OA	QOL	Karimi et al., 2021
Single leg circles	TVA activation; PLS; hip disassociation and mobilisation	CLBP Knee OA Osteoporosis	Pain, physical function, QOL Pain, physical function Pain	Notarnicola et al., 2014; Yang et al., 2021 Mazloum et al., 2018 Abdelatief & Fathy, 2021
Seated half roll down	Abdominal strength; spinal mobility			
Shoulder extension (reverse table)	Shoulder strength and mobility			

Table 5.6 *Rationale and Evidence for Selected Pilates Exercises (continued)*

Exercise	Muscle focus/ Objective	Use in prior RCT - Population	Evidence of effects for prior RCT- Outcomes	Source(s)
Seated twist	Spinal rotation; abdominal control with oblique emphasis	Mechanical neck pain	Pain, disability	Dunleavy et al., 2016
Waiters (shoulder rotation)	Shoulder mobility and rotator strength; posture			
Scapular stabilisation on all fours	Scapulae stabilisation			
Cat	Abdominal control; back extensor strength; lumbar spine stretch; spinal articulation	Mechanical neck pain	Pain, disability	Dunleavy et al., 2016
All fours hip extension (donkey kick)	Shoulder and scapula stabilisation; hip extensor strength; OLS			
Knee hover all fours	Scapula; shoulder and trunk stabilisation with abdominal activation			
Downward dog	Hamstring, calf and spine stretch; upper body strength			
Standing rises	Ankle and calf strength; balance; proprioception			
Pilates tree	Lower limb and hip stability; balance; proprioception			
Standing lunges	Gluteal and quadriceps strength; hip flexor mobility; balance	Mechanical neck pain	Pain, disability	Dunleavy et al., 2016
Standing side bend	Oblique abdominal control and stretch			
Standing quad stretch	Hip flexor and knee flexor stretch; balance			
Standing figure 4 stretch	Hip rotator stretch; balance			
Shoulder rolls	Relaxation			
Standing roll down	Hamstring and back extensor stretch; spinal articulation	Osteoporosis	Pain, physical function, QOL	Oksuz & Unal, 2017
Supine relaxation	Body awareness, relaxation; stress reduction	CLBP Mechanical neck pain	Pain, physical function, QOL Pain, disability	Notarnicola et al., 2014 Dunleavy et al., 2016

Chapter Six
A Mixed-Methods Study of Yoga and Pilates for Adults over 50 years: Randomised Comparative Feasibility Trial and Thematic Analysis of Participant Experiences

This study compares a yoga and a Pilates intervention designed for middle-aged and older adults (aged between 50 and 75 years) using quantitative measures of physical function and pain, combined with a quality of life questionnaire and semi-structured, survey-based qualitative thematic analysis of participants' perceptions and experiences. Interviews of two participants from each group for were added *post h*oc for qualitative depth and these are presented and analysed separately in Chapter Seven. The reporting of this protocol was informed by the SPIRIT checklist (Standard Protocol Items: Recommendations for Interventional Trials) (Chan et al., 2013).

Background

Exercise interventions for older adults are an important aspect of public health in the United Kingdom and the current recommendation is that adults of all ages engage in a mixture of aerobic and strengthening exercise (Department of Health and Social Care, 2019).

Two systematic reviews by the researcher (Denham-Jones, et al., 2021a; Denham-Jones, et al., 2021b) found that both Pilates and yoga are enjoyable, safe forms of physical activity for older adults with chronic or age-related musculoskeletal conditions. The comparison of the reviews in Chapter Three led to the hypothesis that Pilates is more effective compared to yoga for physical function and improved quality of life. This is reflected in a 2019 study by Lim and Park into the effects of yoga and Pilates on functional movement and individual health status of adults between 30 and 40 years, which found Pilates superior to yoga for both outcomes, albeit using a different age group (Lim & Park, 2019). The yoga review (Denham-Jones et al., 2021b) also concurs with other research

(Wieland et al., 2017) that the yoga trial protocols were specifically modified for the populations and conditions in question, whereas this might not be the case in real-world practice. The review found both interventions to be as effective as other forms of strengthening, aerobic, and mind-body exercise, indicating that recommendation and uptake of yoga and Pilates depends on individual exercise preference.

Survey data presented in Chapter Four revealed that yoga enjoyed greater popularity than Pilates despite a higher injury rate. Qualitative data indicated that modifications could optimise physical benefits and reduce injuries. Pilates was perceived as a safe, functional form of exercise with teaching incorporating mind-body elements potentially enhancing appeal. Neither yoga nor Pilates participants were primarily motivated by the existence of musculoskeletal health conditions, although the percentage was higher for Pilates (25%) than for yoga (12%).

The randomised trial, with quantitative measures that are objective and deductive, is generally considered among the most appropriate study designs to accurately assess the clinical efficacy of therapy interventions (Greenhalgh, 1997). Yet there are limits to the assessment of exercise interventions when solely using quantitative outcomes. Since effects of yoga and Pilates can be psychosocial as well as physical, quantitative measures may benefit from being combined with qualitative research to bring depth to the experiential perspective, thereby giving the participants more agency and a stronger voice in the research than using quantitative methods alone. The use of qualitative or mixed methods was highlighted by the UK Medical Research Council framework for the development and evaluation of complex interventions, recognising its value alongside randomised controlled trials as a means of evaluating how interventions are delivered in practice (Campbell et al., 2000; Campbell et al., 2007; Craig et al., 2008; Oakley et al., 2006). In their guidance on maximising the impact of qualitative research in feasibility studies for randomised controlled trials, O'Cathain et al., (2015) note that researchers commonly use qualitative research to address the acceptability, feasibility, practicality, and perceived benefits of an intervention and further identified several specific questions for which qualitative or mixed-methods research were regarded as particularly suitable (O'Cathain et al., 2015). This included asking to what extent the planned intervention needs to be refined or adapted to make it more acceptable to users or more relevant or useful to the specific context in which it is delivered. This is a question identified as central to the present study and therefore meriting the use of qualitative research in exploring this (O'Cathain et al., 2015). Mintzberg (1979) recognises "richness that comes from anecdote. We uncover all kinds of relationships in our 'hard' data, but it is only through the use of this 'soft' data that we are able to 'explain' them, and explanation is, of course, the purpose of research" (Mintzberg, 1979, p. 113).

Mixed methods have therefore been adopted in the present study for a more comprehensive understanding of processes and outcomes. The need for the mixed-methods approach is indicated in the preceding stages in a number of ways. In view of the problems of study quality in yoga and Pilates trials identified in the two systematic reviews (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b), such as non-blinding, which is inherent to trials of this kind including this one, and small sample size, which it was not within the scope of the present study to remedy, the addition of depth to enhance rigour and quality was considered particularly important to this study. Further, the systematic review presented in Chapter Two found that for yoga, quality of life tools did not always capture significant results, even where pain and function improved (Denham-Jones et al., 2021b). Yet there is evidence of quality-of-life effects in other studies and reviews that used slightly different populations (Patel et al., 2012; Sieczkowska et al., 2019; Sivaramakrishnan et al., 2019; Telles et al., 2019). Additionally, in a yoga trial of older adults with back pain resulting in no significant effects (Teut at al., 2016), the participants nonetheless gave the exercise interventions high scores on a numerical rating scale for satisfaction, credibility, and likelihood of recommending it, despite their not having reduced pain, or improved function or quality of life. The researchers suggested that for older adults, patient-centred outcomes are particularly important in designing meaningful interventions, and a mixed-methods approach is advocated to better understand what participants experience, and what is important to them when receiving nonpharmacological interventions (Teut et al., 2016). The qualitative aspect in the present trial was therefore added as an adjunct to the SF-36 to provide depth and to illuminate findings. It takes into account personal perspectives, anecdotal evidence, and individual narratives, putting the experience of the individual at the heart of the research through rich description which is absent in quantitative research.

Qualitative and mixed-methods approaches have successfully illuminated aspects of older adults' experiences of Pilates and yoga trial interventions in existing studies. Gaskell and Williams (2018) used focus group data for a qualitative phenomenological analysis of the experiences of adults (mean age 57) with chronic musculoskeletal conditions following a twelve-week Pilates intervention (Gaskell & Williams, 2018). Findings showed that Pilates aided in the maintenance of other activities and hobbies, promoted self-confidence, and helped participants autonomously manage their conditions (Gaskell & Williams et al., 2018). Patel et al. (2011) used grounded theory to generate the biopsychosocial model of health from qualitative data collected in a focus group before and after a twelve-week yoga intervention for older adults, finding perceived benefits of improved balance and mobility, pain reduction, and better mental health (Patel et al. 2011). Tew et al. (2017) used both quantitative data and a thematic analysis of post-intervention exit interviews in a randomised pilot trial of a ten-week adapted yoga intervention designed to improve physical function and health-related quality of life in physically inactive older adults (Tew et al., 2017). Interview data showed that participants valued the intervention for a range of benefits including pain reduction, increased energy and mobility, calming effects, and social connectedness (Tew et al., 2017). In common with these studies, the interventions in the present study are modified for older adults, but do not target a specific age-related condition or use a population presenting a specified pathology. The existing studies are therefore used for comparison and differentiation in subsequent discussion of findings. It is unique to the present study that it uses both yoga and Pilates which allows for comparison of phenomena related to these associated but different interventions.

Aims and Objectives

The presented trial was designed to assess the effectiveness of an age-targeted yoga and Pilates protocol for adults over 50, as well as qualitatively assess and compare the participants' experiences of the specialised Pilates and yoga interventions. This was undertaken with two related aims:

- To test the protocols for acceptability, feasibility of delivery, appropriateness, and safety, and to determine best practice in delivery for beneficial outcomes including but not limited to those related to pain, physical function, quality of life.
- To test the effectiveness of the interventions for the outcomes pain, physical function, and quality of life

The study included feasibility, qualitative, and quantitative outcomes:

Feasibility Outcomes

- To test the feasibility of delivering an eight-week yoga/Pilates intervention designed for adults over 50 years:
  - Recruitment
  - Attendance
  - Adherence
  - Attrition
  - Adverse events

Quantitative Outcomes

- To measure and compare the effectiveness of yoga and Pilates for physical function, pain and quality of life:
  - Improvements to these outcomes
  - Development of or worsening of pain to assess safety and appropriateness of protocols

Qualitative Outcomes

- To assess and compare the participants' experiences of the specialised Pilates and yoga interventions, both separately and relative to one another:
  - Intervention safety/appropriateness
  - Intervention acceptability/enjoyment
  - Experience with home practice
  - Capture any impact on pain, physical function, and quality of life not captured by quantitative measures

Study Design

The overall design was a concurrent mixed-methods study. The experimental section of this study was an eight-week, randomised comparative feasibility trial with yoga and Pilates groups, which was coupled with survey-derived qualitative thematic analysis of participants' perceptions and experiences. Data analyses were undertaken using the quantitative and qualitative methods concurrently, with the post-trial survey thematic analysis nested in the overall design. Findings are therefore interpreted jointly within this chapter. The quantitative outcomes were reported using statistical analysis, while qualitative and feasibility outcomes were reported narratively.

Eldridge et al. (2016) define feasibility as a broad concept, identifying three types of studies: Randomised pilot studies, which are a smaller scale version of a future randomised controlled trial (for example, to test outcome measurement strategies), non-randomised pilot studies (reflecting the design of a future trial, but without randomisation), and feasibility studies, which are not specifically testing strategies for a future trial, but may still be concerned with informing some aspects of future trial feasibility as well as intervention testing and development. This last definition aligns with the present study.

Methods

Recruitment

Recruitment was conducted using flyers at the fitness venues used in the survey phase of research: The Fort Gym (now Anytime Fitness), an on-site health and fitness facility in the Piper Building, a mixed-use residential and business centre in Fulham, London SW6, and Nuffield Health Club, Battersea, London SW11. The flyers provided interested participants with a link to a website-based online participant information sheet and, if they chose to continue, they could proceed to a website-hosted eligibility questionnaire. If eligible, they proceed on the same platform to the participant information page and a consent form. Contact data was taken at the stage of providing consent. All recruitment documentation is shown in Appendix V.

Inclusion Criteria

- Adults 50-75 years encompassing middle-age (50-64 years of age) (Brown et al., 2017) the age at which functional impairment may develop, (Gardener et al., 2006; Valdes & Stocks, 2018) and including those up to and beyond the U.K. state pension age (Clarke, 2017).

Exclusion Criteria

- Adults under 50 or over 75 years
- Individuals with the following self-reported conditions or circumstances. (Criteria selected by the researcher, informed as notated by the literature review of existing yoga and Pilates trials for those with age-related conditions - back and neck pain, osteo and rheumatoid arthritis, hyperkyphosis, and osteoporosis):
    - Uncontrolled high blood pressure (Cheung et al., 2014; Greendale et al., 2009)
    - Unstable heart condition (Cheung et al., 2014; Greendale et al., 2009; Kuntz et al., 2018)
    - Acute disc prolapse or protrusion with acute neurological symptoms in the past three months (Teut et al., 2016)
    - Surgery in the past six months (Ward et al., 2018)
    - Surgery planned in the next six months (Ward, et al., 2018)
    - Easily aggravated pain with exercise (Dunleavy et al., 2016)
    - Physician-advised abstention from physical exercise (Kuntz et al.,2018)

- Inability to walk or stand unassisted (Greendale et al., 2009; Zacharia et al., 2018)
- Inability to hear or understand verbal cues and see visual demonstration of group exercise (Greendale et al., 2009; Oksuz & Unal, 2017)
- Inability to commit to the duration of the trial (Oksuz & Unal, 2017; Ward et al., 2018)
- Likely to move out of reasonable travel distance in the next six months (Greendale et al., 2009)
- Participation in other yoga or Pilates classes or courses explicitly aimed at the over 50 age group in the last 12 months

Size

The sample size was determined based on feasibility rather than an *a priori* power calculation (Konkya, 2018) with the aim of recruiting a minimum of ten participants in each group. Although for a feasibility study a formal sample size calculation is not necessarily required (Eldrige et al., 2016), a power calculation was also performed in support of this sample size. Using data from a study of Pilates for pain, functional status, and quality of life for women with postmenopausal osteoporosis from the preceding systematic review (Küçükçakir et al., 2013), a power calculation with a level of 80% and alpha 0.05 and beta 0.20 indicated 20 (ten per group) as the minimum sample size using the SF-36 physical function scores and 14 (seven per group) using the SF-36 general health score. This was a particularly effective study and is cited as a best-case scenario for use of a small sample. Power calculations from a range of studies resulted in a very wide range of sample sizes, some running into the hundreds, which would not be feasible for this study.

Data Collection

Personal contact information (name, date of birth, age, email address) were taken at the eligibility questionnaire stage, following consent. Pre- and post-trial outcome measurement data were collected following randomisation. Data collection was in week one, prior to commencement of the intervention, and post-intervention at eight weeks. Blinded mailing lists were compiled for the yoga and Pilates group for communicating the links to the anonymous online data collection surveys hosted on surveyking.com. At baseline this included the SF-36 and NRS pain scale. Post-intervention this included SF-36, pain scale, and qualitative survey. All data was handled according to General Data Protection Regulations (GDPR), stored with password protection, and accessed only by the research team. A data management plan was submitted. Ethical approval was granted by the University of Salford Ethics Committee (Reference number 294) on December 17th, 2020. An amendment that included a Covid-19 contingency protocol was approved February 15th, 2022. This included the option of hybrid delivery that was not implemented due to no restrictions on gathering being in place at the time of the trial. A third amendment for the inclusion of *post hoc* interviews was approved April 14th, 2022. Documents submitted in support of the ethics approval process are included in Appendix V.

Allocation

Eligible participants were electronically randomised using gigacalculator.com (Gigacalculator, n.d.) into either the yoga or Pilates group and contacted by email to inform them of their allocation two weeks prior to the commencement of the trial.

Interventions

The systematic reviews (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b) indicated that best practice included the modification and targeted selection of yoga and

Pilates repertoire for age and chronic conditions. A separate yoga and Pilates intervention for adults over 50 was designed by the researcher, by comparing quantitative and qualitative findings from the systematic review, survey, and other extant literature on the delivery of yoga and Pilates, injury rates, and age-related contraindications. The complete intervention detail and rationale is outlined in the preceding chapter.

The trial and session duration and practice frequency were based on the systematic reviews conducted as part of this research (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b), thereby taking into account available resources and potential attrition. A total of 18 hours practice (at least one of which was a one-hour group class, the balance comprised of self-practice at home) spread over eight weeks was determined to be the optimum delivery, balancing efficacy with feasibility. One 60-minute yoga/Pilates class was delivered in person for eight weeks, and participants were prescribed two shorter pre-recorded video home practice sessions per week. Videos were hosted on streamable.com, an advertisement-free video platform that does not take user data or require login.

Adherence and compliance were assessed by participants and researcher. At the start of the trial, participants were emailed an eight-week practice log and asked to keep a weekly account of sessions completed. The researcher cross-monitored compliance via a register of attendance. The participants’ practice logs were requested and collected by email or in person at the end of the final session in week eight.

Quantitative Outcomes

Pain was measured using a Numerical Rating Scale (NRS). The NRS uses a visual zero-to-ten scale for rating pain, with zero representing no pain and ten representing worst pain imaginable and is considered a valid and reliable tool for measuring pain intensity (Hawker et al., 2011). The NRS has limited validity and reliability when comparing pain in different participants, although this is an inherent limitation in measuring pain, as it is a subjective, self-reported experience and will always be evaluated differently between patients. While the VAS rather than the NRS was the most prevalent for capturing significant results for pain in the studies included in the systematic reviews that preceded this trial, the NRS was chosen due its facility for being administered via an online platform pre-and post-trial. This was a necessary contingency taken in the study design in the case of restrictions on group mixing during the Covid-19 pandemic. Participants were asked to separately assess back, knee, and shoulder pain as these were the most prevalent sites of pre-existing pain and yoga injury reported in the preceding yoga and Pilates participation survey, in agreement with surveys by Wiese et al. (Wiese et al., 2019) and Cartwright et al. (Cartwright et al., 2020). To aid with interpretation of the question, three individual questions on pain asked respondents to rate their "current level" of back, knee, and shoulder pain "in the context of their day-to-day activities", with the instruction to use zero if they had none. Pain in these areas was not a criterium for selection, as the study sought not only to track improvement to existing conditions where present, but also to monitor the development of pain in these areas, to determine the interventions' safety.

Physical Function and Quality of life were measured using the Rand 36 item health survey, SF-36 (Ware and Sherbourne, 1992), which was prevalent in capturing significant effects in several studies (Innes et al., 2020; Küçükçakir, et al., 2023; Notarnicola et al., 2014) in the systematic reviews. In addition another systematic review and meta-analysis of yoga's effect on quality of life using only the SF-36 and SF-12, found that the SF-36 captured significant effects on all 10 measures of the tool (physical function, bodily pain, physical role function, general health, mental health, emotional role function, social function, and vitality) and two summary scores (physical component and mental component) (Benavidez & Hart, 2017).

Although the absence of a performance-based measure of physical function was a limitation, Latham et al. (2008) concluded that self-reported outcomes were comparable to performance-based measures (in clinical trial of hip fracture patients) and recommended taking into consideration the feasibility of the measurement tool (Latham et al., 2008), which was a factor in the decision to use the SF-36 in the present study.

Statistical Analysis

Statistical analysis was performed using PSPP software. The Shapiro-Wilk test was used to assess normal distribution of all data. As normal distribution was not met for all data from the NRS and SF-36, and due to the small sample size, non-parametric tests were used. The Wilcoxon Signed Rank test was used to determine within-group differences, pre- and post-intervention and two-tailed T tests and the Mann Whitney U test were both used to analyse between-group differences at baseline and post-intervention. A P value of <0.05 was considered statistically significant.

Aspects of the SF-36 were reported as individual components. A global or overall score cannot be generated from the questionnaire and although a summary physical component score and mental component score can be reported, all scales contribute in different proportions to the scoring of these, and their correct calculation requires the use of special algorithms, which are strictly controlled by a private company (Lins & Carvalho, 2016).

Two sets of data for each outcome (pre- and post-intervention) were collected. The mean effects of the interventions and the differences between groups for all outcomes and their 95% confidence intervals and P values were calculated. All analyses were conducted on an intention-to-treat basis to prevent drop-outs leading to biased estimates of the interventions' effects.

Qualitative Methods

An open text post-trial survey captured the qualitative data. Themes of the survey questions included enjoyment, perceived benefits and effects, satisfaction with the content, delivery and level of challenge, adverse events (these were also monitored on an on-going basis prior to final data collection), and obstacles to and motivation for practice (including self-practice at home). These themes aligned with the those of the previous survey (Chapter Four) for potential comparison. The survey questions were composed by the researcher based on the aim of exploring these themes. Questions were as follows and all questions were optional:

- *What did you enjoy about the classes?*
- *What didn't you enjoy about the classes?*
- *Are there any physical affects you have observed during the individual classes or over the eight weeks?*
- *Are there any mental affects you have observed during the individual classes or over the eight weeks?*
- *Was the level of the exercises appropriate?*
- *What did you find challenging?*
- *What did you find easy?*
- *Did you experience any injuries during any of the classes?*
- *How was your experience of practising at home?*
- *Did you experience any technical difficulties with the videos, surveys, or communications?*

- *Is there any other feedback you would like to share?*

A survey was chosen over a live or remote focus group based on the hypothesis that anonymised responses could be more candid, and to give each participant the opportunity to address every question uninfluenced by the presence of other participants or the instructor, resulting in a less biased and more even collection of data.

Thematic coding (Braun & Clarke, 2006) was again used to analyse data from the survey for thematic analysis. The data was transposed from the survey into a Microsoft Word (2016) document and read several times. Open coding was used and inductive codes generated by the data. Theory-driven, pre-conceived and deductive codes drawn from the research questions were not used therefore a codebook was not implemented. Yoga and Pilates data were coded separately. Number codes were used, with a short text summary attached to each number, a process completed in Microsoft Word (2016) using the comments function. The initial codes were grouped into categories then modified and similar codes consolidated. Patterns in the coded data were then construed by the researcher and themes identified where data within each code were determined by the researcher to present a compelling point or to help address any research questions. Themes were reviewed by the researcher. In this phase the following questions were addressed (Braun & Clarke, 2012, p.65):

- Is this a theme (it could be just a code)?
- If it is a theme, what is the quality of this theme (does it tell me something useful about the data set and my research question)?
- What are the boundaries of this theme (what does it include and exclude)?
- Are there enough (meaningful) data to support this theme (is the theme thin or thick)?

- Are the data too diverse and wide ranging (does the theme lack coherence)?

At this stage separate subthemes were identified within the yoga and Pilates groups. In the subsequent stage, the data within each theme was analysed to extract vivid items that illustrated the salient points of each theme, and the themes were named. Quotations were pooled from participants, related to the established themes and subthemes. Themes and subthemes were then discussed in a narrative summary with quotations used to illuminate discussion points, adding richness to the findings.

Due to the researcher's involvement in the intervention design and delivery, and the implementation of qualitative analyses in multiple stages of the research, including the survey, the thematic analysis presented in this chapter and of the interviews presented in Chapter Seven, a process of reflexivity was incorporated. The work takes a constructivist position to ontology, wherein reality is viewed as contingent on perception, and an interpretivist position in regard to epistemology, acknowledging the influence of the researcher's interpretation and values. As qualitative methodologies have been used to explore phenomena related to participants' experiences of yoga and Pilates, this position aligns with the understanding that the dual role of teacher-researcher and the involvement of the researcher with the subjects will shape the findings. Reflexivity was used to make transparent the researcher's positionality, power-dynamic with the participants, and context of the research. Gentles et al. (2014) identify a variety of purposes for reflexivity, including neutralising, acknowledging, exploring, and capitalising on it (Gentles et al., 2014). As absolute objectivity was not an appropriate or realistic foundation for the trial presented, the relationships between the researcher and participants have not only been acknowledged, but this subjectivity is framed as an intrinsic and valued asset in the mixed-methods approach, rather than unwelcome and limiting sources of bias.

The process of reflexivity was guided by lmos-Vega et al. (2023) using the definition presented in the AMEE (International Association for Health Professions Education) publication “A Practical Guide to Reflexivity in Qualitative Research: AMEE Guide No. 149” (lmos-Vega et al. 2023). This framework was chosen as it was developed within the context of health professions-related research and provides a comprehensive understanding of reflexivity via an inductive analysis of concepts of reflexivity found in existing literature (Table 6.1), identifying congruences to construct a definition of reflexivity based on a synthesis of these works.

Table 6.1 *Definitions of Reflexivity as Cited in “A Practical Guide to Reflexivity in Qualitative Research: AMEE Guide No. 149” (Imos-Vega et al. 2023)*

Author	Summary Definition of Reflexivity
Walsh, 2003	“That which turns back upon (or takes account of) itself or the person’s self”
Dowling, 2006	“The analytic attention to the researcher’s role in qualitative research. A continuous self-critique and self-appraisal where the researcher explains how his or her own experience has or has not influenced the stages of the research process.”
Gentles et al., 2014	“The generalized practice in which researchers strive to make their influence on the research explicit -to themselves and to their audience.”
Finefter-Rosenbluh, 2017	“A continual internal dialogue and critical self-evaluation of the researcher's positionality (Pillow, 2003), which leaves the researcher changed in its wake (Mauthner and Doucet, 2003).”
Russell and Kelly, 2002	“A process of honouring oneself and others in our work through an awareness of the relational and reflective nature of the task.”
Finlay, 2002	“A thoughtful, conscious self-awareness that encompasses continual evaluation of subjective responses, intersubjective dynamics and the research process itself”
Kuehner et al., 2016	“A strategy of using subjectivity to examine social and psychosocial phenomena, assuming that social discourses are inscribed in and social practices are embodied by the researcher.”
Malterud, 2001	“Attending systematically to the context of knowledge construction, especially to the effect of the researcher at every step of the research process.”

In their analysis, lmos-Vega et al. (2023) define reflexivity as “a set of continuous, collaborative, and multifaceted practices through which researchers self-consciously critique, appraise, and evaluate how their subjectivity and context influence the research processes.” (lmos-Vega et al., 2023, para 4). This definition of reflexivity acknowledges that reflexivity is multifaceted, heterogeneous, and complex, and that reflexive practices should extend beyond personal aspects dimensions of reflexivity. Four dimensions of reflexivity are presented: personal, interpersonal, methodological and contextual (Imos-Vega et a., 2013, Walsh, 2003) and each of these was explored in the present work. Field notes and memos were used in a process of critical self-reflection to document assumptions, decision-making, contexts, and power dynamics throughout all phases of the trial, including the processes of survey and interview question design, recruitment, teaching, interviewing and data coding and reporting. These have been subsequently drawn upon to create a *post hoc* statement of reflexivity, presented in Chapter Eight with the aim of adding transparency and rigour to support the credibility and trustworthiness of the research.

Figure 6.1 *Chart of the Trial Recruitment and Delivery*

Recruitment with flyers. Participants directed to online participant information and link to eligibility questionnaire and consent form.

↓

Interested participants complete online eligibility questionnaire and, if eligible, provide consent and contact details.

↓

Two weeks prior to intervention participants randomised, informed of allocation by email.

↓

One week prior to classes participants sent link to online pre-trial data collection survey.

↓

Weeks 1-8
Participants in each group emailed practice log, invitation to first class, and links to weekly home practice video.

↓

End of Week 8
Participants in each group emailed link to post-trial data collection survey. Once data collected from all participants, each group given access to video content of the other group for optional personal use independent of the trial.

Results

Recruitment of Participants

Participants were recruited from February 16, 2022 until March 4, 2022. Recruitment was closed once 24 participants had been enrolled. Participants were randomised to each group (Yoga *n*=12; Pilates *n*=12). All participants commenced the intervention and all were included in pre- and post-trial analysis.

Flow chart of enrolment process is shown in Figure 6.2. Demographic characteristics of participants are shown in Table 6.2.

Figure 6.2 *Enrolment Flow Chart*

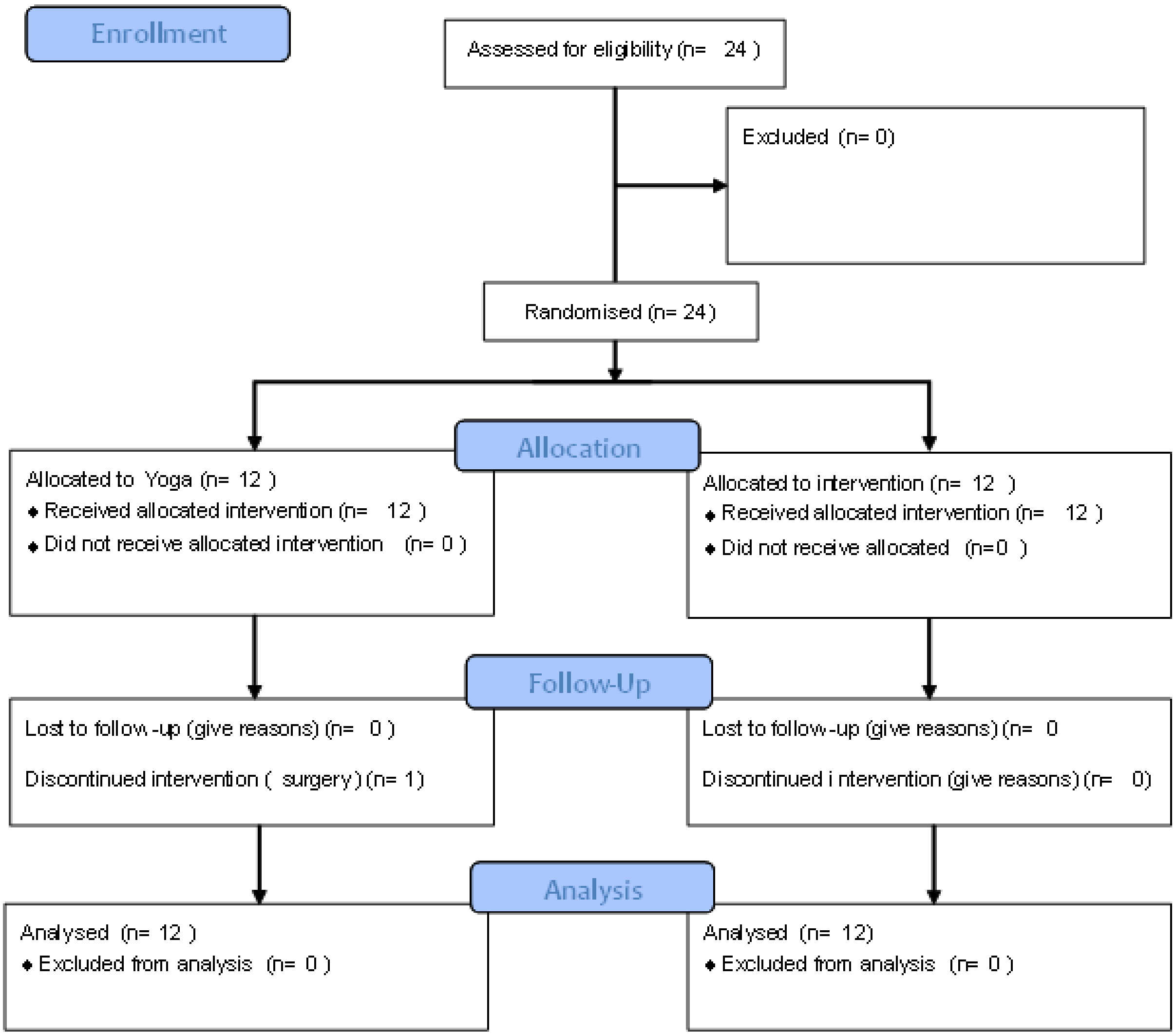


Table 6.2 *Demographic Characteristics of Participants*

Demographic Characteristic	All (*n*=24)	Yoga Group (*n*=12)	Pilates Group, (*n*=12)
Age (years) mean $\pm$ SD	58.33 $\pm$ 7.95	59.75 $\pm$ 6.89	56.91 $\pm$ 8.66
Age (years) range	50.25-76.0	50.67-71.42	50.25-76.0
	n (%)	*n* (%)	*n* (%)
Female	21 (88)	10 (83)	11 (92)
Male	3 (12)	2 (17)	1 (8)
Working full-time	15 (62)	8 (65)	7 (58)
Working part-time	4 (17)	3 (25)	1 (8)
Retired	4 (17)	1 (8)	3 (25)
Not currently working (not retired)	1 (4)	0 (0)	1 (8)

Group intervention sessions were held for one hour per week for eight weeks, yoga from March 9, 2022, until May 4, 2022 and Pilates March 13, 2022 until May 8, 2022. The intervention incorporated a pre-scheduled one-week break to accommodate Easter (due to unavailability of participants and unavailability of the venue).

Attendance, Adherence, and Attrition

Across the eight-week duration of the course, total attendance was 78% for yoga and 80% for Pilates. Nine participants (75%) in each group attended 80% or more of the sessions (a minimum of 6 sessions). All participants were asked to practice at home up to two times per week using a 30-minute home practice video. For each group, one video was provided for the first four weeks, and another for the last four weeks of the intervention. For home video practice recorded in the post-trial self-reported survey data, the yoga cohort completed 38% of the sessions and Pilates 26%. No single participant in either group completed 80% or more of the prescribed home practice sessions. However, five yoga and four Pilates participants completed 50% of the home practice prescription (eight sessions minimum). Overall, six yoga and five Pilates participants found time to practice twice a week, one or more times. The number of participants home-practising 80% of the course duration (six non-consecutive weeks minimum) was eight for yoga and six for Pilates. One yoga and five Pilates participants completed no home practice. Home practice rates were highest in week one and two for yoga, and week one for Pilates. They were lowest in weeks three, four and six for yoga and week four for Pilates. There was no attrition nor any loss to follow-up in either group.

Attendance data was statistically tested for differences between the two groups. Three different data sets were used for each group: Total hours of group practice over eight weeks, total hours of home practice over eight weeks, and the combined total for group and home practice hours over eight weeks. Data was tested for normal distribution using the Shapiro-Wilk test. Data was normally distributed for both yoga and Pilates for group practice and in the yoga group for home practice. For the Pilates group, the home practice data was not normally distributed. Therefore, between-group differences for group practice were measured using a two-tailed T test, but due to the non-normal distribution of the Pilates home practice data, the Mann Whitney U test for non-parametric data was used for home practice and combined group and home practice hours. No statistically significant differences between groups were found (group practice P=0.768, 95% CI -1.32-0.99; home practice P=0.541; combined home and group practice P=0.204).

Baseline Between-Group Differences

The individual pre-intervention scores of the yoga versus Pilates group were assessed for all outcomes using a Mann Whitney U test to establish any statistically significant differences between the two groups at baseline. There was no significant difference between the groups' pre-intervention scores for pain. For quality of life, there was a significant difference between the scores for the Social Functioning and Pain components, for which the Pilates group's scores were overall lower than for the yoga group (*P*=0.03 and *P*=0.01, respectively. (Table 6.3).

Table 6.3 *Statistical Significance of Baseline Score Difference Between Groups*

Outcome (Pain)	*U*-value	*z*-score	*P* value Mann Whitney U test
Back Pain	37.5	-1.962	*P*=0.500
Knee Pain	56.5	- 0.866	*P* =0.384
Shoulder Pain	65.0	-0.375	*P* =0.703
Outcome (SF-36 Component)			*P* value Mann Whitney U test
Physical Function	43.5	1.616	*P* =0.105
Role Limitations Physical Health	42.5	1.675	*P* =0.094
Role Limitations Emotional Health	47.0	1.414	*P* =0.158
Energy/Fatigue	61.5	0.577	*P* =0.561
Emotional Well-being	42.5	1.674	*P* =0.094
Social Functioning	35.0	2.107	***P* =0.034**
Pain	30.5	2.367	***P* =0.017**
General Health	60.5	0.522	*P* =0.522
Health Change	57.0	0.083	*P* =0.400

Bold=Statistically significant *P* value

Pain

In the yoga group, back, knee and shoulder pain were reduced post-intervention but results were not statistically significant. In the Pilates, group back pain was reduced significantly post-intervention (P =0.024) and an effect size of 0.65 was calculated from the

Wilcoxson signed rank test for this metric (z/√N=0.65). If assessing this against the commonly used interpretation of Cohen's d effect sizes as a guide (small *d*=02, medium *d*=0.5, large *d*=0.8) this can be interpreted as a medium effect size (Lakens, 2013). (Table 6.4).

Table 6.4 *Pain Within-Group Differences (calculated using Wilcoxon Signed Rank Test)*

Group / Outcomes	Pre Mean (SD) [Range of scores]	95% CI	Post Mean (SD) [Range of scores]	95% CI	Difference in Means (SD)	95% CI	P value (2 tailed)
YOGA							
Back Pain	1.58 (1.75) [0-5]	0.55, 2.62	1.25 (1.82) [0-5]	0.22, 2.28	-0.33 (0.89)	-0.84, 0.17	0.371
Knee Pain	0.92 (1.31) [0-4]	0.17, 1.66	0.50 (1) [0-3]	-0.07, 1.07	-0.42 (1.08	-1.03, 0.2	0.269
Shoulder Pain	0.51 (0.79) [0-2]	0.06, 0.96	0.01 (0.03) [0-1]	-0.01, 0.02	-0.5 (0.8)	-0.95, -0.05	0.095
PILATES							
Back Pain	3.67 (2.5) [0-7]	2.25, 5.08	2.17 (1.85) [0-5]	1.12, 3.21	-1.5 (1.83)	-2.54, -0.46	**0.024**
Knee Pain	0.58 (1.51) [0-5]	-0.27, 1.43	0.75 (1.76) [0-6]	-0.25, 1.75	0.17 (0.39)	-0.05, 0.39	0.346
Shoulder Pain	1.42 (2.39) [0-5]	0.06, 2.77	0.67 (1.15) [0-3]	0.01, 1.32	-0.75 (1.48)	-1.59, 0.09	0.136

Key to Abbreviations: CI=Confidence intervals; SD=Standard deviation; **Bold**=Statistically significant *P* value

Not all participants experienced back, knee, or shoulder pain at the start of the trial. The distribution of yoga and Pilates participants reporting a zero score for the categories of back, knee, and shoulder pain, both pre- and post-intervention is shown in Figure 6.3. Table 6.5 shows the pre- and post-trial pain scale ratings of each participant in the yoga and Pilates group for back, knee, and shoulder pain. Of the 12 yoga participants, 7 recorded a pain score in any category at baseline. Five of these participants were age 55 or older. Back pain was the most frequently cited type of pain (six participants) and the highest scoring pain rating of 2-5 (out of 10). Of the 12 Pilates participants, 10 recorded a pain score in any category at baseline spread across the entire group age range. Back pain was the most frequently cited type of pain (ten participants) and the highest scoring pain rating of 2-7.

A sub-group scatter plot analysis was completed of the statistically significant back pain improvements of Pilates participants to determine any correlation between hours of Pilates completed and points of improvement on the numerical rating scale. All those reporting back pain at the start of the Pilates intervention (*n*=10) were used in this sample. This analysis did not reveal a discernible correlation between the levels of improvement in back pain and the number of total sessions, group session, or home sessions completed (Figure 6.4, 6.5, 6.6).

Figure 6.3 *Participants with Zero Pain Score for Back, Knee and Shoulder Pain Pre- and Post-Intervention*

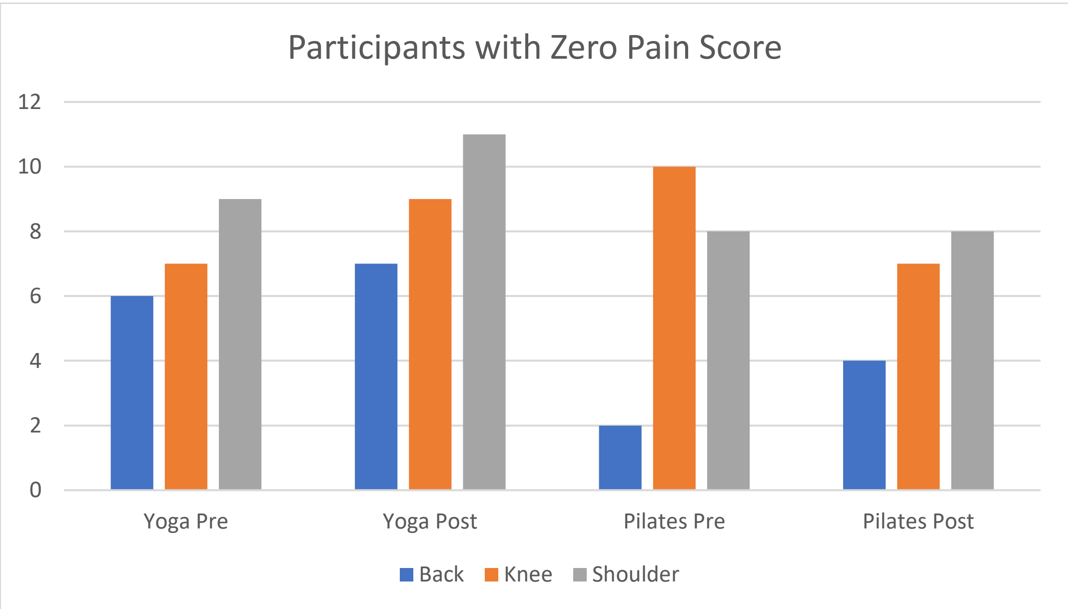


Table 6.5 *Individual and Average* Pain Scores Pre- and Post-Trial*

Age	Back			Knee			Shoulder			No. Weekly Sessions Completed Over 12 weeks		
Yoga Group	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Group (60 min)	Home (30 min)	Total
50	2.0	2.0	0	1.0	0.0	-1	0.0	0.0	0	4	6	10
51	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8	9	17
54	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	8	6	15
55	0.0	0.0	0	4.0	1.0	-3	0.0	0.0	0	4	6	10
55	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6	10	16
57	3.0	3.0	0	0.0	0.0	0	0.0	0.0	0	5	1	6
57	4.0	4.0	0	2.0	2.0	0	1.0	0.0	-1	7	8	15
60	5.0	5.0	0	0.0	0.0	0	0.0	0.0	0	6	9	15
65	0.0	0.0	0	0.0	0.0	0	1.0	0.0	-1	6	5	11
68	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	6	11	17
69	3.0	0.0	-3	2.0	0.0	-2	2.0	0.0	-2	8	0	8
71	2.0	1.0	-1	2.0	3.0	1	2.0	0.0	-2	7	2	9
Avg	**3.1**	**2.5**	**0.66**	**2.2**	**1.2**	**1.0**	**1.5**	**0.0**	**1.5**	**6.3**	**6.1**	**12.4**

Age	Back			Knee			Shoulder			No. Weekly Sessions Completed Over 12 weeks		
Pilates Group	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Group (60 min)	Home (30 min)	Total
50	7.0	5.0	-2	0.0	0.0	0	0	0	0	8	7	15
50	6.0	2.0	-4	0.0	0.0	0	0	0	0	7	6	13
50	2.0	3.0	1	0.0	0.0	0	3	0	-3	8	0	8
50	0.0	0.0	0	0.0	0.0	0	2	1	-1	7	8	15
50	3.0	3.0	0	0.0	0.0	0	0	0	0	8	0	8
50	0.0	0.0	0	0.0	0.0	0	7	3	-4	7	10	17
51	7.0	5.0	-2	0.0	0.0	0	0	0	0	5	1	6
58	3.0	3.0	0	2.0	2.0	0	0	1	1	6	0	6
59	3.0	2.0	-1	0.0	1.0	1	0	0	0	6	8	14
65	5.0	0.0	-5	0.0	0.0	0	5	3	-2	6	0	6
69	6.0	3.0	-3	0.0	0.0	0	0	0	0	4	10	14
76	2.0	0.0	-2	5.0	6.0	1	0	0	0	5	0	5
Avg	**4.4**	**2.6**	**1.8**	**3.5**	**3.0**	**0.66**	**4.2**	**1.6**	**1.8**	**6.4**	**4.1**	**10.6**

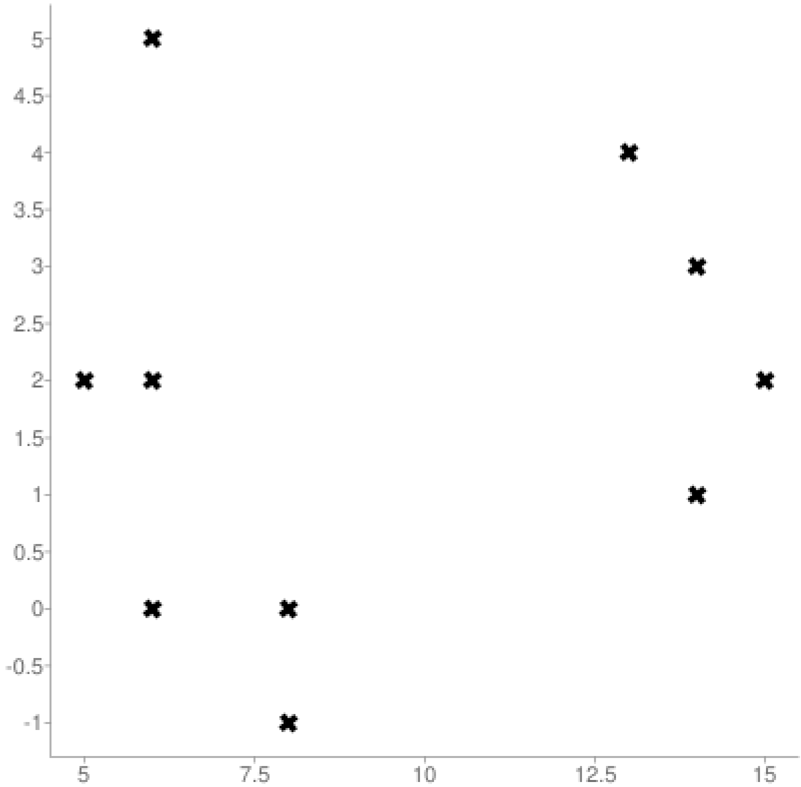
(Key: Participant **Reported pain**; Pain Present; Pain Reduction; Pain Gone; Pain Worsened; Net Improvement; Net Worsening; No Change)

*Averages are for participants reporting pain at outset

Figure 6.4 *Scatter Plot – Total Pilates Sessions Completed and Back Pain Score Point Improvement*

y=Number of points back pain score improved

y=Number of points back pain score improved



x=Total number of home and group Pilates sessions attended over 12 weeks

Figure 6.5 *Scatter Plot – 60-minute Group Pilates Sessions Completed and Back Pain Score Point Improvement*

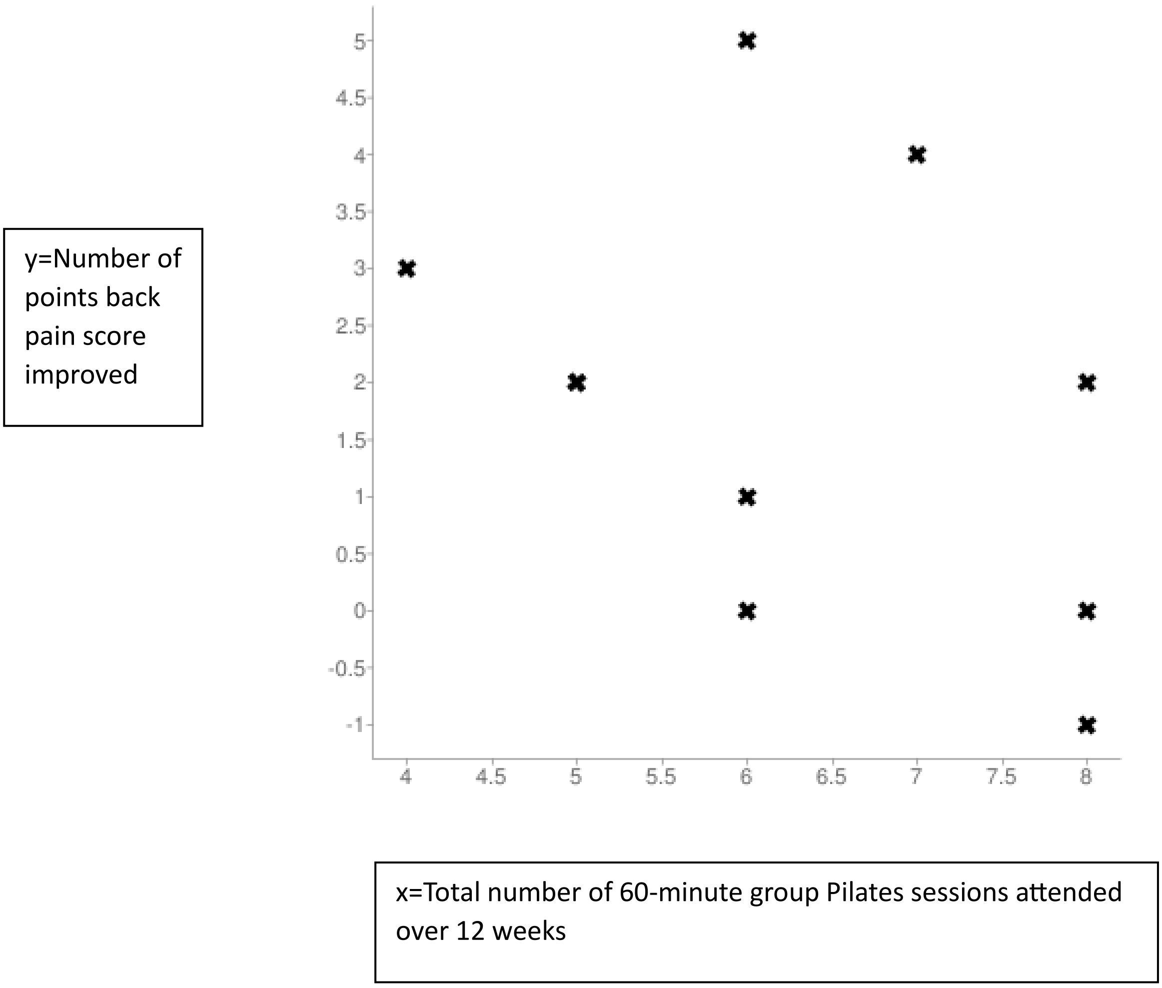
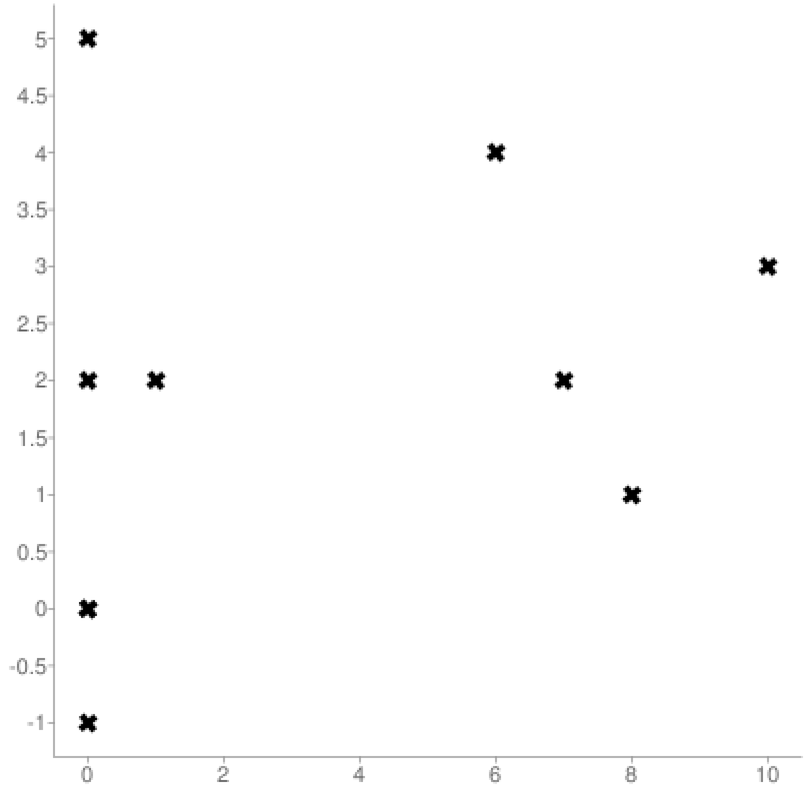


Figure 6.6 *Scatter Plot – 30 minute Home Practice Pilates Sessions Completed and Back Pain Score Point Improvement*

y=Number of points back pain score improved



x=Total number of 30 minute home Pilates sessions attended over 12 weeks

Quality of Life

The SF-36 data was scored using the online Rand 36 score calculator (Rand 36 Score Calculator, n.d.). No statistically significant improvements were found in either group for any of the SF-36 quality of life categories. In the yoga group, the physical function score worsened significantly post-intervention (*P* =0.040). (Table 6.6).

Table 6.6 *Results for Quality of Life (SF-36) Within-Group Differences (calculated using Wilcoxon Signed Rank Test)*

Group **SF-36 Components**	**Pre Mean (SD) [Range of scores]**	**95% CI**	**Post Mean (SD) [Range of scores]**	**95% CI**	**Difference in Means (SD)**	**95% CI**	***P* value (2 tailed)**
YOGA							
Physical Functioning	88.75 (9.08) [75-100]	83.61, 93.89	82.08 (9.16) [70-100]	76.9, 87.27	-6.67 (9.13)	-11.83, -1.5	**0.040**
Role Limitations Physical Health	85.42 (19.82) [50-100]	74.2, 96.63	87.5 (19.94) [50-100]	76.22, 98.78	2.08 (16.71)	-7.37, 11.54	0.766
Role Limitations Emotional Health	77.83 (32.84) [0-100]	59.26, 96.41	63.92 (43.74) [0-100]	39.17, 88.66	-13.92 (55.98)	-45.59, 17.76	0.359
Energy/Fatigue	42.5 (12.15) [25-70]	35.62, 49.38	44.58 (12.33) [25-65]	37.61, 51.56	2.08 (11.17)	-4.24, 8.4	0.499
Emotional Well-being	71.67 (9.87) [60-88]	66.08, 77.25	72.33 (10.71) [60-88]	66.27, 78.4	0.67 (9.32)	-4.6, 5.94	0.675
Social Functioning	95.92 (8.05) [75-100]	91.36,100.47	91.75 (11.06) [75-100]	85.49, 98.01	-4.17 (13.42)	-11.76, 3.42	0.410
Pain	83.58 (14.51) [45-100]	75.38, 91.79	83.17 (8.11) [68-90]	78.58, 87.76	-0.42 (9.87)	-6.0, 5.17	1.000
General Health	65.83 (12.58) [40-85]	58.71, 72.95	68.75 (13.16) [50-100]	61.3, 76.2	2.92 (19.59)	-8.17, 14.0	0.888
Health Change	47.92 (16.71) [25-75]	38.46, 57.37	56.25 (15.54) [25-75]	47.46, 65.04	8.33 (22.19)	-4.22, 20.89	0.240
PILATES							
Physical Functioning	76.67 (19.92) [25-100]	65.39, 87.94	78.33 (14.35) [50-100]	70.21, 86.46	1.67 (10.3)	-4.16, 7.49	0.670
Role Limitations Physical Health	43.75 (50.14) [0-100]	15.38, 72.12	62.5 (34.54) [0-100]	42.96, 82.04	18.75 (42.81)	-5.47, 42.97	0.172
Role Limitations Emotional Health	61.08 (28.00) [33-100]	45.24, 76.93	61 (37.27) [0-100]	39.91, 82.09	-0.08 (31.85)	-18.1, 17.94	0.931
Energy/Fatigue	38.75 (12.27) [25-55]	31.81, 45.69	32.5 (15.88) [10-55]	23.51, 41.49	-6.25 (13.67)	-13.99, 1.49	0.124
Emotional Well-being	62 (12.93) [44-80]	54.68, 69.32	59 (11.71) [44-80]	52.38, 65.62	-3 (14.98)	-11.47, 5.47	0.672
Social Functioning	79.33 (19.43) [63-100]	68.34, 90.32	80.5 (13.47) [63-100]	72.88, 88.12	1.17 (17.94)	-8.99, 11.32	0.632
Pain	65.42 (20.76) [33-90]	53.67, 77.17	68.33 (16.39) [45-90]	59.06, 77.61	2.92 (16.81)	-6.59, 12.43	0.525
General Health	62.5 (19.6) [40-100]	51.41, 73.59	52.92 (17.64) [35-80]	42.94, 62.9	-9.58 (14.99)	-18.07, -1.1	0.065
Health Change	41.67 (19.46) [25-75]	30.65, 52.68	54.17 (20.87) [25-75]	42.36, 65.98	12.5 (22.61)	-0.29, 25.29	0.105

Key to Abbreviations: CI=Confidence intervals; SD=Standard deviation; **Bold**=Statistically significant *p* value **Red**=Negative outcome (condition worsened)

Post-Intervention Group Differences.

To determine differences in the level of change between the yoga and Pilates groups an inter-group comparison of difference in means (the difference between the pre- and post-intervention scores), calculated using a two-tailed T test, was used. A significant difference was only found for the physical function component of the SF-36, which declined significantly in the yoga group and increased (non-significantly) in the Pilates group. (Table 6.7 and Table 6.8).

Table 6.7 *Yoga Versus Pilates* **–** *Between-Group Differences for Pain*

Outcome	Yoga Difference in Means (SD)	Pilates Difference in Means (SD)	Between Group Difference (SE)	*P* value 2 tailed T test
Back Pain	-0.33 (0.89)	-1.5 (1.83)	-1.17 (0.59)	0.059
Knee Pain	-0.42 (1.08)	0.17 (0.39)	0.59 (0.33)	0.089
Shoulder Pain	-0.5 (0.8)	-0.75 (1.48)	-0.25 (0.49)	0.611

Key to Abbreviations: SD=Standard deviation; SE=Standard error **Bold**=Statistically significant *p* value

Table 6.8 *Yoga Versus Pilates* **–** *Between-Group Differences for Quality of Life*

Outcome (SF-36 Component)	Yoga Difference in Means (SD)	Pilates Difference in Means (SD)	Between Group Difference (SE)	*P* value 2 tailed T test
Physical Function	-6.67 (9.13)	1.67 (10.3)	8.34 (3.97)	**0.047**
Role Limitations Physical Health	2.08 (16.71)	18.75 (42.81)	16.79 (13.27)	0.219
Role Limitations Emotional Health	-13.92 (55.98)	-0.08 (31.85)	13.84 (18.60)	0.464
Energy/Fatigue	2.08 (11.17)	-6.25 (13.67)	-8.33 (5.10)	0.116
Emotional Well-being	0.67 (9.32)	-3 (14.98)	-3.670 (5.10)	0.479
Social Functioning	-4.17 (13.42)	1.17 (17.94)	5.87 (6.47)	0.374
Pain	-0.42 (9.87)	2.92 (16.81)	3.34 (5.62)	0.558
General Health	2.92 (19.59)	-9.58 (14.99)	-12.50 (7.12)	0.093
Health Change	8.33 (22.19)	12.5 (22.61)	4.17 (9.14)	0.652

Key to Abbreviations: SD=Standard deviation; SE=Standard error **Bold**=Statistically significant *p* value

For the outcomes that showed statistical significance in the Wilcoxon Signed Rank Test analysis (back pain which improved in the Pilates group, *P* =0.024, and the physical function component on the SF-36 which declined in the yoga group, *P* =0.04), an additional test of *P* values for between-group differences was conducted using the Mann Whitney U test, using the individual difference in mean scores (the difference between the pre- and post-intervention scores) for each group. The between-group difference was not significant (*P* =0.238 Pilates versus yoga for back pain; *P* =0.643 Yoga versus Pilates for Physical function. (Table 6.9).

Table 6.9 *Yoga Versus Pilates* **–** *Within-Group and Between-Group Differences for Back Pain and Physical Function*

Outcome	Yoga Within Group Difference in Means (SD)	*P*=*	Pilates Within Group Difference in Means (SD)	*P* =*	Between Group Difference (SE)	*P* =**
Back Pain	0.33 (0.89)	0.371	-1.5 (1.83)	**0.024**	-1.17 (0.59)	0.238
Physical Function (SF-36 Component)	-6.67 (9.13)	**0.040**	1.67 (10.3)	0.670	8.34 (3.97)	0.064

*Wilcoxson signed rank test (one sample, two tailed)
** Mann Whitney U test (two sample, two tailed)

Adverse Events

Participants were asked to report any adverse events verbally to the instructor during or after the sessions and safety issues and injury were also addressed in the post-trial survey question, “Did you experience any injuries or discomfort during any of the classes?” No adverse events were reported to the instructor after any session. The post-trial survey data identified minor adverse events in both groups in the form of physical discomfort during exercise. One yoga participant mentioned wrist pain if weight bearing on the hands for too long and another mentioned a hernia “popping out” in certain positions. Two Pilates participants mentioned back pain. One noted that this was even present in supine positions (supine with legs raised in a “tabletop position” and when raising the hips and moving through an articulation of the spine into a “bridge” position) with this participant suggesting that one-to-one sessions may have suited them better than the group class. Two Pilates participants mentioned issues when kneeling on hands and knees (shoulder pain; a tingling arm), one of whom also experienced some neck pain when doing abdominal strengthening exercises. Another mentioned the return of shoulder pain due to an old injury. In summary:

One yoga participant – wrist pain

One yoga participant – disturbance of re-existing hernia

Two Pilates participants – back pain

One Pilates participant – shoulder and neck pain

One Pilates participant – pain from previous shoulder injury

Further insight into the level and suitability of the interventions were gleaned from answers to the open text survey questions:

Was the level of exercises appropriate?

What did you find challenging?

What did you find easy?

All yoga and Pilates participants who responded (12 yoga, 8 Pilates) agreed that the level of the exercises was appropriated, with five of the yoga participants citing the usefulness of modifications for the postures and movements. Four yoga participants cited postures involving hip or hamstring flexibility as being difficult to achieve and a further three mentioned that back extensions were challenging. For the Pilates group, three mentioned that they struggled with their balance. Both groups (nine yoga respondents and six Pilates) noted that floor-based or relaxation exercises were among the easiest.

Thematic Analysis of Survey Qualitative Data

The post-trial survey included ten optional, open-ended questions for collecting qualitative information about participants' enjoyment of the intervention, perceived physical and mental benefits, and their experience with practising at home. Reponses were analysed drawing upon Braun and Clarke's framework for thematic analysis (Braun & Clarke, 2006) as outlined in the study methodology. Four themes were identified: Enjoyment, Physical Effects, Mental Effects, and Finding Time for Home Practice. As the themes were extracted from an identical set of open text survey questions for each group, this resulted in the same themes being identified for both the yoga and Pilates groups. Under the umbrella of three of the themes (Enjoyment, Physical Effects, and Mental Effects), subthemes belonging to each group were further identified and discussed to allow for contrast and comparison.

Theme One: Enjoyment

In the yoga group, three subthemes were identified that related to the enjoyment of the classes: Relaxation, Class Level/Pace, and Class Structure. For the Pilates group four subthemes were identified: Fun, Class Structure, Development of Strength and Flexibility, and Degree of Variety/Progression. In the yoga group only, a theme of Personal Limitations was identified that may have negatively impacted enjoyment.

Subtheme One: Relaxation (Yoga Group).

The theme of relaxation and stress reduction emerged clearly from the yoga group, with 8 of the 12 respondents to this question mentioning that they enjoyed the opportunity to relax. This included the enjoyment of a break in a weekly routine or work pattern with participants mentioning "the chance to take a break in my day", "a chance to relax in the middle of the day/week", and "a chance to switch off from my workday". Respondents also mentioned pleasurable social aspects based on friendships within the group. One made reference to "positive energy. Chatting to others!" while another wrote of "combining fitness, relaxation, and seeing my friends".

Subtheme Two: Fun (Pilates Group).

The emphasis in the Pilates group was on the welcoming class atmosphere, with three participants each commenting that the class was "friendly" and "fun". This is in some contrast to the yoga group where the elements of enjoyment were more closely related to individual relaxation and respite.

Subtheme Three: Class Level/Pace (Yoga Group)

Three yoga respondents referred to their enjoyment of the moderate pace, with one commenting that this made the class particularly practical, commenting, "[The] moderate pace also meant there wasn't a lot of time needed to shower afterwards, so it was easy to fit into my day."

Subtheme Four: Class Structure (Yoga Group and Pilates Group)

Three yoga participants referred in various ways to an enjoyment of the class structure, with comments centred on variety and progress, one noting that "the classes offered a lot of variety and each week was a little bit different" and another "feeling a little bit of progress each week". As with the yoga group, four Pilates participants enjoyed the way the course was organised, with an appreciation for variety, clarity of purpose, and progression reflected in comments. One participant commented that the classes were "well- structured and [it was] clear what each exercise is for." Another said, "No two sessions were the same. I like the gradual progressions each week."

Subtheme Five: Development of Strength and Flexibility (Pilates Group)

Three Pilates participants cited either strength or stretching progress as a source of enjoyment. Comments included, “I’ve enjoyed getting stronger” and “It’s been good to stretch out and strengthen muscles” while another referred to “the chance to strengthen and stretch muscles I don’t use in other classes”.

Subtheme Six: Degree of Variety/Progression (Pilates Group)

The level of variety and progression was mentioned as a source of enjoyment by four Pilates participants, although in contrast to the yoga group, two mentioned a lack of variety in the weekly routine or as a function of exercise repetitions, with one mentioning they could have “advanced at a slightly faster pace”.

Subtheme Seven: Personal Limitations (Yoga Group).

Five yoga participants expressed frustration with limitations. In two cases this was due to a specific limitation (glaucoma; knee issue). Others expressed dissatisfaction with their current level of ability in contrast to their younger self, with one commenting, “…I felt old and was reminded of how I can’t do things that I used to be able to do!” and another, “Sometimes it’s frustrating that I am not as agile as I used to be.”

Theme Two: Physical Effects

Subtheme One: Flexibility/Mobility (Yoga Group).

Seven of the ten yoga participants responding to this question reported improvements to their flexibility or mobility which coincided with the yoga intervention. Two participants mentioned shoulder mobility in particular, with one noting an improvement to mobility following a “frozen shoulder” injury, stating, “I’ve recently re-gained movement in my shoulder following years of so-called frozen shoulder problems, and I've been happy to find I've regained and maintained my shoulder mobilities with no re-injury."

Subtheme Two: Pain Reduction (Pilates Group).

Reduction of pain, including back pain (three cases) and shoulder pain (two cases) featured among the Pilates respondents, while effects related to pain were notably not a feature among the yoga group.

Subtheme Three: Postural/Body Awareness (Pilates Group).

Four of the comments from Pilates participants reflected improved awareness of posture and physical movement and the ability to exercise some control in these areas, including feeling more comfortable in the body when exercising and in with daily activities. One commented, "I am more aware of my bad posture and how I am standing." Another gave specific examples, stating, "I feel better and more in control of movement and posture while exercising and in daily activities (sitting at work, housework, getting up and down off the floor)." Others expressed a more general state of ease, with one participating saying that at the end of the intervention, "I felt more comfortable in my body."

Theme Three: Mental Effects

Subtheme one: Relaxation/Stress Reduction (Yoga Group).

Four yoga participants mentioned learning an ability to relax and reduce feelings of stress, with two referring to workplace stress in particular. This theme is an overlapping reiteration of one of the main sources of enjoyment within the yoga group.

Subtheme Two: Well-being and Self-Efficacy (Yoga Group)

Three yoga participants referred to feelings of well-being after the yoga activity, leading to further feelings of self-worth and confidence in some cases. One commented on feeling "a sense of achievement for that day" while mentioned the impact on their work, commenting, "Taking a break, I've felt better able to face work in the afternoon…more confident directly following the sessions each week, feeling I can face challenges."

Subtheme Three: Self-confidence/Self-efficacy (Pilates Group)

Six of the Pilates group also reported feeling a sense of well-being or achievement or both following the Pilates sessions, and similarly to the yoga group these were expressed as feeling of confidence and self-efficacy. Participants mentioned a "sense of accomplishment after attending", a "sense of achievement", and feeling "more focused during and after". Three participants noted an improvement to confidence following a break from exercise. One mentioned "building [my] confidence back up after being a very active person and then being diagnosed with chronic pain". Another "increased confidence returning to exercise after a break" while a third participant "felt good about getting some regular exercise after being very limited due to my neck and shoulder pain".

Theme Four: Finding Time for Home Practice

Participants were asked to comment on their experience of practising at home with the videos that were provided to each group. No technical difficulties associated with pre-recorded video practices were reported. The main obstacle for both groups was time, which was cited by five yoga and three Pilates participants, with family and work commitments mentioned. Four participants from the yoga group also cited discipline and motivation as an obstacle. Nonetheless, there were several reports of positive experiences. One participant from the yoga group commented that "it was convenient and took less time and effort than having to travel" while another linked the ability to practice at home to a period of "working from home". Similarly, four of the Pilates participants enjoyed the home practice element and were able to establish a successful routine (although one practised at home without the use of the video aid). Comments included:

"I managed every week which gave me a sense of accomplishment and I think helped my progress in the weekly course."

"I am fortunate enough to have a little gym area at home for this. I got into a routine with the home videos."

"I did a little bit each week but I just memorise exercises from the classes rather than trying to use video."

"Enjoyed [home practice] as the videos were very similar to the classes so easy to follow."

Neither group experienced any technical or communication issues during the trial.

The findings of the open text portion of the survey are organised in Table 6.10, comprising of the survey questions along with both discrete and overlapping data points identified in participants' responses for the yoga and Pilates groups, with shared data highlighted in colour. Crossover and discrete data are further summarised visually in Table 6.11.

Table 6.10 *Summary of Qualitative Findings*

Question	Number of Respondents	Yoga (times mentioned)	Pilates (times mentioned)	Crossover
What did you enjoy about the classes?	Yoga=12 Pilates=11	Relaxation/Stress Reduction (8) Class level/pace (4) Class structure (3)	Fun/friendly atmosphere(4) Class structure (4) Development of strength and flexibility (3)	Participants in both groups enjoyed the class structure, including variety and progression.
What didn't you enjoy about the classes?	Yoga=9 Pilates=9	Personal limitations (5)	Degree of variety/progression (3)	
Physical effects observed?	Yoga=10 Pilates=5	Improved flexibility/mobility(7)	Pain reduction (5) Postural awareness (3)	
Mental effects observed?	Yoga=7 Pilates=8	Relaxation/Stress reduction (4) Well-being and self-efficacy (3)	Self-confidence and self-efficacy(6)	Participants in both groups reported increased feelings of self-efficacy.
Was the level of exercise appropriate?	Yoga=12 Pilates=8	Yes (12) Modifications and options (5)	Yes (8)	Participants in both groups felt that the level of exercise was appropriate.
What did you find challenging?	Yoga=12 Pilates=10	Hips and Hamstrings (4) Back extensions (3)	Balance (3)	
What did you find easy?	Yoga=12 Pilates=10	Floor-based/relaxation (9)	Floor-based/relaxation (6)	Participants in both groups noted that floor-based exercise and relaxation were easy and achievable.
Injuries or discomfort during classes?	Yoga =12 Pilates=10	No (12)	Shoulder/upper limb (3)	
How was your experience practising at home?	Yoga=11 Pilates=10	Time constraints (5) Discipline and Motivation (4)	Time constraints (3)	Participants in both groups faced time constraints when attempting home practice
Did you experience any technical difficulties with the videos, surveys, or communications?	Yoga=10 Pilates=8	No (10)	No (8)	Neither group experienced any technical or communication issues during the trial.

Table 6.11 *Shared and Discrete Data Points Among Yoga and Pilates Practice Groups*

Shared Concepts
Enjoyed Class Structure
Yoga
Pilates
Developed Flexibility/Mobility
Yoga
Pilates
Developed Self-Efficacy
Yoga
Pilates
Level of Exercise Appropriate
Yoga
Pilates
Found Floor-Based/Relaxation the Easiest
Yoga
Pilates
Home Practice Time Constraints
Yoga
Pilates
No Technical Difficulties
Yoga
Pilates
Yoga
Relaxation/Stress reduction
Enjoyed class level or pace
Did not enjoy personal limitations
Experienced sense of well-being
Enjoyed modifications/options
Hip and hamstring limitations
Challenges in back extension
No injuries sustained
Pilates
Fun/Friendly atmosphere
Enjoyed variety/progression
Pain reduction
Postural awareness
Self confidence
Improved balance
Shoulder/upper limb discomfort

Discussion

The mean age of the trial sample was 58.3 (59.7 yoga, 56.9 Pilates) with a range from 50-73, (yoga 50-71, Pilates 50-76), a demographic close in age and range to the sample previously surveyed (mean age 59.9, range 50-73). The cohort recruited for this study was also predominantly female, both overall and in each group, a trend observed in the survey (77%) and reflected in previous studies of U.K. yoga and Pilates participation (Cartwright, et al., 2020; EMD U.K., 2018; Taylor et al., 2020) as well as in yoga participation studies conducted in the United States (Atkinson & Permuth-Levine, 2009; Birdee et al., 2008; Cramer et al., 2016; Park et al., 2016; Saper et al., 2004; Quilty et al., 2013) and Australia (Cagas et al., 20200; Penman et al., 2012). This may limit the transferability of findings to female populations in these geographical areas. There was some disparity in the employment status, with 57% of the prior survey cohort in work and 43% not working or retired, versus 79% of the trial cohort in employment and 21% not working or retired. Nevertheless, in both studies most of the participants were working adults. From this data it can be concluded that the demographics of the present trial sample and the preceding survey participants are similar when drawing any comparisons in results.

Adherence rates indicate sufficient compliance. In a review of how to define and measure older adults' adherence to exercise classes, Hawley-Hague et al. (2016) identify attendance as an important subset of adherence (Hawley-Hague at al., 2016) and note that general exercise literature defines successful adherence as completion at least of two thirds of an exercise prescription (King et al., 1997; Hawley-Hague et al., 2016). High total attendance (>78%) across the eight-week interventions without attrition indicated the feasibility of an eight-week course format of 60-minute classes, as well as engagement with the yoga and Pilates teaching and content.

Adherence to home practice, as self-reported based on participants' practice logs, was less consistent. Home practice was included to increase the total volume of weekly practice so as to optimise the efficacy of the interventions, as set out in the protocol and indicated by the preceding systematic reviews (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b). Both frequency of practice in general, and home yoga practice in particular, have been associated with positive health outcomes in previous research. Cartwright et al. (2020) found that yoga practice frequency was a stronger predictor than overall years practiced for health outcomes including those related to musculoskeletal conditions and age, such as back, neck, and shoulder pain, arthritis, and menopause symptoms. Hours and number of days of home practice per week were strongly correlated with health impact (Cartwright et al., 2020). Similarly, in the study of yoga for sarcopenia, Pandya (2019) observed that those who self-practised demonstrated better gait, balance, muscular strength and lower falls risk, post-test, with self-practice the strongest predictor of increased scores on the Dynamic Gait Index and Manual Muscle Test (Pandya, 2019). The value of both yoga practice frequency and home practice is also reflected in a U.S. national survey of yoga practitioners that found that frequency of practice predicted subjective well-being and that home practice specifically predicted health better than years of practice or class frequency (Ross et al., 2012). This notion supports the theory that efficacy is in part contingent on the participant's personal investment in the practice of yoga (Horovitz & Elgelid, 2015).

In the present trial, the adherence to home-practice did not meet the prescription. Although only 38% of the yoga group and 26% of the Pilates group completed 80% or more of the total prescribed sessions, and only 50% of yoga and 42% of Pilates participants found time to practise twice a week at least once, 75% of yoga and 50% of Pilates participants did practice at home for at least 80% of the course duration (six or more weeks out of eight). These figures indicate that the two prescribed weekly home sessions were impracticable, rather than the expectation of sustaining a home practice over time. The lower number of Pilates participants practising at home, and the fact that 42% (5 participants) in Pilates (versus 8%, or 1 participant, for yoga) completed no home practice at all, perhaps suggest that yoga is more conducive to self-practice than Pilates, or that yoga practitioners are more confident or willing to practice without an instructor present. Further survey or interview-based qualitative research specifically to compare home Pilates and yoga practice barriers and motivators would be needed to explore this hypothesis.

While the two home sessions were informed by the previous data concerning the relationship between frequency, home practice and efficacy, it is noted that the prescribed home practice component comprised of over 50% of the total practice, which is not representative of real-world practice habits found in survey literature. Cartwright et al. (2020) found that yoga practitioners who were not teachers practised at home 1.62 hours per week versus 2.5 in class, therefore 39% of practice hours were at home (Cartwright et al., 2020). Park et al., (2016) noted that students practised a mean of 245 minutes per week in a yoga studio and a mean of 85 minutes per week at home, home practice representing only 25% of total practice (Park et al., 2016). Similarly, Penman et al., (2016) found that 79.1% of yoga survey respondents did most or all of their practice in a yoga class, rather than at home (Penman et al., 2016).

The findings related to home practice adherence in the present research are not anomalous. Despite benefits cited when adherence is observed, home exercise programme adherence rates in general can be as low as 30% (Beinart et al., 2013) while the World Health Organisation has called for further research into improved adherence to self-management protocols for chronic conditions as a priority (Chaudri, 2004). This view is shared by Cheung et al. (2017), who recommended future studies are undertaken to identify effective strategies for improving home-based exercise for in older adults with knee osteoarthritis (Cheung et al., 2017) and Zacharia et al. (2018), who found that a weekly phone call and email for four weeks following an intervention was insufficient stimulus for the adoption of self-practice in an uncontrolled environment (Zacharia et al., 2018).

The identification of facilitators to home practice of yoga and Pilates has the potential to improve compliance within a trial setting, as well as in the on-going adoption of the practices beyond a controlled intervention. It is known that audio-visual aids, such as the videos used in the current trial, are acceptable and feasible tools for engagement. In a survey of yoga prevalence, patterns and predictors, Cramer et al. (2016) found that the main sources of yoga information used by respondents were DVDs and CDs (36.5%), the Internet (26.9%), and printed media (24.3%) while Cartwright et al. (2020) reported that 20.7% of all practising yoga at home were using online resources or DVDs (Cartwright et al.,2020; Cramer et al., 2016). However, the present research found a need to identify strategies to improve the frequency of home practice using such resources.

Behaviour change has been linked to the presence of capability, opportunity, and motivation, and strategies to address barriers will depend on which obstacles are presented (Michie et al., 2011). In the present trial, the primary barriers were ‘opportunity’ in the form of time constraints, as was found in the yoga and Pilates systematic reviews and other studies (Cox et al., 2021; Denham-Jones et al., 2022a; Denham-Jones et al., 2022b) as well as lack of motivation. One proposal by Ward et al. (2018) for improving home yoga practice compliance is to provide more choice and autonomy in offering a variety in the length and type of visual aids and audio aids so that participants can choose those that suits their needs in terms of time and space constraints (Ward et al., 2018). Past yoga survey participants have mentioned that home practice allowed them to explore how to vary the practice according to their own bodies and needs, which they did not do as much in the studio classes (Cagas et al., 2020a). Similarly, another study notes that the frustration when a group class was not adapted to suit physical limitations became a motivator for practising yoga at home (Cox et al., 2021). This idea of autonomy and agency is supported by broader research into adherence of home physiotherapy exercises, particularly with regard to emphasising choice and making the suggested home exercise segments shorter. The field of behavioural economics has provided evidence that simple strategies to increase adherence include helping patients identify goals and supporting them to co-design their programme (Altinger et al., 2024). This approach might involve the teacher or therapist guiding the participant in a bespoke and selective approach, allowing the individual to choose from a selection of take-home exercises. Scaling down the duration of each session is also advocated (Altinger at al., 2024), and there is other research to support this: A cohort study looking at improving adherence to a home exercise programme for neck and low back pain reported that those with six or more exercises had lower odds of adherence than those with three or fewer (Medina-Mirapeix et al., 2009). Small but regular practices are also known in the field of psychology to have a positive, cumulative effect on well-being (Mochon et al., 2008). Therefore, a choice of sequences and a more graduated approach to home practice than implemented in the present trial might have potential to increase adherence. As past adherence predicts future adherence, duration of each home session can be increased once adherence is established (Altinger et al., 2024).

A more active and ongoing monitoring and feedback process could be implemented, as this absent from the present trial. Using this strategy, discussion of the importance of adherence should focus on the benefits of practice, known as 'gain-framed approach', which is thought to be more effective than a 'loss-framed approach' focusing on the harms of not practising (Altinger et al., 2024).

The lack of adherence to home practice and the associated barriers could also be interpretated as indications of the appeal and importance of group exercise in providing inviting physical spaces and social interaction. Dedicated yoga spaces have been identified as motivators for group classes with elements such as lighting, high ceilings, and fellow participants creating a supportive space that cannot not be captured at home (Cox et al., 2021) and lack of space a barrier to home practice (Cagas et al., 2020a). One qualitative study of group Pilates adherence also reflected this phenomenon: Lorenzo-Villarreal et al. (2024), argued that although the Pilates exercise routines could be executed at home, the spatial design of the studio where the study was conducted and its intimate, familiar environment contributed to Pilates adherence and satisfactory experiences (Lorenzo-Villarreal et al., 2024). Prior research has proposed that in group yoga, everyone moving and breathing at the same time offers participants a sense of belonging (Novotney, 2008), and that middle-aged and older adults attending group classes have benefited from the sense that yoga is an individual practice within a community offering social connection (Patel et al., 2001; Tew et al., 2017; Wertman et al., 2016). Similarly, a qualitative study examining participants' experiences of both group/supervised and home Pilates sessions for multiple sclerosis found that the need for self-discipline and the lack of social interactions presented obstacles to the home-based programme, while social contact was perceived as a valuable component of the group classes (Fleming et al., 2022).

The quantitative results showed that all pain scores on the NRS went down (indicating less pain) with the exception of knee pain the Pilates group which went up, although none of these results had a *P* value of <0.05 to indicate statistical significance, therefore this could be due to random error or chance rather than the intervention. Only one positive statistically significant result was captured, for back pain reduction (*P*=0.024) in the Pilates group. This agrees with the back pain studies (Cruz-Díaz et al., 2015; Donzelli et al.; 2006; Notarnicola et al., 2014) included in the preceding systematic review (Denham-Jones et al., 2020a). It should be noted that the Pilates group differed from the yoga group pre-intervention in back pain at baseline. Of Pilates participants 8 out of 12 (75%) compared with 6 out of 12 (50% for yoga) were experiencing some level of back pain pre-intervention with a score range of 0-7 versus 0-5 for yoga (Figure 1, Table 2). In two components of the SF-36 a statistically significant pre-intervention between-group difference was also found, with the Pilates group scoring lower than the yoga group in the pre-intervention for pain (*P*=0.017) and social functioning (*P*=0.034) (as participants' social functioning may have been impacted by their levels of pain) (Table 5). As participants were randomised into their groups rather than self-selecting, the prevalence of back pain sufferers in the Pilates group should be attributed to chance rather than preference. Although the within-group result captured in the Pilates group may have been influenced by the higher prevalence and level of pain in the make-up of the group at baseline, the degree of change in back pain pre- and post-intervention was not at a statistically significant level in relation to the yoga group in the between-group comparison (Table 8).

There was an absence of any other significant changes in the pain scores for back, knee or shoulder pain at the start of the interventions. These sites of pain were chosen for monitoring due to their prevalence in previous yoga studies (Cartwright et al., 2020; Cramer et al., 2016; Penman et al., 2012; Saper et al., 2004) and the yoga and Pilates participation survey (Chapter Four). It is possible that adherence rates to home practice impacted outcomes. The prescribed level of practice determined for improvements to pain, physical function, and quality of life based on the prior systematic reviews was one hour with two additional home practice sessions of approximately 30 minutes each per week (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b) and due to the sub-optimal levels of home practice, collectively this was not achieved in this trial, potentially diminishing results. Nonetheless, collectively participants finished the intervention with overall lower levels of pain than at the start of the trial. Another aim was to monitor the worsening of pain, as well as the development of pain in these areas in participants who had no pain at the start of the intervention. No significant worsening of pain was recorded and there was no onset of new pain, indicating the safety of the intervention in relation to back, knee, and shoulder health.

In the yoga group the physical function component of the SF-36 score significantly *worsened* (P=0.04) post-intervention, despite no significant changes in the pain scores or other SF-36 components and nothing in the qualitative data to account for this. This unexpected result may simply be a function of a small sample. No serious adverse events were recorded in either group.

The inability to capture significant quality of life results using the SF-36 mirrors the findings of the prior systematic review of yoga (Denham-Jones et al., 2022b) as well a study of the Gentle Years yoga programme for older adults with multimorbidity which found no statistically significant improvements for health-related quality of life (using the EQ-5D-5L), despite the programme having been found safe and acceptable, and valued highly by some participants (Tew et al., 2021). The lack of significant quality of life results in the Pilates group is at odds with the prior systematic review (Denham-Jones, et al., 2022a) which included several studies that found statistically significant results in older populations with chronic musculoskeletal conditions: One chronic low back pain study (Notarnicola et al.,

2014) and two osteoporosis studies (Küçükçakir et al., 2013; Oksuz & Unal, 2017). The reasons for this disparity are unclear, although contrary to the studies in the systematic review, participants in the present study were not recruited on the basis of pain levels or chronic musculoskeletal conditions, so it is possible that they enjoyed a good quality of life and a ceiling effect was in play (Feeny et al., 2013).

Due to the limited reliability of statistical significance using a small sample, to further assess validity of findings, a *post hoc* decision was made to evaluate results in terms of The Minimal Clinically Important Difference (MCID) of outcomes where this metric was available. The MCID provides an estimate of outcome scores that represent the minimum change needed to reflect changes that are meaningful to a participant or patient (Jaeschke & Guyatt, 1989).

The MCDI for the NRS for chronic low back pain has been estimated in past research as 2.5 (Ostelo & de Vet, 2005). The average improvement changes in scores of yoga participants who reported back pain pre-trail was 0.66, including those who saw no change. For yoga participants who saw an improvement, the average change was 2.0 points. Both results indicate no clinically important difference, in agreement with the *P* values which did not show statistical significance. The average improvement change in scores of Pilates participants who reported back pain pre-trail was 1.8, including those who saw worsening or no change. This is at odds with the *P* value for this outcome which did show statistical significance (*P*=0.024, effect size 0.65). However, the average for Pilates participants who saw an improvement, the change was 2.7 points. So, for those whose back pain improved through Pilates the improvement was estimated to be clinically important.

For knee pain on the NRS an estimate of 2 points was used, although the precision of this estimate is limited in relation to the current study as it pertains only to pain from osteoarthritis (Farrar et al., 2001). Average knee pain improvement change for participants who reported knee pain, including those who experienced no change or worsening, was 1 point for yoga participants and 0.66 for Pilates. For yoga participants who experienced improvement, the average change was 2 points, which could cautiously be interpreted as clinically important for those individuals. There were no improvements to knee pain for Pilates participants for comparison.

An estimate of 2 points was used as an estimate for the MCID for shoulder pain on the NRS (Michiner et al., 2011). Average shoulder improvement change for participants who reported shoulder pain pre-trial, including those who experienced no change or worsening, was 1.5 points for yoga participants and 1.8 for Pilates. For those that reported improvement, the average change was 1.5 points for yoga participants and 2.5 for Pilates participants. Again, it could cautiously be interpreted that where pain improved for Pilates participants, it made a clinically important difference. (Individual and average scores are shown in Table 6.5).

A MCID estimate for the SF-36 was not available due to the specificity of population psychometrics in existing research for this outcome measure which were not applicable to the present study. This limited the threshold for measuring impact on quality of life to statistical significance of $P=\leq 0.05$.

The thematic analysis allowed for the organisation of the survey data in a way that allowed for the extraction of overlapping themes and feedback points common to both groups, as well as issues that arose in the groups discretely (Table 6.10, Table 6.11).

Both groups mentioned the class structure as a point of enjoyment, and most participants in each group found the class level to be appropriate, reflecting an element of success in the design of each class and the weekly progression of the interventions over the eight weeks. Floor-based and relaxation exercises were found to be the easiest for both yoga and Pilates. Both groups cited time constraints as the main obstacle to home practice. Neither group experienced any technical difficulties, again signifying the feasibility of administrative communications, delivery, and data collection being executed electronically.

Flexibility and mobility were cited as a physical benefit by both groups, although this was noted more often in the yoga group. Both groups cited forms of self-efficacy as a mental benefit, with a stronger emphasis on this in the Pilates group. This finding is broadly in line with the motivators identified in the preceding survey, which found that improving flexibility was the primary motivator for attending yoga, and strength, which might result in feelings of self-efficacy, was the more prevalent motivator for attending Pilates. Similarly, the experiences that were unique to each practice were also aligned with those that emerged in the prior survey. In agreement with other qualitative data following yoga interventions for older adults (Patel et al., 2011; Tew et al., 2017) a strong theme of stress-reduction ran through the yoga qualitative data, with stress-reduction, relaxation or well-being mentioned 15 times, though this largely absent in the Pilates data. Pilates practitioners, in contrast, made more references to the “fun” and “friendly” aspects of the classes. In the preceding survey, stress reduction was a motivator for 41% of yoga but only 4% of Pilates participants, while conversely social aspects drove 16% of Pilates participation, but only 4% for yoga. This would suggest that the biases towards flexibility and relaxation in the yoga classes and strength in the Pilates classes found in the survey were also inherent in the interventions designed and delivered for this trial. However, it is perhaps unusual that social contact was not emphasised along with the mental health benefits by yoga participants, as this has emerged as a strong theme in other qualitative studies of group yoga interventions for older adults (Patel et al., 2011; Tew et al., 2012) and older adults practising in an uncontrolled real-world setting (Wertman et al., 2016). The reasons for this are unknown, although it is possible that in this sample good social health was already enjoyed, creating a ceiling effect.

In terms of positive references to physical function and its enhancement of daily life and activities, there was perhaps a stronger emphasis on this in the Pilates group. Improved balance, postural awareness and pain reduction were themes unique to this group, and these may have contributed to the aforementioned feelings of self-efficacy, as well as self-confidence, which was cited six times for Pilates participants. This finding reflects the work of Gaskell and Williams (2018) in their qualitative study of the experiences and perceptions of adults with chronic musculoskeletal conditions following a 12-week Pilates exercise programme (Gaskell & Williams, 2018). Conversely some participants in the yoga group spoke of some frustration at physical limitations, despite the age-targeted design and the well-received use of modifications. Movements involving hip, hamstring, and spinal mobility were cited as difficult, which is perhaps unsurprising given that, compared with the Pilates intervention, the yoga intervention required more range of motion in these areas. This is possibly an unavoidable facet of traditional yoga repertoire and, while presenting challenges, increasing mobility in these areas is also what drives people to the practice.

Despite the mentions of discomfort, no yoga participants reported sustaining any injuries during the intervention. This is in contrast to yoga injury rates found in existing research that places yoga injuries between 12% (preceding survey data) and 20.7% in the United Kingdom (Cartwright et al., 2020) and 35.4% (Cramer et al., 2015) and 55% in the United States (Wiese, et al., 2019). This positive outcome is an indication that the yoga intervention used in this study was, on balance, safer and more accessible due to its evidence-based design aimed at minimising risk in the light of common age-related limitations. While only two yoga participants mentioned aspects of discomfort (wrist pain upon weight bearing; movement around an existing hernia) there were five mentions of discomfort in the Pilates group – related to existing back pain, past shoulder injury, and upper body pain or tingling when weight bearing. At the time of writing there is no extant study of Pilates injury rates in order to put this finding into a wider context. The mild discomfort among Pilates participants in this study suggest that one-to-one instruction might be more suitable for some back pain sufferers, as well as careful modifications provided for shoulder issues in four-pointed kneeling positions and potentially more focus on non-weight-bearing shoulder stability and rehabilitation sequences when teaching older populations. Notably no knee injury or discomfort was reported in the survey narrative in either group. No seriously adverse events were recorded, allowing all participants to complete the eight-week courses.

Feasibility was assessed by recruitment, attendance, adherence, attrition, and adverse events. In view of these criteria, both the yoga and Pilates designed for the population of study were considered feasible interventions and the study protocol a feasible method of delivery for testing. The study was able to exceed the target number in enrolment (target per group *n*=10, recruitment per group *n*=12), indicating interest in the activities and willingness to participate without an incentive other than the classes themselves. As noted, attendance and adherence were acceptable, with no drop-outs or loss to follow-up, which may be attributable to the content of the interventions as well as the duration of the study, and is an important factor as it enables intention-to-treat analysis. No technical difficulties were reported in relation to accessing the pre-recorded video home practices, suggesting that this is an acceptable and practical format for these sessions, although contingent on participants having access to computer or mobile devices at home, which was the case with this sample. Adherence to the home practice could be improved by offering more choice within a varied suite of shorter practices. Due to the occurrence of several non-serious adverse events in each group, feasibility of the interventions themselves could be improved through greater encouragement to raise any concerns during the class so that *ad hoc* modifications can be offered.

Strengths

Strengths of the study include the parity between the demographics of the two groups and a lack of attrition allowing for the collection of pre- and post-trial data for all 12 participants in each group for an intention-to-treat analysis. Fidelity to the protocol and intervention delivery was ensured by the use of a single instructor, preventing heterogeneity when evaluating the effectiveness of the exercises, sequence, and progressions. CONSORT guidelines, including the CONSORT extension to randomised pilot and feasibility trials, were followed in reporting of the trial for transparency (Eldridge et al., 2016; Schulz et al., 2020).

Limitations

Limitations include an unblinded study design and the use of self-reported pain, quality of life, and home practice data measures. As a feasibility study, it was beyond the scope of this trial to pilot and standardise the qualitative element of the post-trial survey. Therefore, validity related to the interpretation of the questions to ensure capture of appropriate data, and reliability concerning the reproduction of results under the similar conditions were not established (Boynton & Greenhalgh, 2004). In the thematic analysis, the identified themes were not verified with the participants, *post hoc*. These factors may contribute to bias from a participant or researcher perspective and limit the dependability of findings. Although using variations and modifications was a strength of the intervention in that it ensured exercises remained adaptable and appropriate, this resulted in some heterogeneity in the delivery.

The types of pain measured were specific and limited to back, knee, and shoulder, so results for other types of pain were not identified or quantified. An exploration of MCID could only be undertaken for pain outcomes based on available estimates, so the SF-36 results can only be presented in terms of statistical significance and not MCID. An aim of the study was to monitor the development of new pain as well as to existing pain, but in the absence of pain or musculoskeletal conditions from the recruitment inclusion criteria was a limitation of construct validity using the chosen outcome measures. Previous or current participation in yoga or Pilates or other forms of exercise was not an exclusion criterium, therefore those with prior or current practice may have been less responsive to the interventions.

Confounding factors in participant age, sex, and work status were not analysed, however randomisation was performed to prevent systematic errors from occurring from group assignment and no statistically significant group differences were found in baseline data for outcomes measures pre-interventions. CONSORT 2010 discourages statistical tests of baseline characteristics on the basis that significance tests assess the probability that observed baseline differences could have occurred by chance, but it is already known that any differences in demographic characteristics following randomisation are caused by chance (Schulz et al., 2010; Senn, 1994;). However, additional factors that were not controlled for, but that may have affected results, were previous experience of yoga or Pilates and previous or current participation in other forms of exercise or therapies. Data on these were not gathered, nor were these factors included in exclusion criteria in the interests of recruitment uptake, as well as the impracticality of enforcing non-participation in other forms of physical activity or therapies for the eight weeks of the trial.

The small sample and recruitment strategy may limit the ability to generalise. As the presence of musculoskeletal conditions was not a criterium for participation, results cannot be applied to the wider musculoskeletal population. As with the survey, the sample was self-selected, limited to one geographical area and two types of facility (gym and yoga centre). While the socioeconomic status of the sample can only be inferred, it nonetheless comprised of those already involved in physical activity and of a socio-economic stratum able to afford a computer or mobile device and gym membership or group classes in a metropolitan residential area of Southwest London. Applicability of findings may be limited to this group, representative of active, urban gym-goers over 50. It is known that in the U.K. musculoskeletal conditions are more prevalent in areas of socioeconomic depravation. In 2023, the prevalence of long-term musculoskeletal conditions in the most deprived fifth of society in England was 21% compared to 14% in the least deprived fifth (Versus Arthritis, 2023). More specifically, a study of the prevalence of low back pain and osteoarthritis in England between 2004 and 2019 found continuing socioeconomic inequalities, with the widest gap in low back pain incidence and prevalence over socioeconomic status found in populations in the north of England and in London and in those of working age, peaking at 45–54 years (Yu et al., 2023). Although recruited in London and inclusive of working adults, it is unlikely that the sample used in this study drew from a similar population to those most impacted, and therefore the study could not estimate the effects of the yoga and Pilates interventions on segments of the population who perhaps may have had the most to benefit from them.

Differences between participants and the general population may not have been limited to socio-demographic issues and may have included attitudes towards the trial and interventions involved because of volunteer bias (Brassey et al., 2017), which can present a challenge to the external validity of a research project of this nature (Boughner, 2010). It is not possible to conclusively determine the impact of volunteer bias and the direction of its effect. However, research has shown that study volunteers tend to have higher levels of education, come from higher 'social class' and be more approval motivated (Brassey et al., 2017; Rosnow & Rosenthal, 1976). Therefore, it is inferred that the sample may not have been drawn from the segment of society in which musculoskeletal conditions are known to be more prevalent (Versus Arthritis, 2023), and it is acknowledged participants may have expressed more favourable views of the interventions due to self-selection.

Conclusion

In conclusion, both yoga and Pilates were found to be safe and engaging forms of group exercise for adults over 50 years, particularly females, with good levels of adherence. As participants were randomised to the respective groups, rather than self-selecting as the previous survey participants were, the good level of engagement suggests that the design and delivery of the interventions were accessible and inclusive. The study found evidence of statistically significant results for the improvement of back pain in the Pilates group using a minimum of one hour per week for eight weeks. Recommending one or more home exercise session in addition to group classes proved unrealistic for most participants, and two group classes per week could be recommended in real-world scenarios.

The thematic analysis revealed that yoga and Pilates had several unifying factors in terms of participant experience, but there are distinct and proprietary qualities to each practice that drive preferences and results, with evidence in this study and elsewhere suggesting that yoga restores mobility and engenders overall feelings of well-being and relaxation, while Pilates influences strength and functional movement and contributes to feelings of community and self-confidence. A modified practice eliminated the occurrence of injury in the yoga group, a factor which could increase confidence and uptake in older novice yoga practitioners in real-world settings. More research is needed into contraindications and caution with respect to group Pilates for older adults, to support its reputation as a remedial form of exercise. In combination, the survey and trial underscore the qualitative distinctions between the two practices, one that may contribute to the formation of preferences that drive attendance or equally in informing referrals. This is something that will be explored through in-depth interviews in the subsequent chapter.

Future research areas were identified in relation to home practice motivations and barriers. The evidence base could further be strengthened by research using larger power-tested samples for reliability, with a balanced male to female ratio and potentially conducted in locations outside of the United Kingdom or United States for a more robust understanding of the transferability of findings.

Chapter Seven
Reflexive Thematic Analysis Using In-Depth Interviews of Four Trial Participants

Introduction

Individual interviews of four participants were undertaken with the aim of adding descriptive richness to the qualitative survey data to better understand participants' experiences, views, beliefs, and thought processes (Lambert & Loiselle, 2008), and to understand existing themes and extrapolate new ones in depth (Jamshed, 2014). A reflexive approach to thematic analysis was used to interpret the interviews (Braun & Clarke, 2019). The purpose was to enrich and add greater detail to the data from the pre- and post-trial pain scale, SF-36, and survey in view of some of the limits of a small sample size (*N*=24) by providing depth where breadth is not possible.

Interview data was used in a number of the existing qualitative studies of yoga and Pilates for older adults cited in the introductions to Chapter Four and Chapter Six (Cox et al., 2021; Gaskell & Williams, 2018, Patel et al., 2011) including the implementation of additional interviews of a subset of focus group or survey participants for a more intimate exploration of lived experiences (Sivaramakrishnan et al., 2017; Wertman et al., 2016). For yoga, these include Cox et al. (2021), a study exploring the experiences of middle-aged women through interpretative phenomenological analysis of interviews (*N*=22), Patel et al. (2011) an interview-based grounded-theory exploration of perceptions of a community intervention for older adults (*N*=12), Sivaramakrishnan et al. (2017), exploring perceptions of yoga in practising and non-practising older adults including interviews of a subset of focus group participants (*N*=6), and Wertman et al. (2016), comparing the experiences of middle-aged and older adults through a mixed-methods approach using survey data and interviews with a subset of participants (N=20) (Cox et al., 2021; Patel et al., 2011;

Sivamakrishnan et al., 2017; Wertman et al., 2016). In the field of Pilates, Gaskell and Williams (2018) used focus group data for a qualitative phenomenological analysis of the experiences of adults with chronic musculoskeletal conditions following a twelve-week Pilates intervention (*N*=22) (Gaskell & Williams, 2018). Exit interviews were also used post-intervention in the Tew et al. trial of the Gentle Years adapted yoga programme, although not analysed in depth in the published study (Tew et al., 2017). Findings revealed a range of themes including improved confidence related to physical ability from both yoga and Pilates (Cox et al., 2021; Gaskell & Williams, 2018), social connection (Tew et al., 2017; Wertman et al., 2016) as well as feelings of hesitation around yoga teachings or physical postures (Sivaramakrishnan et al., 2017; Wertman et al., 2016). These works represent a useful backdrop of studies similar to this one in that the population of interest was older adults without ties to a specific pathology, which allowed for later contextualisation and comparison in the discussion of findings.

While the use of anonymous post-trial open text questions allowed for some generation of themes related to participants experiences, this type of data is limited as there is no time or opportunity for explanation, elaboration, or expansion as there is in the two-way conversation. The use of in-depth semi-structured interviews and conversational data gathering techniques following a yoga or Pilates intervention is an under-used strategy and in this study was implemented to provide richer and more complex data as well as more data volume about lived experiences than considered possible with open text survey data. Once again, side-by-side contextualisation and discussion of yoga and Pilates allows for informative comparison and differentiation of themes related to experiences associated with them, which has not been undertaken in previous studies to date.

Aims and Objectives

- To add depth and richness to data taken from a small sample in the randomised comparative feasibility trial (Chapter Six)
- To use data to generate themes related to:
  - the overall thesis questions (as listed in the thesis Introduction and below)
  - the feasibility outcomes of the trial (as listed in Chapter Six and below)
  - the qualitative outcomes of the trial (as listed in Chapter Six and bellow)

Methods

Recruitment

Participants were recruited from the cohort taking part in the trial which ran from March 9, 2022 until May 8, 2022. Recruitment for interviews began in the final week of the trial. The participants were invited by email and in person by the researcher and informed then that interview was optional and voluntarily (Appendix V). Those volunteering to be interviewed were able to choose between an in-person, telephone, or a Zoom interview at their home.

Interview Content

The interviews were intended to be exploratory. A semi-structured method was used, whereby 14 questions were asked to address topics pre-determined by the researcher to add depth to data collected in the post-trial survey of all trial participants and create scope for comparison with a previous survey of real-world yoga and Pilates classes to understand preferences, benefits, motivators, and barriers. The open-ended nature of the questions allowed for unanticipated, interviewee-led topics of conversation to emerge and be explored (Tod, 2010). In designing the interview questions, the original research questions and outcomes of interest to be addressed in this section were identified as follows in order to map questions to research aims:

Overall Thesis Questions

a. What might be the benefits of yoga and Pilates from a musculoskeletal health perspective?

b. Are benefits found in controlled trials experienced in practice?

c. Should/how should we make yoga and or Pilates safer and more accessible to older adults?

d. How can these resources be developed?

Feasibility Outcomes

e. Recruitment

f. Adherence

g. Attrition

h. Adverse events

Qualitative Outcomes

i. Intervention safety/appropriateness

j. Intervention acceptability

k. Intervention enjoyment

l. Capture any impact on pain, physical function, and quality of life not captured by quantitative measures

Additional questions (labelled “context”) were included that did not directly address the original research questions of the thesis or trial but were to establish a profile and background for each participant in order to place the responses within the context of the individual's personal experience. The questions and rationale for each, and the research question or area they aim to address, are shown in Table 7.1.

Table 7.1 *List of Interview Questions with Rationale*

Question	Rationale	Research Question Mapping
1. What were your expectations of yoga/Pilates* in general (*depending on which group assigned to)?	Provide understanding of preconceptions about the protocols and expectations of outcomes	Context
2.How you would describe the differences between yoga and Pilates, based on personal knowledge and/or experiences?	Deepen understanding of participants' expectations of these interventions	Context
3.How would you define "fitness"?	Refine definition in context of this study and gain insight into participants' own notions of this term	Context
4.How would you define "well-being"?	Refine definition in context of this study and gain insight into participants' own notions of this term	Context
5. How is your current level of health?	Opportunity to assess responses and outcomes in context of account current health and changes in health over the lifespan	Context
6. Before you took part in this trial, what has been your experience of physical exercise?	Opportunity to assess responses and outcomes in relation to previous or other current activities undertaken	Context
7. Is there anything you particularly enjoyed about the 8-week course?	Opportunity to assess and analysis participant-teacher relationship and teaching style	a,b,d,f,g,i,j,k, l
8. Were there aspects you struggled with, didn't enjoy?	Opportunity to assess and analyse class levels, teaching style, motivation, barriers, injuries, pain	a,b,d,f,g,I,j,k, k
9. Did you notice any physical or mental benefits you experienced that you think may be associated with taking part?	Opportunity to add depth to SF-36 data on functional fitness, enhancement of physical, social activities, and other aspects of daily living	a,b,f,g,I,l
10. Can you think of any challenges you faced performing the exercises and movements in the classes?	Gain further insight into suitability of exercises, and level of challenge	i,j,l
11. Were they any practical challenges, such as time management, maintaining motivation or regular attendance?	Opportunity to analyse motivation, adherence and attrition	f,g
12. How was your experience practising at home between group classes? Did you manage this?	Opportunity to analyse importance of group classes versus, or in relative to, self-practice	f
13. Do you intend to continue with practising yoga/Pilates following this eight-week course?	To gain insight into motivators/barriers, adherence sustainability, attrition	d,f,j,k
14. Is there anything else you'd like to share?	Opportunity to give participants full agency in the research; reduce bias in ensuring interviewer wasn't 'leading' conversation with selective questioning	All; context

Interview Technique

An interview technique was used that aimed to ensure the balanced participation of both interviewer and interviewee in the process, and to allow the interviewee at times to lead rather than be led. A flexible approach was taken towards wording of questions, as well as an "active listening" mode, with the use of additional questions and comments to explore and clarify topics of conversation that arose (Berg & Lune, 2012; Kvale, 1996). Where appropriate, the researcher repeated what the interviewee had said for confirmation, indicating that they were being heard and to encourage the flow of the conversation (Roulston et al., 2003; Ryan et al., 2009). Participants were not required or pressured to share or discuss anything involuntarily, so at to respect boundaries and observe the ethical obligation to prevent harm in the researcher-participant relationship (Dickson-Swift et al.,2006; Haynes, 2006; Miller et al., 2012).

Ethics Approval

The addition of interviews to the study was approved by the University of Salford Ethics Committee using an amendment form addended to the original application (Reference 294)

Participants were provided with an information sheet about the general natural of questions and themes and how the research would be used (Appendix V). A written form was used to gain informed consent (Appendix V). All data was referenced by the researcher only and anonymised for dissemination. A General Data Protection Regulation (GDPR) checklist was completed and observed to ensure that work was in line with guidance issued by the Information Commissioner's Office (ICO), the Legal and Information Governance team and local School procedures (Appendix V). GDPR is designed to give individuals better control over their personal data and establish one single set of data protection rules across

Europe.   Recordings were transferred to a USB device as MP3 files with a backup on the researcher's University Microsoft OneDrive account, both stored with password protection, with the password known only to the researcher.

Data Analysis

Reflective thematic analysis was used to analyse the data and then identify and report themes across the group (Braun & Clarke, 2019). Reflexive thematic analysis is a theoretically flexible interpretative approach to qualitative data analysis that facilitates the identification and analysis of patterns or themes in a given data set in which the researcher plays an active interpretative role in the generation of knowledge (Braun & Clarke 2019). In a reflexive approach to thematic analysis, themes are not predefined but produced by organising codes around core or central concepts that the researcher interprets from the data (Braun & Clarke 2019). Codes and themes therefore represent the researcher's interpretations of patterns of meaning across the dataset, without the goals of consensus among multiple coders or of reproducibility (Braun and Clarke, 2019). This method was chosen for its flexibility and suitability for a sole researcher (Braun & Clarke, 2014). It is a qualitative method appropriate for the constructivist paradigm of this research, with reflexivity, subjectivity, and creativity seen as assets in the process of knowledge production (Braun & Clarke, 2019).

For accuracy, interviews were recorded (audio only) and transcribed verbatim (Jamshed, 2014). The first step in exploring the responses from interview questions was to review the audio recordings. The researcher became fully immersed, familiar, and actively engaged in the data by first listening to the recorded interviews, then transcribing them, and finally reading the transcripts twice more.

Once familiar with the data, the data was coded. Each transcript was coded separately. During this process, the researcher inductively identified initial codes with which to categorise features of the interviews that were interesting and meaningful. There was no use of theory-driven, pre-determined codes or a code book, so that the codes could be generated by the data itself. Number codes were used, with a short text summary attached to each number. This process was completed in Microsoft Word (2016) using the comments function.

Both semantic and latent codes were used. Semantic codes are explicit and solely descriptive of the content of the data. Latent coding attempts to assign meaning or ideology that may help to interpret the semantic content of the data and involves the researcher in a more interpretative role (Braun & Clarke, 2012). Therefore, the theoretical lens used in the process contains elements of both an experiential or realist approach, concerned with objective elements of reality as well as relativism examining the meaning of the realities expressed in the data (Braun & Clarke, 2006).

Coded data for each participant were then deductively grouped to create Participant Experiential Themes. These included but were not limited to inter-related topics that were reiterated by the participant, creating a pattern determined by the researcher to convey meaning and insight related to the questions.

A deeper review of identified themes followed, to combine, refine, separate or discard initial themes and to ensure that data in each theme was cohesive and themes distinctive from one another. In this phase the following questions were addressed (Braun & Clarke, 2012, p.65):

- Is this a theme (it could be just a code)?

- If it is a theme, what is the quality of this theme (does it tell me something useful about the data set and my research question)?
- What are the boundaries of this theme (what does it include and exclude)?
- Are there enough (meaningful) data to support this theme (is the theme thin or thick)?
- Are the data too diverse and wide ranging (does the theme lack coherence)?

Participant Experiential Themes were then analysed for divergences and convergences to create the final Group Experiential Themes. The review of themes was repeated for the Group Experiential Themes using the steps above.

The themes were further refined through ongoing analysis, with names assigned that captured the essence of each. Quotations were pooled from participants, related to the established themes, and these used in a narrative exposition of the findings. In this analysis, a high proportion of direct quotations were used in order to give participants an authentic voice in the process, free from researcher paraphrase. Ellipses were used to connect related thoughts, with filler words removed from the verbatim text for clarity. The aim was for a synthesis of data rather than to answer each individual question of the interview.

Generation of codes, themes, and their interpretation in the narrative involved subjective judgments made by the researcher. A statement of reflexivity making transparent the researcher's interpretative role follows in Chapter Eight. For practical and time-management reasons, data coding and creation of themes was conducted solely by the researcher and did not involve of a wider team to provide inter-rater reliability and reduce bias. However, Smith & McGannon (2017) propose that reliability of qualitative research can nonetheless be ensured by the use of "critical friends" during the process, in order to encourage reflection by providing questions and feedback concerning data interpretation and themes (Smith & McGannon, 2017). This is not conducted with a view to reaching consensus, but to encourage reflection on alternative interpretations and refinement of themes in order to enhance the rigour of the work (Smith & McGannon, 2017). This process was fulfilled by the input of the research supervisors.

The implementation and reporting of this study followed the COREQ guidelines to meet the criteria for reporting of qualitative research including interviews and used the 32-item checklist to ensure relevant points were accounted for within this thesis (Tong et al., 2007).

Results

A self-selected sample of four participants were recruited for interviews, two yoga participants and two Pilates participants (Table 7.2). Participant names have been changed for anonymity.

Table 7.2 *Characteristics of Interview Participants*

Name	Sex	Age at Interview	Employment Status	Group (yoga/Pilates)	Interview Date	Interview Length	Interview Location (Mode)
Eric	Male	65y 4m	Retired	Yoga	9/5/22	42:22	Participant's home (In-person)
Georgina	Female	70y 3m	Working part-time/freelance	Pilates	10/5/22	36:37	Participant's home (Zoom video call)
Judy	Female	71y 4m	Working full-time	Yoga	12/5/22	21:58	Participant's home (In-person)
Elaine	Female	75y 11m	Working part-time/freelance	Pilates	25/5/22	21:05	Participant's home (In-person)

Participant Profiles

The mean age of the interviewee group was 70.5, 12.2 years higher than the trial cohort as a whole (mean age 58.3), with an age range of 65.4-75.1 years versus 50.2-76.0 for the cohort as a whole. The two yoga interview participants' mean age was 68.2 (64.3 and 71.3) compared with 59.7 for the whole cohort (range 50-7-71.4). The two Pilates interview participants’ mean age was 72.8 (70.2 and 75.9) compared with 56.9 (range 50.2-76.00) for the whole cohort.

Data taken largely from answers to questions 1, 5, and 6 (Table 2) were used to create a background profile of each participant. The four participants had a range of previous experiences with physical exercise, differing positions in terms of self-perceived health status, and various motivations and expectations related to participation in yoga or Pilates.

Eric (Yoga).

Eric had been practising yoga for eight years prior to participating in the trial, having been advised by the NHS to try yoga for angina-related breathing difficulties. His previous experience of exercise included swimming and sailing but he had struggled to find time to exercise regularly due to a busy work schedule in the years when he was employed full-time. At the time of the interview his concurrent physical activities included Nordic walking and breathing exercises, both prescribed to him by the NHS as part of a cardio-rehabilitation programme following heart surgery seven months prior to the start of his participation in the present project. Eric described his health as “good” but “could get much better”, although he felt he had “progressed a lot on the last month”. His motivations and expectations while participating in the trial of yoga targeted for older adults were to “open his chest”, re-gain muscle strength, and develop the confidence to begin attending a general level group yoga class.

Georgina (Pilates).

Georgina described a lifetime of involvement in physical activity, including school sports and dance, adult dance, and group fitness classes, including exercise to music, yoga, Pilates, high intensity interval classes as well as outdoor running. Georgina stated that her health was good, particularly in comparison to less fortunate contemporaries and three siblings who suffered from Parkinson's disease, arthritis, and emphysema. Her perception of Pilates was that it could improve flexibility, strength, and balance.

Helen (Yoga).

Helen began structured physical exercise in mid-life approximately 20 years ago when she took up jogging during a period of long work hours and additional caring responsibilities that depleted her energy. In the past approximately 12 years she had also worked with a personal trainer in a gym setting. Helen also stated that her general health was good in comparison to some of her contemporaries but had declined in the past five years "from pretty much nine out of ten to probably down to about seven". She reflected on the fact that she no longer felt able to complete a ten kilometre race as she had five years ago, and also felt that contracting the Covid-19 virus may have had a negative impact, including possibly causing a mild heart condition. Helen's expectation of yoga was that it would improve flexibility, which she viewed as both more important and more difficult to maintain with age.

Elaine (Pilates).

Elaine's experience of physical activity following sports at school was primarily walking, until the age of approximately 40 when she began running and spent the subsequent 25 or more years a recreational marathon runner, stopping at the age of approximately 65 following a foot operation. She then substituted running with weight training and cycling in the gym. At the time of the trial, she participated in indoor cycling and group exercise classes at a gym. Elaine described her health as "not good" and her fitness levels low, with pain and limited range of motion in both knees. Aside from this she described herself as "quite reasonably healthy" although believed she was not breathing well due to contracting Covid-19 and ageing. Elaine's expectation of Pilates was that it could improve posture, suppleness, and strength including "core strength". Before practising Pilates, she had viewed it as a "soft option" that would not provide her desired experience of working hard during exercise.

Themes

Five key themes were identified and explored using data from the interviews: Definitions of Fitness Changes with Age, Perceptions and Preferences, Wellbeing Beyond Physical Fitness, The Important of Confidence, and Engagement.

Theme One: Definitions of Fitness Change with Age.

When asked how they would define "fitness", there was evidence that participants' expectations of their personal fitness had been modified with age. Some individual components of fitness were cited as muscles strength, stability, and resilience (Eric), aerobic fitness, flexibility, balance, and strength (Helen). However, personal ideas about fitness were less performance-based and more rooted in the functional capacity to manage daily activities, with an awareness of the importance of maintaining functional ability in the face of the ageing process.

Helen:

"As you get older, what you think about in terms of fitness does evolve…fitness is very related to energy levels. It's very related to competence to do things. And it's very related to how well your body is performing."

"I think flexibility's really important, even for everyday life. 'Cause there are lots of things you observe that older people can't do because they lack flexibility. Balance is important because falls are a real threat. It's astonishing how important that is in terms of morbidities for older people."

"And then finally strength. I'm still finding that there is degradation. You know, I can open some bottles and jars but not as many as I used to. Strength for carrying or just performing tasks."

Elaine:

"Personally, well, for me, it's to be able to walk properly. To be able to walk up stairs without getting puffed…Mountain walking when we're in Italy without getting up too early, without having joint issues."

An awareness of declining fitness also impacted expectations and choices related to physical exercise.

Helen:

"It's only five years since I ran a 10K race. I don't think I could do that now."

Elaine:

"For me unfit is getting puffed out and not being able to walk up hills, and it used to be different. It used to be…feeling unfit was not being able to run sort of five miles, you know. That was unfit. But now, you know, 'cause I'm old… I suppose my idea of what fitness is modified as I've got older… simply because I can't do things."

Georgina:

"I've reached the age now where I start thinking about things like Pilates and flexibility and strength and balance because I'm getting older, where I would never have considered it or wanted it or had anything to do with it when I was in my twenties."

"When I was in my thirties, I'd think nothing of doing a class in south west and south west eight, getting on my bicycle and cycling to bloody Arsenal football ground afterwards to do a class up there and sometimes cycle back again. You know. Well, I wouldn't do that now."

Theme Two: Perceptions and Preferences.

The prevailing perception of yoga was that is slower paced and placed a much greater emphasis on flexibility, breathing, and mental or overall well-being than Pilates which was associated with mechanics, strength, and a faster pace.

Eric:

For Eric, Pilates was about *"the mechanics of the body", "the mind is not involved so much"* with the *"breathing left on the side"* and generally faster-paced than yoga.

Helen:

"Pilates is very, very focused on strength and core strength, and maybe flexibility…But I do like very much the emphasis in yoga on focusing on the moment and the way it's described now as mindfulness. I think yoga's probably more focused in that way than Pilates is."

Georgina:

"[Yoga is] very slow. There's nothing wrong with that. It's very meditative. Sometimes. There is a lot of emphasis on relaxation and breathing."

Among three of the four participants (Eric, Georgina and Elaine), strong preferences were expressed for or against yoga or Pilates, and these had been formed based on past experiences outside of the present trial, rather than pre-conceptions based on theory or hearsay. Eric had found Pilates dry and limited, while yoga was described as pretentious, inaccessible, and intimidating by Georgina and Elaine.

Eric:

"I'm not expecting yoga to be therapy. Because the therapy's as much as you make it a therapy, I think, yourself…That's why Pilates bores me to some point…Pilates seems a bit more dry, if you see what I mean."

"I'm going to work on the core. Which is all the vocabulary used, actually, when you think about it…Yoga teachers speak [about] more other things than just the muscles."

Georgina:

"[Pilates is] not as pretentious. I think it [yoga] got a bad press in my head because it came with all the yummy mummies and all the yoga mat paraphernalia and all the matching outfits and all the 'Oh, this person is good' and it's so good for you, and blah, blah, blah. Pilates to me was more accessible as a lay person."

Elaine:

"I was so ashamed that I was like a kind of bent bicycle frame and everybody else was sort of supple and rubbery, and could do things, you know. And I felt more self-conscious not being able to do yoga and I feel less self-conscious not being able to do Pilates."

Differences in breathing techniques between yoga and Pilates were noted by Eric and Georgina based on their past experience of both, and this was a point of consternation.

Eric commented that cues to breathe through the mouth in Pilates were "disconcerting" after being taught to breathe through the nose in yoga, and in his experience felt Pilates instruction provided with less clarity than yoga instruction on the breath.

"And then you feel, why can't this teacher just tell me, because I'm a bit lost here. 'Cause that's what I like in yoga. The fact that there's some sort of constant reminder, how to, where, don't forget to breathe, and you are inhaling when you are doing this. To me that's quite important."

Georgina found this an issue in her experience with both yoga and Pilates.

On yoga: *"I concentrate too much on the breathing, you tie yourself up in knots, you actually don't do what you're supposed to do 'cause you're more concerned about trying to get the breathing right and you can't grasp it, and so you're forever playing catch-up."*

On Pilates: *" I get tied up in knots with the breathing sometimes." "Oh God, am I meant to be breathing in or breathing out?"*

There was also evidence from Georgina and Eric that despite yoga being more strongly associated with mental well-being, this can also be achieved through Pilates or other exercise.

Georgina:

"I've always liked some kind of exercise. Don't matter what it is, run, sport, team, individual…I like it. I use it personally to keep sane."

"I really do use it for mental…I don't know what word to use. Stop me going mad –I could be melancholic."

Eric:

"Many other activities you can have where it's very physical, if you do football or whatever, or tennis. Which, maybe I'm wrong, because when you do all this, mental is going on also. But let's say it's much more open in yoga. That you are actually going for it. Where the others, it's like a sub-product."

Theme Three: Well-being Beyond Physical Fitness.

Participants had various definitions of well-being, indicating that notions of this were largely personal to the individual. Their unifying factor was that they all acknowledged multiple, interdependent elements including physical fitness, mental health, self-care, and personal relationships. Most of the participants (Eric, Helen, and Georgina) emphasised the importance to well-being of both mental and physical health together, while Elaine identified signature aspects of well-being related to social functioning and personal relationships.

Eric:

"It envelopes your mental side, and your physical side."

Helen:

"[Fitness is] a necessary but not sufficient condition because it does help with mental well-being, but mental well-being goes beyond this and is about so many other things in your life. So, I would say fitness is absolutely essential but it's not the whole answer to well-being."

"Well-being means all sorts of things, like being able to deal with what life throws at you, having good relations, relationships, having satisfaction in what you do…enjoying life."

Georgina:

"I think it's the whole package...It's an awareness, and every individual is different, of your body or physicality, your flexibility and your mental state, all together. And I think everybody's access and how they define their own well-being is going to be different."

Elaine:

Elaine spoke of efforts to maintain a healthy and balanced lifestyle in terms of diet, exercise and personal appearance, and work, in order to maintain a sense of self-worth. For Elaine, paradoxically this was somewhat driven by a sense of obligation.

"If I break those kinds of unwritten rules, you know, I feel guilty. I like to live my live so I don't feel too guilty."

Elaine also mentioned that her well-being was affected by the happiness and well-being of her husband and stepdaughter.

"If he's unhappy, I'm really unhappy."

"So, my sense of well-being isn't entirely wrapped up in myself. It is wrapped up in their well-being, as well."

Comments from the yoga participants indicated that the emphasis on relaxation, stress release, and balance as a philosophy, rather than a physical state involving proprioception, helped in navigating challenges in daily living.

Helen acknowledged that both physical and mental benefits in yoga were helpful in daily living. Of the physical strength gained she commented, "I could walk for an hour comfortably, couldn't stand still for ten minutes comfortably, and now I can." She also referred to the feeling of relaxation and the release of stress from her body following a yoga session and expressed that she felt "more in control of things".

Eric found some of the mind-body teachings of yoga to be a transferrable skill for daily living. Speaking about the balance in yoga between "trying not to go too far and actually pushing a bit", he suggested this has a functional application and is "something you can transpose in your life somehow, in other actions you may have…or decisions or way of being. So, it is very interesting."

Theme Four: The Importance of Confidence.

As previous themes have illustrated, participants were mindful of illness or age-related physical decline, although there was an awareness or expectation of how yoga or Pilates might help delay this. While participation improved confidence as function and well-being improved, for all participants levels of confidence and ability also played a role in willingness or reluctance when choosing which activity to participating in, as well as levels of enjoyment and satisfaction.

Eric found taking part in the modified yoga group was a stepping stone to attending a general group yoga class, and to re-build his confidence following surgery. The gentle, self-paced nature of the classes and the fact they were held in a controlled, indoor environment with consistent temperatures was reassuring to him in terms of controlling his breathing.

"I had a lot of fear after the intervention [surgery] that I could get back to – what should I do, how fast should I go, I'm going to hurt myself. If I go to a class, I may just be too willing to copy others and then end up doing too much…So I felt this would target more this condition to help me to go back ultimately to the class."

Speaking of yoga in general comparison to outdoor exercise he commented, *"Walking I could do, except that usually it was windy, it would block my breathing, you know…It's part of the symptoms you have with angina. So, if there's too much wind or if it's too steep. So, with yoga, you see, it's indoors, there's no wind, the heat doesn't go up, you are static… so, you don't get worked up. Your breathing doesn't get worked up. Even though there are limits to it. You know, it can be a bit too much sometimes, but if do it to your own rhythm it's OK."*

Georgina spoke of finding Pilates accessible but linked this to her own confidence in understanding it.

"You can grasp [it], if you were confident enough. If you were unconfident, it might be a different kettle of fish, or if you really didn't know what you were doing and were not comfortable with the fact that you didn't know what you were doing."

This was in contrast to a past experience of yoga, where too steep a learning curve negatively affected her confidence in trying it again.

"The class was packed. He didn't say at the outset 'Is anybody new?'. I was like a meerkat with my head up looking around seeing what was going on, when it was a general class, and he paid no attention to the fact that I was a newbie and hadn't a clue what I was

doing. I was even looking at what people were doing either side of me because I just couldn't follow anything."

Elaine echoed that her perception of yoga and Pilates was influenced by her lack of confidence due to difficulty with balance but was comfortable and satisfied with the largely floor-based modified Pilates programme.

" *I supposed I've felt with yoga…I have real issues, because I can't balance. Some Pilates I've gone to are even more difficult for me than the yoga because there was so much leg work standing up and I can't balance. But the Pilates I do with you, because it's floor-based, I find much more satisfactory…because I was just too embarrassed in yoga, because I was so…it seemed kind of more competitive to me in classes."*

Elaine's comments on the modified Pilates programme suggested that is it possible to increase confidence by ensuring exercises are achievable but to some extent novel or challenging.

"[Pilates has] made me see that strength isn't just lifting huge weights or running enormous distances, it's about…controlling muscles, doing things correctly, and doing things correctly is actually very hard. It's quite a surprise how difficult I'm finding the Pilates…it's not just to do with the fact that I'm unfit at the moment. It is touching parts of my body that I have neglected for years and years and years."

Finally, while **Helen** did not mention confidence explicitly, she also acknowledged the importance to her sense of self of venturing into new activities.

"Each birthday now I try and do something, start something different…'Cause I think as you get older, you can get very set. So, I think you've got to keep developing."

Theme Five: Engagement

Engagement was interpretated as a multi-dimensional phenomenon based on facilitation, motivation, enjoyment, and adherence. Facilitation and enjoyment of the interventions were influenced by the structure and commitment of an organised course, trust in and affinity with the teacher, and the provision of individual attention in the teaching.

Eric:

"I just need to feel I'm in a structure or something I believed would be good."

"I would not go with any teacher. I would not go with anything. I've got to feel yes…it's obvious it's going to be beneficial."

Helen

"I'm really, really enjoying it. And feeling the benefit. And I miss it if there's a week when I don't do it."

"I don't feel a risk of motivation because at the moment I really find it so valuable and enjoyable."

Georgina:

"It's quite nice to see if you can do something. You don't think you can do something." "It's a safe environment to be able to do that, as well."

Elaine:

"You pointed out things that I was doing that I hadn't realized that I was doing…So, I've noticed, I really try and do the things that you tell me." "I knew there was something going wrong, but you've named things that I do, which I find really helpful."

For all participants, the belief that the intervention was having positive effects and a sense of progress were motivators in adherence. All participants indicated that they intended to continue with yoga or Pilates beyond the duration of the eight-week trial.

Discussion

The interviews provided an opportunity for a deeper understanding of four participants' expectations, formation of preferences, and outcomes related to their participation in yoga or Pilates. The interviews unfolded so that these insights pertained not only to the age-targeted interventions of the trial but were also related to previous experiences of these practices.

The mean age of participants was 70.5, higher than the mean age of the total trial cohort which was 58.3. This possibly accounts for the prevalent themes around declining health and fitness and how needs and expectations had been modified and shaped by that. The same theme was also evident in a study of middle-aged women's experiences of yoga, where several participants explicitly compared their abilities to their younger selves, expressing nostalgia and disappointment that they were not as strong or physical able as they used to be (Cox et al., 2021). Three of the participants were experiencing symptoms of chronic conditions – knee pain and arthritis (Elaine) and angina (Eric and Helen). Only in some cases was the intervention credited with improving and managing symptoms. Eric self-reported evidence that the targeted yoga intervention allowed for the return of muscle strength and confidence and that yoga in general allowed for better breathing control in a setting that was felt to be superior and more suitable than outdoor exercise. Elaine commented on improved posture through teaching cues that engendered better postural awareness. However, in relation to her knee pain, the appropriateness of a largely floor-based Pilates programme was based around avoidance of standing and balancing, rather than improvements to the knee condition. None of the participants mentioned pain reduction as a perceived effect of participation, with benefits instead centred around psychosocial themes.

Notably, findings align closely with an interview-based evaluation of older participants' perseverance with a hybrid yoga programme, which identified several of the same themes found in the present study, including confidence in the instructor, a feeling of achievement, social connection, a sense of commitment and structure, an appreciation of yoga's "special properties" of mindfulness and embodiment, and the perception that video instruction was less effective (Haynes et al., 2022). The causal link between liking and trusting the teacher, believing in the intervention, and continuing participation is also reflected in a Pilates study of the relationship between exercise satisfaction and exercise continuity in participant-instructor interaction (Kim, 2022). This found that a relationship of reliability and intimacy between instructor and participants had a significant effect on exercise satisfaction, and that this in turn led to exercise continuity (Kim, 2022).

For yoga participants in particular, the aspects of breath, relaxation, and mindfulness were a key part of the enjoyment and perceived effectiveness of the interventions. This aligns with other qualitative studies which found that relaxation including the meditative aspects of breathing exercises (Sivaramakrishnan et al., 2017) and mindfulness (Cox et al., 2021, Wertman et al., 2016) were enjoyed by yoga participants, and this can result in feelings of stress reduction (Wertman et al., 2016). This finding is also reflected by Gilchrist et al. (2022) in a qualitative study specifically of the importance of mind-body exercise centred around yoga for older adults to prevent falls, whose results showed that relaxation, breathing, and yoga's mind–body connection created a satisfying and enjoyable internal focus on physical sensation and that mindfulness and embodiment enhanced engagement in other physical activities (Gilchrist et al., 2022).

Both interventions gave participants a sense of confidence, achievement or self-efficacy in the light of the decline of previous fitness levels with age, as has been found in previous qualitative analysis of yoga, with Cox et al. (2021) and Sivaramakrishnan et al. (2017) noting an increase in body confidence among older women (Cox et al., 2021; Sivaramakrishnan et al., 2017) and of Pilates participation in those with chronic musculoskeletal conditions (Gaskell & Williams, 2018). Yet there was evidence that this type of satisfaction was only achieved by participation in an intervention that the individual preferred or enjoyed. While some expectations and preferences had arisen from an informed understanding of yoga and Pilates repertoire, most of the motivating beliefs that facilitated adherence were based on experiences gained through participation and not through theoretical information or prescription. For both interventions, motivation to practice was contingent on an atmosphere and setting in which the individual was comfortable, group dynamics, and trust in the student-teacher relationship. This was also found in other qualitative study of perceptions and experiences of yoga among middle-aged and older adults, which suggested that creating a supportive and non-threatening environment was important for effective delivery of yoga to this population (Cox et al., 2021; Sivaramakrishna, 2017). In the present study, avoidance was shaped by past negative experiences with the intervention in which they were not participating in at present, with some particularly resounding reflections on the inaccessibility of yoga in some cases. Aside from the barrier posed by knee pain and balance, facilitators and obstacles centred less around the repertoire of exercises of yoga and Pilates, and more around the differences between their generic qualities, such as pace, breathing cues, and vocabulary. There were also suggestions that these elements combine to contribute to create a certain culture, which is subject to taste. The past yoga experiences Elaine and Georgina with regard to feelings of inadequacy or dislike of the culture or atmosphere of yoga classes have been reflected in previous studies. In a focus group (which comprised of those who had never practiced yoga, those who had practiced for less than a year, and those with more than a year of practice, recruited from a U.S. yoga studio and a workplace), some of those that had started but not continued yoga felt that classes were unsafe or judgmental, while another male participant voiced the pre-conception that yoga was associated with unappealing “alternative lifestyles” (Atkinson & Permuth-Levine, 2009). This was also raised in the qualitative by Patel et al. (2011), who suggested religious belief conflicts deserve consideration in yoga interventions for recruitment and retention of participants, as four participants withdrew from a community-based intervention for older adults before the commencement, due to perceptions that yoga conflicted with their religious beliefs, despite the absence of religious or faith-based elements in the planned intervention (Patel et al., 2011). Similarly, a trial of yoga for arthritis, Middleton et al. (2015) called for greater awareness and acknowledgement that spiritual references and iconography in yoga settings can be a deterrent to practice, particularly when participants come from a diversity of cultures and backgrounds (Middleton et al. 2015). A humanistic, secular approach to yoga is one solution, although where teachers feel this compromises the essence of yoga and negates spiritual aspects that some find beneficial, then transparency should be encouraged and participants able to make an informed choice about participating, considering their cultural beliefs (Middleton et al., 2015). These findings highlight the importance of considering preferences, cultural backgrounds, life journeys, and personalities in exercise referral for uptake, adherence, and benefits to be achieved.

Although no distinct theme was found around participation in the supplementary video practices, the interviews provided an opportunity to establish more detail around barriers to using these. None of the interviewees engaged with the pre-recorded video content – Elaine and Helen reported that they would instead integrate some additional practice into their routine at home and that was self-led. Eric expressed difficulty in watching and following an audiovisual aid while performing the movements at the same time. Georgina described herself as a "people person" who enjoyed the company provided by group classes. This finding is at odds with other studies that noted the feasibility, acceptability, and convenience of online video delivery of yoga (Brosnan et al., 2021; Brinsley et al., 2021; Ward et al., 2021) and feelings of engagement and progress associated with online delivery of Pilates (Taylor et al., 2020). However, in the case of Taylor et al. (2020) and Ward et al. (2021) the intervention was delivered live rather than recorded (Taylor et al., 2020; Ward et al., 2021), which may have been more engaging. In addition, with the exception of Brinsley et al., (2021) these were all studies where online delivery was the only mode available and in-person attendance was not on offer. Literature involving *comparison* between live and online classes does reflect some of the objections to the video practices found in the present study and their deficiency in terms of the virtual rather than actual presence of other students and the instructor. In a study of a hybrid intervention of yoga for fall prevention in adults over 60 years, Haynes et al. (2022) reported that in-person participation was associated with participants' ability to benchmark capabilities against others' and to watch others around them to gauge whether they were correctly interpreting instruction (Haynes et al., 2022). Similarly, in their comparison of satisfaction with online versus in-person yoga, Brinsley et al. (2021) reported that disadvantages of online yoga included problems related to understanding teaching cues, the absence of feedback and modifications, and the lack of a sense of community (Brinsley et al., 2021). These concerns broadly reflect the comments of Eric and Georgina regarding difficulty following video instruction and desiring to be amongst a group of people, respectively.

Further research is needed to determine preferences between in-person delivery, synchronous (live) video delivery or asynchronous (recorded) video delivery of yoga and Pilates generally when offered as a distinct choice. In the present study, the videos were specifically added to facilitate self-practice with the aim of increasing weekly frequency in a manner feasible within the resources and time constraints of the trial. Findings have illuminated barriers in using these that were not stated in the post-trial survey, suggesting there is also scope for comparative research on various home practice instructions options, such as a written study guide, live, interactive online delivery, video or audio recordings, or an absence of guidance entirely with merely encouragement towards participant-led self-guided practice, to determine which is best accepted and most effective.

Study Rigour

In reference to rigour, a standard by which research quality can be measured, Jootun et al., (2009) propose that the concepts of reliability and validity that are normally used to measure quality are inappropriate for qualitative research which is more subjective in nature (Jootun et al., 2009). Sandelowski (1993) proposes that 'trustworthiness' is used as a standard of rigour in qualitative research, whereby practices and decisions are made transparent and traceable (Sandelowski 1993). Several strategies were used to ensure the rigour and trustworthiness of this study. COREQ reporting guidelines (Tong et al., 2007) were followed to ensure the justification and description of each stage of the research, research supervisors provided critical challenge following the coding and theme generation process (Smith & McGannon, 2017), and the reflexive aspects of the research process were made transparent by the statement outlining reflexive practice (Jootun et al., 2009).

Strengths

Two interview participants came forward from each group came forward, creating a balanced cohort from which to data related to the yoga and Pilates interventions. Ethical issues inherent in the methodology were acknowledged by the researcher and mitigated in practice: To minimise bias from the influence of the interviewer, adequate questioning was undertaken with clear, accurate interview schedules and documentation Ryan et al., 2009; Tod, 2010). Although the researcher had also taught the intervention to interviewees, creating the potential for self-censorship amongst participants, this was possibly offset by the prior establishment of ease and familiarity in the student-teacher relationship. This ensured the sense of trust and rapport thought to be important in interview relations and communicated in interviewer's demeanour (Legard et al., 2003; Ryan et al., 2009). Both negative and positive feedback about various aspects of yoga and Pilates arose, suggesting that authentic discussion was achieved. The closeness in age of the participants (three of the four between 70 and 75) provided the opportunity for a 'snapshot' sub-group analysis of participants 65 to 75 years.

Limitations

Only one of the four interviewees was male, but this in line with extant literature on the female-to-male ratio in real-world yoga cohorts (Atkinson & Permuth-Levine, 2009; Birdee et al., 2008; Cagas et al., 2020; Cartwright, et al., 2020; Cramer et al., 2016; EMD U.K., 2018; Park et al., 2016; Penman et al., 2012; Quilty et al., 2013; Saper et al., 2004; Taylor et al., 2020). Participants were self-selecting as it was not feasible for the researcher to identify and select individuals who were outliers or representative in order to explore pre-determined themes. Again, due to self-selection, favourable impressions of the interventions may have been attributable to volunteer bias and the tendency for volunteers to be approval motivated (Brassey et al., 2017; Rosnow & Rosenthal, 1976). Being a qualitative study, sample size was not determined by a power calculation. The sample of four allowed for depth and insight in exploring those cases, but not for data saturation. Achieving saturation, a point at which no new themes are observed, was not a component of this study for reasons of feasibility as well as for theoretical reasons around the concept of saturation in qualitative research. The purpose of the interviews was to add depth to the research, and to aid protocol development and delivery by exploring the background and experiences of a small cross section of participants. The frequency of specific opinions was not a primary concern. Saturation has been described as a judgement, or a prediction about the unobserved based on the observed (Saunders et al., 2018). As such, the ability for a researcher to identify a point of saturation and conclude that no new themes will be discovered has been questioned (Saunders et al., 2018). In some research projects, continued sampling has been used to provide evidence of saturation (Saunders et al., 2018) which in the case of the present study was not practicable as interviewees volunteered from an already small sample. Saturation neither defines nor invalidates the quality of the research and since it was not used in the present study rigour was sought, as recommended, through justification of data collection methodology and reporting of limitations (O'Reilly & Parker, 2013).

As the mean age of the interviewees was substantially higher than that of the trial cohort, this limited generalisation on issues related to yoga and Pilates for adults over 50 years, as those aged between 65 and 75 may have different needs and limitations from those at the younger end of the middle-age spectrum included in the broader study. Due to the absence of musculoskeletal conditions among the interviews an assessment of the impact on these was not possible from the interview data.

Interview transcripts were not returned to participants for verification and participants did not play a role in confirmation of themes.

Conclusion

The views of the interviewees provided depth and detail related to reasons for adherence, examples of the safety and acceptability of the interventions, and feedback related to their future delivery. Older yoga and Pilates participants demonstrated a strong awareness of age-related fitness declines which affirmed the need for face-to-face, targeted, slower-paced, and floor-based classes and the continuation of research into best practices related to their delivery. Yoga and Pilates served similar purposes in creating a sense of self-efficacy and these benefits were broadly comparable. Differences were observed in the teaching and delivery of yoga and Pilates, and participants held strong preconceptions and preferences that shaped participation. Adherence was largely rooted in trust and enjoyment of the participant-teacher relationship and a sense of benefit and progress gained from experienced rather than from prescription based on hypothetical outcomes. To ensure sufficient engagement at the outset and to prevent attrition or avoidance, these elements in each activity should be instilled through clarity and simplicity in breathing cues, potentially maintaining an element of mindfulness in Pilates to enrich the experience, and provision of a yoga environment inclusive to older learners, with sensitivity and transparency about any teaching of “spiritual” elements.

General health and well-being benefits featured more prominently in participant feedback than specific musculoskeletal improvements or the reduction of pain. Participants expressed ideas that multi-faceted well-being gained from exercise including yoga and

Pilates was important in coping with day-to-day activities. This would suggest that along with the physical attributes of exercise such as aerobic fitness, strength, flexibility, and balance, mental health components such as self-efficacy and confidence play an essential role in functional fitness and should be considered an integral rather than separate or less important component in future research.

Chapter Eight
Statement of Reflexivity

The following statement of reflexivity is guided by the AMEE (International Association for Health Professions Education) publication "A Practical Guide to Reflexivity in Qualitative Research: AMEE Guide No. 149" (Imos-Vega et al., 2023), as detailed in Chapter Six. The aim of this statement is to maintain transparency and rigour and to support the credibility and trustworthiness of the preceding research.

Personal Reflexivity

At the time of the trial, I had been a practitioner of yoga for 36 years and Pilates for 15 years, and a teacher of yoga for 21 years and of Pilates for 13 years. I had been physically active throughout my life, participating in dance, running, and group exercise. I was also beginning this research as an adult in my fifties. My personal perception at this time was that I had benefited from yoga and Pilates in terms of maintaining mobility and strength and minimising injury and pain, enabling physical activity, both in regard to the self-contained practices of yoga and Pilates themselves (including the ability to continue teaching and earn an income), but also in respect to other forms of exercise, such as dance and running. As a practitioner, this led to a conscious favourable perception of yoga and Pilates as tools for functional fitness and wellbeing throughout the lifespan up to middle-age. However, in my career as a teacher I had encountered students who had expressed a strong dislike for either yoga and Pilates, sometimes based on pre-conception and sometimes experience, as well as students who enjoyed either or both practices, but found some aspects of the repertoire difficult to practice due to physical limitations, injury, illness.

This positionality had a positive impact on the trial design in that research aims arose from several decades of experience, although caveated by the acknowledgment that it is only the experience of one teacher and a finite number of students. The contribution of this positionality included:

- The goal of designing adaptable, evidence-based protocols that could be scaled for various abilities and needs of older adults for successful delivery of and participation in group class settings.
- The post-trial questions regarding what was and was not enjoyed by those in each randomised group to gain more insight into why some individuals dislike practices that I perceive as beneficial and would prescribe, yet conversely cannot be beneficial if not enjoyed or adhered to by others, and whether this can be changed.
- The post-trial questions on appropriate levels and injury to determine whether accessibility and safety had been achieved, a question which upon reflection was posed both for best practice and to aid in the flow, effectiveness, and ease of teaching from my perspective.

As questions were created based on what I wanted to know, an open text box for “any other feedback” was included so that participants could also include their own reflections, in an effort to reduce bias in the power-dynamic, giving participants a greater hand in data generation. It is acknowledged that an imbalance in the co-creation of data inevitably remains. The questions were purposely designed to extract specific themes and there was only one opportunity for open text expression, meaning that this data generation remained researcher led. Again, this is not presented in a negative light as the purpose of this was to keep the research on topic.

The individual interviews expanded on the post-trial survey to include questions on expectations, definitions of fitness and wellbeing, current levels of health, past levels of exercise, and time management, to view experiences through the lens of participants whose perspectives of these differed from my own. It is acknowledged that in authoring the questions, I was to partially authoring the data, and therefore participants were asked if there was anything further they wished to add in order to reduce bias. It is nonetheless acknowledged that the resulting themes were constructed by my own interpretation (Varpio et al., 2017). Therefore, to clarify the origins of the themes and evenly weight the voice of the researcher and interviews, a balance of participant quotes (direct speech) and discussion (indirect speech) was utilised in this section. The use of participant quotations to elucidate themes is recommended as a criterium for reporting qualitative research as a means of reducing bias (Tong et al., 2007).

Interpersonal Reflexivity

It is acknowledged that data is a product of the power dynamic and relationships of researcher and participants (Finlay, 2002). Three of the Pilates participants (including one of the interviewees) had previously been taught by me prior to the trial (one in yoga classes, the other two in Pilates), as had two of the yoga participants (one in prior Pilates classes, the other two in yoga classes). As teacher, I was mindful to avoid favouring any group, participant or interviewee with special treatment, time or attention based on mutual prior relationships or acquaintance. In terms of interpreting their data, this was mitigated from my perspective as researcher as pre- and post- trial data gathering was anonymised. However, for participants, an element of acquaintance and trust was at play that may have led to confirmation bias in their perceptions of their course in the trial, as well as potentially wanting to be seen favourably in their responses to questions and completion of self-practice diaries. This potentially influenced the data itself and is acknowledged in the interests of transparency.

Methodological Reflexivity

This research adopted a constructivist-interpretivist paradigm. In doing so, the present work takes the position that in studying human participants and in utilising a mixed-methods approach incorporating qualitative research, science is understood to be a social process, during which the researcher will make nuanced judgments. Malterud (2001) differentiates between preconceptions and bias and the researcher's perspectives (Malterud, 2001). The researcher's perceptions and experiences aided in the co-construction of data with participants with a heterogenous pool of differing experiences, leading to the richness of data. Subjectivity is therefore embraced and made transparent, rather than being presented entirely as a limitation.

Contextual Reflexivity

Yoga and Pilates are heterogeneous practises. An aspect of this research involved reflecting on their definitions in the context of my own teaching. These were limited to somatic practises in which I was trained and delivered in conventional urban gym and group exercise settings, the venues from which participants were recruited. The findings therefore inform the delivery of yoga and Pilates in this specific context. Critical self-reflection on this point led to identifying the limitation that a different geographical and socioeconomic context may have led to different data and an acknowledgement that despite credibility internally, the findings of qualitative research of this nature are not necessarily transferrable.

Chapter Nine
Triangulation, Contextualisation, and Conclusion

For each phase of this research the rationale, findings, strengths, and limitations have been presented in the preceding chapters. In this chapter, an overarching discussion is presented, followed by a summary of overall strengths and limitations, and applications of findings in practice, and recommendations for future research.

A triangulation of the findings from each methodology utilised in the preceding stages of research was conducted to extract and highlight key themes with which to address the initial research questions, explore related areas of interest that emerged, and to inform final conclusions and recommendations. Findings are considered against the backdrop of existing literature to place them in context within current evidence and guidelines.

Van Maanen (1979) and Jick (1979) were among the first organisational researchers to explore the concept that qualitative and quantitative methods need not be mutually exclusive, advocating a combination of multiple methods to 'triangulate' findings for theory development and enhancement, providing a more comprehensive account of a phenomenon than either methodology could achieve on its own (Jick, 1979; Van Naanen, 1979). Triangulation enhances a study's trustworthiness and validity (Noble & Heale, 2019). The use of information from a variety of sources tests for inconsistencies as well as convergences, strengthening reliability and providing a comprehensive, qualitative understanding of the phenomenon for a balanced reasoning and discussion (Patton, 1999). Denzin (1970) identified four types of triangulation: Data triangulation, which includes various periods of time, spaces, or people; investigator triangulation, employing more than one researcher in a study; theory triangulation, which utilises several theories in data and phenomena interpretation; methodological triangulation, which includes several data collection methods, for example observation and interviews (Denzin, 1970, p.301). The present research makes use of a methodological triangulation.

Noble and Heale (2019) identified some specific characteristics of triangulation that further support its appropriateness to this particular study: Triangulation can be used to explore and explain complex human behaviour using various methods to offer a more balanced explanation; it is a procedure that can be used in both quantitative and qualitative (and therefore mixed-method) studies; triangulation enriches research in providing a variety of datasets to explain differing aspects of a phenomenon of interest, and it can be used to help interpret results (Noble & Heale, 2019). It is therefore a useful tool for analysing non-pharmacological interventions and human participants, as in the case of assessing yoga and Pilates, taking into account the complexities of participants' experiences, as well as providing a pathway to the discussion of the reasons for, and implications of, the findings.

One criticism of triangulation is that it implies that there can be a single definitive account of the social world (Bryman, 2004). However, this research takes a constructivist/interpretivist approach which counters this criticism but recognises a different limitation in that when combining research methodologies, triangulation cannot be achieved in a uniform manner (Nobel & Heale, 2019), and the subjective interpretations of the researcher are acknowledged .

Figure 9.1. provides a broad illustration of the relationship between the project components.

Table 9.1 Illustrates the ways in which each section in this research informed the next and its contribution to the field.

Figure 9. 1 *Project Components*

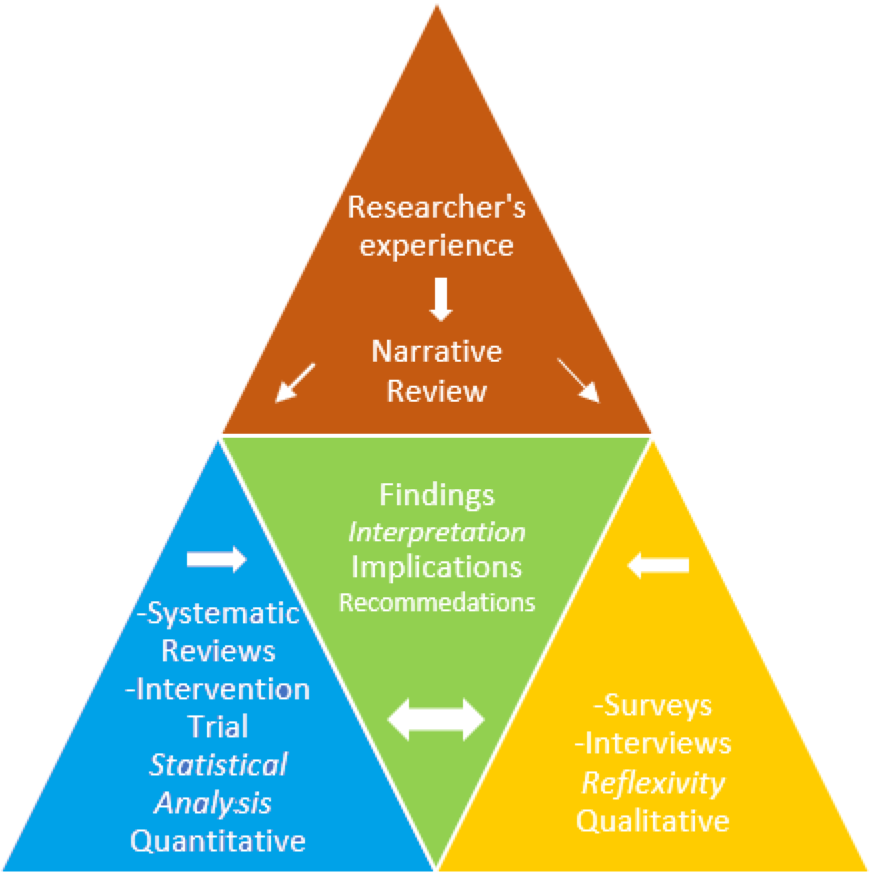


Table 9.1 *Connections Between Sections, Findings, and Contribution to the Field*

Section/Key Findings	**How Key Findings Informed the Subsequent Phase**	**Contribution to Knowledge/Dissemination**
Narrative Review -Working population ageing - MSK conditions affect ability to work - Yoga/Pilates may benefit pain & strength	-Study middle-age population rather than elderly -Conduct two systematic reviews on a variety of MSK conditions, reflecting naturalistic setting/real class -Use SR outcomes Pain and Physical Function as yoga/Pilates recommended for these in public health guidelines -Use SR outcome QOL (to ensure improvements carry over to daily living	Established research gaps: -Fewer studies on "middle age" than "elderly" -Many studies of specific pathologies, but less research needed into real-world scenario involving a mix of MSK conditions -Little research comparing yoga with Pilates
Systematic Reviews: -Yoga and Pilates effects for pain and function for MSK -Yoga trial interventions custom designed for MSK -Yoga and Pilates non-superior to other exercise - No QOL effects for yoga	- Survey to establish how well real world classes suit those with age-related MSK -Include questions to establish why people practice yoga & Pilates -Established potential need for more qualitative/mixed-methods -Effective studies in SR influenced choice of outcome measures for trial (NRS, SF-36)	-No previous reviews of yoga and Pilates for range of age-related conditions associated with onset middle-age -Research was disseminated by through conferences and publication for use by other researchers and clinical practitioners -Both published in Musculoskeletal Journal (2021) -Presented as poster at BASES student conference and SPARC (2021)
Survey -Yoga more popular -Yoga higher injury rate -Participants not primarily motivated by MSK conditions	-Established potential areas of improvement for safer and inclusive interventions -SR interventions found in effective studies combined with survey qualitative data and yoga/Pilates injury literature to design age-targeted yoga and Pilates interventions to test in trial -SR and Survey data used to establish practice duration and frequency and trial duration for balance between effectiveness and acceptability -Monitor common sites of pain rather than specific MSK conditions	-Creation of yoga & Pilates participation survey instrument as none existed with potential for further testing and standardisation
Trial + Interviews -Protocols safe and acceptable -Pilates protocol effective for backpain -Qualitative insights into appeal of each practice >70% female participants	Areas of Future Research: At what age are modifications needed? Do older adults even want special classes? Pilates research - Participation survey - Gender and participation - Contraindications	-Fully documented and reported novel interventions created for appropriateness, acceptability and feasibility of delivery -Knowledge of comparative effects of yoga and Pilates in age-targeted class series -Knowledge of views, motivators and barriers amongst over 50s regarding yoga or Pilates -Critique of best study designs for non-pharmacological "subjective" interventions

Discussion and Contextualisation of Key Findings

This research compared the effects of yoga and Pilates for adults over 50 years, focusing on pain, physical function, and quality of life using a mixed-methods approach. The exploration of the contraindications, physical activity guidelines, and participant history and experience inform best practices in yoga and Pilates design, delivery, and referral.

Summary

The narrative literature review highlighted a prevalence of studies of yoga and Pilates in relation to specific pathologies, and studies of the elderly, frail population, both with age-related conditions and healthy. Having established the growth of the ageing working population (Department for Work and Pensions, 2023; Harper et al., 2016), health-related absenteeism and early retirement (Centre for Ageing Better, 2020; Office for National Statistics, 2021), and the recommended use of yoga and Pilates for age-related conditions (Department of Health and Social Care, 2019; NHS, 2020; Royal Berkshire NHS Foundation Trust, 2022), two systematic reviews were undertaken, examining yoga and Pilates for populations with variety of musculoskeletal conditions. The reviews were novel, covering a range of conditions such as a teacher might encounter in a naturalist setting. A separate review of both yoga and Pilates allowed for assessment of their respective strengths as therapeutic forms of physical activity for older adults, who may have age-related musculoskeletal conditions. Pain and physical function were selected as outcomes as yoga and Pilates are broadly recommended for these in public health guidelines (Department of Health and Social Care, 2019; NHS, 2020; Royal Berkshire NHS Foundation Trust, 2022) and quality of life was included to assess whether improvements carried over to daily living. The reviews (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b) found that yoga showed statistically significant effects for improving osteoarthritis pain and neck pain and Pilates was effective for back, neck, osteoarthritis pain, and secondary osteoporosis pain, while improving physical function and quality of life for back pain and osteoporosis patients. However, the yoga interventions were carefully designed and delivered to address specific populations in most cases. There was also no evidence that either yoga or Pilates were superior to other exercise comparators. Further, there were no improvements to quality of life found in the yoga studies, although quality of life improvement was found for Pilates, and despite yoga having been identified as a popular (EMD U.K., 2018) and NHS-endorsed activity for pain relief in the initial literature review (NHS, 2020; Royal Berkshire NHS Foundation Trust, 2022). Of note, the lack of quality of life findings for yoga was found in three other systematic reviews in the evidence base, two of back pain (Cramer at al., 2013; Wieland et al., 2017) and one of knee osteoarthritis (Lu et al., 2024).

These findings led to the decision to conduct a survey of middle-aged adults to explore motivations for attending yoga and Pilates classes outside of a volunteer-based trial setting, as well as to assess and compare this population's views and experiences of general, non-remedial yoga and Pilates classes that do not have condition-specific therapeutic objectives in-built, including barriers to participation. The survey identified three common sites of injury or exacerbation, the back, knee, and shoulder, which was corroborated elsewhere in the evidence base (Cartwright et al., 2020; Wiese et al., 2019). Themes of general wellbeing were associated with yoga practice, while Pilates participants sought more physically therapeutic goals such as strength and sometimes expressed distaste with yoga teachings.

Given this information, the researcher set out to design yoga and Pilates class formats with a view to optimising appeal and appropriateness to middle-aged and older population including but not limited to those with musculoskeletal conditions or pain. Following an examination of exercises used in the effective studies from the systematic review and use of background literature on indications and contraindications in yoga and Pilate repertoire, the targeted yoga and Pilates interventions were designed for testing. A primary goal was again to compare the two forms of activity, as at the time of writing there was a paucity of research comparing yoga and Pilates, despite their being unofficially coupled in the public perception, based on the observations of the researcher in the field. The systematic review and survey data were also used to establish practice duration and frequency, and trial duration.

Thematic analysis of a post-trial survey and depth via participant interviews were added following the observation at the systematic review stage that effective and popular interventions did not always show an effect on quality of life when using established survey-based measurement tools. This use of mixed methods was undertaken to capitalising on the researcher's experience and allow for interpretation of data as well as to enrichen a small study conducted by one researcher that was of limited scope and sample size, in part because of contingencies due to the Covid-19 pandemic and restrictions, as outlined in the Covid impact statement. Musculoskeletal conditions were not among the inclusion criteria to ensure sample numbers, and so as to gather a cohort reflective of a real-world class. Although the measuring of pain, physical functioning, and quality of life was justified in that some of the participants did suffer from musculoskeletal and other health conditions as might be anticipated with this age group, and the research was able to monitor the any development of new pain in areas previously identified as most vulnerable, the use of a largely healthy cohort in combination with these outcomes may have limited the ability to capture significant data across these outcomes.

Discussion

The overarching aim of this research was to compare yoga and Pilates for adults over 50 with the primary outcomes of focus being pain, physical, functioning and quality of life. Although these outcomes were measured quantitatively, survey and interview data added value in providing depth and detail to aid in the understanding of qualitative themes related to these outcomes. While the systematic reviews focussed specifically on musculoskeletal conditions, following the survey stage the focus of the research shifted away from specific conditions, as these were not among the top motivators for participation, and centred on the most common sites of existing pain and yoga injuries among practitioners, as a way of addressing intervention safety more broadly and assessing effects in both directions. Back pain was found to be the most common site of among older adults in the survey and a motivator for practising yoga in other literature (Cartwright et al., 2020; Cramer et al., 2016; Penman et al., 2012; Saper et al., 2004) as well as a site of yoga injury (Wiese et al., 2019b). There was no comparable peer-reviewed survey literature available for Pilates, however in the survey conducted as part of this project, although musculoskeletal conditions were not a top motivator for practice in either group, twice as many Pilates as yoga participants were motivated by the presence of a musculoskeletal condition, and back pain was the most prevalent condition among both groups who cited a health condition as a motivator. Pilates was found to be beneficial for back pain in the feasibility trial in which there was a statistically significant improvement to back pain in the Pilates group (P=0.024; medium effect size of 0.65) using the novel Pilates protocol. No statistically significantly results were recorded for back pain in the yoga group, or in either group for knee or shoulder pain, physical function or quality of life. However, there may have been methodological reasons for this, discussed in the limitations section below, the primary one being the fact that a musculoskeletal condition or pain was not a factor among every participant as these were not recruitment criterium, preventing positive change in these key quantitative outcomes from being captured. However, the effect for back pain reduction in the Pilates group is corroborated by the researcher's own systematic review of Pilates for musculoskeletal conditions in older adults (Denham-Jones et al., 2022a) and a considerable body of other research which was recent at the time of writing. This includes two other 2022 systematic reviews on Pilates for back pain (Luiz Lisboa Cordeiro et al., 2022; Zorba & Evangelopoulos, 2022), a 2023 systematic review that reported statistically significantly effects for pain (but not for quality of life) (Yu et al., 2023), an overview of reviews of Pilates-based exercise in the reduction of the low back pain (Gholamalishahi et al., 2022), and a study of mat-based Pilates for chronic non-specific low back pain in older women (Lytras et al., 2023). Although recommendations cannot be made on the findings of the small study presented, it can cautiously be interpreted as in agreement with the evidence that Pilates can be recommended for chronic non-specific low back pain. Findings show that this should be preference-based in consultation with the individual.

The in-depth interviews highlighted strong personal preferences for or against yoga and Pilates participation in some individuals, which may impact adherence and therefore outcome. The prior systematic review of Pilates (Denham-Jones et al., 2022a) agrees with another recent systematic review and meta-analysis of Pilates versus other forms of exercise for chronic non-specific low back pain, finding that pooled evidence does not indicate definitive recommendations of Pilates over other forms of exercise for this population (Wong et al., 2022).

The findings for Pilates for back pain reduction have the potential for meaningful impact. In 2019 it was estimated that ten million people in the United Kingdom have back pain (Versus Arthritis, 2019). With its associated work absenteeism, disability, and healthcare costs, back pain is a socioeconomic problem (Maher et al.,2017; Van Tulder et al., 2006). Health and Safety Executive figures from the U.K. Labour Force Survey revealed that in 2016/17 3.2 million workdays were lost due to work-related back disorders, with an average of 16.5 days lost per case (Buckley, 2017). Back pain is also one of the leading causes for premature retirement (Maher et al., 2017). Current treatment guidelines shift the emphasis away from medication which can be ineffective or addictive, surgery which carries risks and high costs, and imaging which can prove costly and unreliable (Foster et al., 2018). Guidelines instead recommend non-pharmacological first line treatments addressing the symptoms of both the pain and its comorbidities and consequences (Maher et al., 2017; National Institute for Health and Care Excellence, 2016). There is a noted overlap of chronic non-specific low back pain with psychological factors such as stress, depression, anxiety, and reduced feelings of self-efficacy (Hartvigsen et al., 2018) with participation in work, social, and family life negatively impacted (Maher et al., 2017). Hence, there has been a shift away from a solely biomedical model of treatment to a biopsychosocial one to address these symptoms (Buchbinder, et al., 2018, Foster et al., 2018; Hartvigsen, et al. 2018; Lederman, 2001; Maher et al., 2017). Although there is no conclusive evidence to suggest that Pilates is superior to other forms of exercise for alleviating back pain, a teaching approaching that emphasises stress reduction and fear-avoidance patterns, as used in the present trial, aligns it particularly well with this aspect of treatment guidance. This is corroborated by a study for Pilates for chronic low back pain that found that reductions in pain catastrophising and kinesiophobia partially mediated reductions in pain intensity and improvements in physical function, validating the importance of the psychological elements of the practice (Wood et al., 2023).

The lesser, clinically non-significant reduction in back pain in the yoga group is in agreement a systematic review of yoga for chronic non-specific low back pain by Wieland et al. (2022), which found low-to-moderate-certainty evidence that yoga offered small and clinically unimportant improvements in back-related pain compared to no exercise (Wieland et al., 2022). Further to this, a meta-analysis by Fernandez-Rodriguez et al. (2022) found that Pilates, strength, core-based, and mind-body exercises all worked for chronic low back pain (Fernández-Rodríguez et al., 2022). In contrast, stretching, which is a central component in yoga – and 'flexibility' a key motivator for yoga practice found in the present survey and post-trial qualitative data – did not influence pain (Fernández-Rodríguez et al., 2022). The case for recommending yoga for chronic low back pain needs further examination.

This project suggests that yoga's place in the evidence-based practice is perhaps less directly connected to specific musculoskeletal outcomes and quantitative measures of these, which can be difficult to determine, perhaps due to heterogeneity in physical practices when conducting meta-analyses, but as the qualitative research indicated its value is situated in biopsychosocial benefits. Indeed, the survey in Chapter Four found that while 25% of Pilates participants cited a health condition as a motivator for practice, for yoga the proportion was 12.5%. It could be proposed that yoga is a mental rather than physical therapy, whose benefits were shown by qualitative analysis to be useful in ways related to the perception of and attitude towards physical activity for older adults and those with musculoskeletal conditions. While evidence around pain reduction and functional strength for yoga was not found to be as strong as that for Pilates in either the systematic review (Denham-Jones et al., 2022b) or the present trial, there was evidence in the interviews of two participants' increased confidence in exercise and movement. In the case of one of the participants in the trial and interviews, the desire to return to general group yoga classes in a gym, as well as reducing the feeling of breathlessness when walking for exercise, were motivators for participating first in a modified yoga practice. As the end outcome of these goals was not monitored as part of the present study, it was beyond the scope of this research to fully assess yoga's impact on the instigation of, or return to, other physical activities and this aspect represents a future research gap identified. However, evidence elsewhere suggests that this is a warranted motivator for practice, with an existing review of yoga programmes for older adults (60-79 years) reporting that yoga's blend of mindfulness and physical benefits can enhance older adults' exercise experience, lead to more frequent exercise, and potentially improve overall health (Martens, 2022). Yoga was also positively associated with improved self-reported and physical attributes that increase quality of life (Martens, 2022; Tulloch et al., 2018). This positioning of yoga is somewhat different to its positioning within NHS and government guidelines for physical activity which are rooted in strength and pain relief benefits.

The findings of this research related to Pilates, yoga and notions of well-being are broadly reflected in a study of the difference in effect of Pilates and yoga programmes on the well-being of women with a mean age of 50-four years using the Subjective Exercise Experiences Scale (McAuley & Courneya, 1994). A significant improvement to positive well-being was found after both programmes but was higher for the yoga programme. Similarly, there was a statistically significant reduction in psychological distress for both programmes, but a greater decrease for yoga (Rokka et al., 2019). These findings support the theory developed in the present research that both yoga and Pilates may improve well-being in female populations over 50 years, but that the characteristics of the practices result in a greater perception of enhanced well-being through yoga.

Although the present research did not find a clinically significant change in physical function or quality of life for either trial group using the SF-36, the addition of qualitative analysis allowed for the excavation of these benefits by utilising interviews, which being more open-ended, participant-led, and able to go beyond the confines of the instrument tool, may have been a more appropriate and useful way of exploring these factors. It is possible that another quality-of-life instrument would have yielded a different result. For specific populations, where quality of life may be influenced by the presence or improvement of a health-related issue, then condition-specific tools may be more appropriate. An osteoporosis-specific tool was used to capture statistically significant quality of life effects in osteoporosis population in Pilates studies (Küçükçakir et al., 2013; Oksuz & Unal, 2017) included in the prior systematic review (Denham-Jones et al., 2022a). Oksuz & Unal (2017) also captured statistically significant results using the Satisfaction with Life Scale with a population mean aged 60 years (Oksuz & Unal, 2017). For yoga, Welford et al. (2022) used the Satisfaction with Life Scale and the Life Satisfaction Index-Z and found that compared to a waitlist control group, both yoga and aerobic exercises were associated with subjective well-being in older adults of a mean age 72.5 with a medium magnitude effect size (Hedges' g = 0.65 and 0.56 respectively) (Welford et al., 2022). While it is beyond the scope of this research, the testing of quality-of-life instruments on older populations is an area for potential future research which could include a comparison of condition-specific tools with generic ones, as well as narratively comparing quantitative results with qualitative in the same cohort.

Findings were considered in relationship to current U.K. back pain care and general exercise guidelines and in the context of evidence-based exercise recommendation and referral. At the time of writing, the U.K. National Health service accurately reflects recent evidence and includes yoga and Pilates along with walking and swimming as exercise suggestions for those with back pain (NHS, n.d.), providing a link to a Pilates and general exercise videos, although not yoga.

The U.K. Chief Medical Officer's Physical Activity Guidelines are the same for general adults and older adults in recommending 150 minutes of moderate or 75 minutes of vigorous physical activity weekly, two days per week devoted to improving strength, with older adults advised to work on improving balance to prevent falls (Department of Health and Social Care, 2019). The poster produced by the Department of Health and Social Care suggests and depicts yoga as a strength-building activity (Department of Health and Social Care, 2019). However, a 2022 paper on strength prescriptions for older adults recommends the removal of the yoga pose image (along with an image of carrying bags) for "active adults" on the grounds that it is considered too low intensity effort for the purpose of strength-building (Gluchowski et al., 2022). This raises issues around yoga's place as part of evidence-based exercise in relation to the physical activity guidelines. Gluchowski et al. (2022) advocate that strength prescriptions for older adults are measured using perceived exertion rating scale, and that guidelines should mention the progression principle of a gradual increase in training stress (through load, volume, duration, frequency, etc.) for continued muscular strength gain. (Gluchowski et al., 2022; Steele et al., 2017). Although strength was not an outcome in the present trial, for the yoga group, one unexpected outcome was that the physical function score in worsened significantly post-intervention (P=0.040). It is possible that yoga was included on the physical activity guidelines poster due to what we know about its popularity, being more popular than Pilates and the most popular form of group exercise in U.K. gyms, as noted in the prior participation survey and national group exercise research (EMD U.K., 2018). Yoga differs from other personal training and fitness training in that progression and results are not generally quantified or recorded. For example, the practice does not involve numbers of repetitions or timed exercises or the use of weights or resistance bands. There is more potential for this in Pilates instruction, which uses repetitions and can involve measured forms of resistance in weights and bands of different resistance levels. Gluchowski et al. (2022) also argue that exercise instructors in general do not necessarily employ the perceived exertion and progression principles in a systematic fashion (Gluchowski et al., 2022). In Pilates teaching a systematic approach among instructors, especially those working with small groups or one-to-one, can be recommended. Although this level of measurement would not be possible in a group class yoga setting, it is something that could be implemented in the use of yoga by yoga-trained physiotherapists. In this respect, this finding agrees with a study of the integration of yoga and physiotherapy in clinical practice whose findings suggested that physical therapists increase their assessment and documentation of functional outcomes for clients participating in yoga (Thomas et al., 2021).

Another aspect of a more systematic approach to Pilates, that can also be applied in yoga, is that of dosage. The present trial used one 60-minute group session and prescribed two 30-minute home practice sessions for a goal total of 18 hours practice (at least one of which was a one-hour group class, the balance comprised of self-practice at home) spread over eight weeks. This was based on the systematic reviews conducted as part of this research (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b), identifying the shortest effective studies when determining trial duration (Cheung et al., 2014; Cheung et al., 2017; Cruz-Díaz et al., 2015), in order to take into account sustainability for both researcher and participants in the trial. In a real-world scenario, the practice should be maintained beyond a definitive number of weeks as part of an on-going commitment to physical activity as implied in national guidelines (Department of Health and Social Care, 2019). The twice-weekly frequency of the interventions aligns with the guideline recommendations of focusing on strength twice a week for older adults (Department of Health and Social Care, 2019), although in agreement with Gluchowski et al. (2022) more specificity in the guidelines regarding duration and intensity of the sessions is needed (Gluchowski et al., 2022). This observation is also made in a systematic review of Pilates for chronic low back pain which noted that the frequency, workload, and intensity of Pilates protocols could be better defined in research (Patti et al., 2015; Patti et al., 2023). Although 60-minute session were found to be prevalent in the systematically reviewed studies (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b) which informed the presented trial, the 60-minute length might simply be an arbitrary group exercise convention, observed to justify the travel time and expense of a live class. Further study is needed to determine whether a shorter session could be as effective or if online classes (or shorter videos) are comparable. A further point of contention is whether a shorter session length is by definition superior or whether some people desire a long time practising, as taking personal time for exercise may itself be a benefit.

The home practice session was thought to be make a feasible contribution to the proposed optimum dosage but the prescription was not adhered to, although there was no evidence that it influenced outcomes. More research is needed into the usefulness of such prescriptions including insight into adherence. Some strategies for home practice adherence were proposed in the present research, including more flexibility in the type of exercise suggested and time spent. It was found that more yoga than Pilates participants took up home practice so within this area there is also scope for research into Pilates self-practice habits and facilitation, either in isolation or in comparison to other forms of exercise, for better outcomes. While home practice can allow participants to move at their own pace, lack of adherence underscored the role and appeal of accessible and sympathetically paced group classes, which include a component of social interaction in a dedicated space.

A key aim of this research has been to explore the appropriateness and accessibility of Pilates and yoga practices for older adults. A U.S.-based study of the increase in yoga practice from 2022 to 2017 found young people were driving an increase in participation, with yoga use pattern change over time significantly related to younger age ($P < 0.001$) (Zhang et al., 2021). Both the present survey and some of the content in the in-depth interviews, discussed in preceding chapters, suggested that yoga was sometimes perceived as less inclusive than Pilates for older adults, and the systematic review (Denham-Jones et al., 2022b), as well as the literature sourced when designing the intervention used in the present trial, indicated that yoga requires more emphasis on modifications of traditional repertoire for older populations than does Pilates. The development of specialist programmes such as the Yoga for Seniors Practice Continuum (Krucoff & Carson, 2023) and the Gentle Years yoga programme aimed at inactive adults over 60 years (Tew et al., 2017) also support this notion. In the light of this, it is surprising that in a qualitative study exploring *young* people's perceptions and experiences of yoga, one participant mentioned that peer attitudes were that yoga was *for* "old people" (Cartwright & Doronda, 2023), although this could be reflective of perceptions of *relative* age or cyclical trends. However, the same study (Cartwright & Doronda, 2023) also indicated that young people's perceptions and experiences were closely aligned to those of adult over 50 found in the present research survey and interview analysis. As with older adults, young people aged 10-18 years found that yoga helped with confidence and stress-management, while barriers included self-consciousness around not being flexible enough, and males felt that yoga was female dominant (Cartwright & Doranda, 2023). Another study asking, “What brings young adults to the yoga mat?” similarly found young adults motivated by enhanced fitness and stress reduction/relaxation (Kramer-Kostecka et al., 2022) just as with the older adults studied in present research. This would suggest that the motivators and benefits identified in the present research are not exclusive to the older population. Instead, the indication is that yoga is a suitable practice for all ages *including* older adults because its benefits and applications apply to a range of ages and are not diminished over the life span. However, for this to be the case, modifications are indicated, due to the higher likelihood of the onset of chronic musculoskeletal conditions in later life (Hoy et al., 2014). Evidence from the yoga systematic review (Denham-Jones et al., 2022b) of those with musculoskeletal conditions, the survey of yoga participants over 50 years, and the evidence behind the design of the trial protocol strongly suggest the need of modifications to traditional yoga postures for accessible, safe, and effective practice in later life, whether as part of an age-targeted class marketed toward older adults or by way of ensuring that public class formats are scalable and in yoga education promoting a sensitivity to older adults’ perspectives and priorities.

Although chronological age is not the sole trigger for introducing modifications, and capacity and capability influenced by lifestyle can also be a factor, age nonetheless provides a useful if approximate measure for grouping populations and targeting physical activities. Further research is needed to establish the age at which such modifications are best implemented. One government resource (Victoria State Government Department of Health, n.d.) suggests this might be as early as age 40 for osteoarthritis, rheumatoid arthritis, and sarcopenia, and age 50 for osteoporosis. A literature review establishing age onset for conditions such as osteoarthritis, rheumatoid arthritis, osteoporosis and sarcopenia could inform practice in this respect and fill a gap found in research.

At the time of writing, a corresponding study of young people's perceptions of Pilates could not be sourced for comparison with yoga, but there is equally nothing to suggest that that the perceived benefits of Pilates are limited by age at the upper range. Qualitative data on the perceived benefits of Pilates for adults of a mean age of 57 with chronic musculoskeletal conditions (Gaskell & Williams, 2018) including increased feelings of self-confidence, autonomy, and motivation to exercise. Those findings are comparable to outcomes of a systematic review and meta-analysis of Pilates mental health benefits which reported statistically significant improvements to symptoms of depression, anxiety, and fatigue and statistically significant increases in feelings of energy and the mental health components of quality of life across studies with a range of populations and a lower mean age of 38 (Fleming & Herring, 2018).

Accessibility was a barrier to yoga in both the survey and interview sections of this research, as exemplified by two interviewees and in the prior survey data where disinclination included a specific dislike of yoga teachings. In contrast, no similar issue or barrier was not found in connection with Pilates as the method is not rooted in a spiritual doctrine and does not have the complex theosophical legacy associated with yoga. Maintaining transparency at the outset around any spiritual elements to yoga teaching is recommended (Moonaz et al., 2015). There is also a place for secular yoga, which may be more accessible and appealing to individuals from a range of cultural or religious backgrounds. A study of spiritual and secular yoga has shown that it does not make a difference whether the yoga activity contains a spiritual component for the ritual of practice to support a feeling of social bonding (Charles et al., 2022).

Strengths and Contribution to the Field

The research fills a gap in providing a mixed-methods study of the comparative effects of yoga and Pilates in the ageing but active population, about which there was no existing published research at the time of writing. It challenges assumptions concerning unconditional recommendations of these practices and offers a detailed and unique understanding of both the practices, the population, and the relationship between the two. It is distinct from the numerous studies of single pathologies and the population studied is distinct from the frail and elderly. The thesis provides information and resources useful to teachers and practitioners who may need to field queries about the differences between the two practices, make recommendations and deliver safe, inclusive classes to cohorts that increasingly may include middle-aged and older adults. As the working population ages, it can be hypothesised that these same individuals will begin or continue to take up their places in suitable group exercise venues, so the concerns and resources will become increasingly relevant.

The systematic reviews presented (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b) have made a contribution to knowledge in being the first of their kind, as they were undertaken when there were no previous reviews of yoga and Pilates for a range of conditions associated with the onset middle-age, as well as providing the opportunity for an evidence-based comparison of the two types of intervention which was an under-studied area at the time of writing. The publication of both reviews offered the opportunity for peer review and dissemination.

The survey phase resulted in an original contribution to knowledge creating a yoga and Pilates participation survey tool suitable for further testing and standardisation, as there was no existing instrument. While it was not pilot tested in this study, rigour was exercised by referring to peer reviewed literature from the British Medical Journal on survey design and development (Boynton, 2004; Boynton & Greenhalgh, 2004; Boynton et al., 2004) and rationale for the survey questions are provided Table 4.2. As the instrument asked identical questions of the same sample about yoga and Pilates, it yielded data on exercise history, motivation, barriers, injury, and preference that allowed for a side-by-side analysis, resulting in an original understanding and comparison between participation in the two practices. The locally recruited cohort was deemed to be representative of the larger national yoga participant population for yoga when compared with a national survey (Cartwright et al., 2020). The trial cohort was then recruited from the same sites as the survey for continuity. There was also parity in the demographic characteristics of the yoga and Pilates trial groups. This allowed for more meaningful comparison of survey and trial findings, and between the two trial groups, and for interpreting findings within the broader context established by the diversity of studies in the systematic review. Meticulous data management and recording, maintenance of participant confidentially, and accurate recording of interviews were all undertaken to ensure the confirmability of the work.

The protocol development phase contributes two new, fully documented, rationalised, and reported evidenced-based yoga and Pilates exercise protocols supported by research and literature to reflect best practice and generate the best effect, resources which can be used to inform teaching and delivery. This phase of research collated knowledge of movement and exercise contraindications that, while not novel from the clinical and physiotherapy perspective, have been translated across specifically to yoga repertoire, a process not found in detail in other studies encountered during this research. While designed with age-related conditions and limitations in mind and the inclusivity of middle-aged and older adults central to the protocols, there is also nothing inherent in them that explicitly excludes participants of other age groups. Therefore, in their present un-branded state, they provide a more universal and scalable teaching resources for use with, but not limited to, the older population.

The participant interviews added depth and provided a detailed picture of the variety of experiences of older learners, including rich examples of attitudes towards health and physical activity in later life, experience and views of yoga and Pilates from an older adult's perspective, and discussion around limitations and contraindications encountered. Despite a small sample, themes were constructed which add to the conversation around sensitivity to older learners' needs. In combination with the protocols themselves, information of this nature can enable yoga and Pilates educators of any age, including younger, to view the practices as refracted through an older adult's lens.

This was a novel project straddling the intersection between clinical science and social science, with a panoptic, mixed-methods design. It challenged the limitations of quantitative-only methodologies, aligning the study of yoga and Pilates with an ontological and epistemological position that acknowledged researcher involvement and interpretation as a means to knowledge generation and interpretation, while maintaining transparency through a reflective process about both the advantages and limitations of this approach.

The methodological triangulation allowed for knowledge to be distilled from several sources, offering a broad scope of data, and allowing for greater depth of analysis by pooling of sources to strengthen themes. As this was a mixed-methods study, with a constructivist and interpretivist set of ontological and epistemological assumptions, qualitative sections could not always be held to the same notion of internal validity as is used as a criterium used for quantitative studies, therefore this use of triangulation was an important element in the effort to maintain and demonstrate the credibility of the work.

Shortcomings are acknowledged in a transparent fashion and unanswered questions and research gaps beyond this study's scope have been identified throughout as areas for future research and discovery.

Limitations

The wide lens of this thesis presented several limitations. Heterogeneity in study populations and methodologies in the studies in the systematic reviews (Denham-Jones et al., 2022a; Denham-Jones et al., 2022b), primary research, and other cited existing literature limit generalisability. Due to potential diversity in these practices, effectiveness of yoga or Pilates may be contingent on a specific choice of exercises for specific pathologies and the wide range of musculoskeletal conditions that exist, an exercise protocol effective for one population may not be safe and effective for another.

Double blinding is not possible in any yoga or Pilates study, including this one, so participants' awareness and preconceptions of the interventions delivered may bias self-reported data, although this limitation is somewhat offset by comparison of the present data with other studies to validate themes and findings.

The primary research phases, including the survey, the trial, and interviews were undertaken by a sole researcher, and their small scale and scope presented several challenges and limitations to internal and external validity. The size and nature of the samples were limiting factors, affecting both the ability to capture data, and the transferability of results captured. Both the survey and trial used small samples (N=35 and N=24 respectively) in part due to Covid-19-related restrictions and guidance at the time of recruitment. The decision not to specify musculoskeletal conditions in the inclusion criteria may also have had a limiting effect on the ability to capture any changes in pain, physical function and quality of life as there was less or little scope for positive change in participants. It is also possible that in the trial non-effectiveness was due to type II error (erroneous acceptance of null hypotheses for all quantitative outcomes excepting pain in the Pilates group) due to the low statistical power of the tests on a small sample. The lack of significantly positive effect for either intervention on quantitative outcomes for physical functioning and quality of life, and the possibility that there were methodological reasons for this, meant that these could not be meaningfully assessed from the trial data. While the use of one geographical area and potentially one socioeconomic bracket allowed for continuity between the survey and trial phases, these are also factors which inevitably limit the generalisability of findings. Further, this recruitment strategy did not allow for consideration of the effects interventions on inactive populations or on populations in deprived areas where musculoskeletal conditions are most prevalent (Versus Arthritis, 2023).

Although the researcher's relationship to students and role in shaping the research has been made transparent through the process of reflexivity, the potential for volunteer bias resulting in favourable views of the interventions among survey, trial, and interview volunteers, presents another issue potentially impacting reliability of data.

With respect to construct validity, the scope of the thesis did not include piloting of the survey instrument or the piloting and standardisation of the qualitative element of the post-trial survey, and validity related to the interpretation and the reproduction of results under the similar conditions were not established (Boynton & Greenhalgh, 2004).

Recommendations

Overall findings indicated that for older adults the Pilates intervention, and Pilates generally, can be recommended for chronic non-specific back pain, yoga for overall well-being and perceived stress reduction, and either intervention, based on participant preference, for mobility and increased feelings of self-confidence.

Although Pilates may be effective in reducing back pain there is a lack of evidence to support its superiority over other forms of exercise for this outcome. The present research indicates that Pilates is sought out by those seeking functional strength and postural improvements and sometimes this includes those deterred by prior experiences with yoga, revealing that preferences for one intervention over the other can be strong. The individual should have agency in choosing to participate if referred, and engagement and outcomes can be improved by taking as inclusive and individualised approach as is feasible in a group setting. Where limitations are present in the participant, the style of class should be considered, as the inclusion of standing exercises was identified as a barrier in the case of knee pain.

The research found that effective yoga trials were contingent on carefully designed interventions, sometimes delivered by specialists. In designing the intervention used in the present research a range of contraindications were identified in the literature and taken into consideration when selecting postures and practices to include. As no evidence was found that yoga was superiority to other exercise comparators in any stage of this project, the research presents a challenge to the somewhat broad and unconditional recommendation of yoga in physical activity guidance. When referring older adults to yoga, clinicians should be mindful of the range of styles and intensities of yoga practice and, in the case of older adults and those with musculoskeletal pathologies, should direct participants towards beginners' classes or small groups. Any home practice programmes should involve an element of participant choice and some flexibility in terms of content, use of media, and time spent. Given the popularity of yoga centred around its mental health benefits, there is potential to enhance its physical therapy benefits, particularly for older adults and those with musculoskeletal conditions or limitations, through the greater development and promotion of yoga training to physiotherapists.

For both practices, more systematic approach to class structure, including weekly progression for regular participants is recommended if Pilates and yoga are to fulfil the strength component suggested in physical activity guidelines.

Future Research

A prevailing research gap located in this work related to disparities in knowledge between yoga and Pilates. This includes survey-based research related to motivations and barriers as well as participation among genders. Yoga and Pilates participants were found at all stages of the research to be predominantly female, and while some reasons for this such as self-consciousness about ability and belonging were identified in the literature for yoga, more research is needed into the equivalent issues in male participation in Pilates. Similarly, in designing the interventions used in this research, several surveys relating to injury and clinical studies relating to contraindication were found the literature for yoga, whereas comparable data was not available for Pilates. There is scope for further research into contraindications and caution with respect to general group Pilates for older adults in real-world class settings. A national survey would contribute greatly to the understanding of what motivates individuals to practice, what deters them, the frequency and longevity of the practice, the practices of Pilates at home, and rate and location of any associated injuries. As with yoga, Pilates research should include qualitative data gathered from sources such as surveys, interviews, and cohort studies, to monitor outcomes in non-'designed', non- trial situations, in the recreational and community settings in which adults generally experience exercise. The reputation of Pilates as a remedial form of exercise supports the continued need for research in this area, so that Pilates instructors and physiotherapists delivering Pilates can continue to deliver safe programmes, based on evidence, throughout participant lifespan.

This research laid groundwork for further testing of the protocols developed within it. Although the novel interventions used were deemed safe and did not cause or exacerbate injury, there is now scope for further testing using larger samples of specific populations. This could include explicit inclusion criteria for cohorts with back, knee, or shoulder pain which were found to be the most prevalent sites of existing pain, injury or exacerbation as well as those with common conditions related to age such as osteoarthritis, osteoporosis, and sarcopenia.

As has been mentioned, the protocols developed in this work were inclusive of older adults, but not exclusive to them. If developing or promoting them further, it would also be useful to establish whether older adults prefer classes specifically designated to their age group or whether they prefer to attend general, mixed level groups based on ability rather than age. In their current form there is scope for the eight-week protocols and home practices to be more formally collated and recorded in a user-friendly form of teaching or study materials such as an instruction and practice manual and video recordings, for use by teachers and participants, as a tangible way to aid in their utilisation and impact.

The thesis takes the position that mixed-method studies have a particular value in contributing to the understanding of yoga and Pilates. While quantitative studies have done much to validate yoga and Pilates from a clinical perspective for addressing the symptoms of various pathologies, randomised controlled trials are inherently limited in suitability for these complex practices. The interventions are heterogeneous, unblinded, and may present any number of subtle confounding factors, such as participant history, both socially and physically, or the manner and language of the instructor. Qualitative methods, including those considered to be lower on the research hierarchy, such as cohort and case studies, could play a valuable role, both as stand-alone methodologies and to illuminate quantitative results in understanding lived experiences in physical activity.

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Appendix I
Narrative Review Literature Search Strategy

A literature search was conducted searching Cochrane, Pubmed, Pubmed, CINAHL, Sports Discus and Psycinfo databases and Google Scholar. Search keywords remained consistent, although the terms or strategies evolved according to the nature and capacity of each database. In the case of Google Scholar, due to volume, a decision was made to select results from the first three pages only.The following Keywords and Boolean Phrases were used:

yoga AND back AND pain

yoga AND stress AND (workplace OR work OR office)

yoga AND (“older population" OR "older people" OR "aging" OR "ageing")

yoga AND stress

yoga AND (workplace OR work OR office OR desk)

Yoga Therapy

Pilates AND back AND pain

Pilates AND stress AND (workplace OR work OR office)

Pilates AND (“older population" OR "older people" OR "aging" OR "ageing")

Pilates AND stress

Pilates AND (workplace OR work OR office OR desk)

Clinical Pilates

A medical subject heading (MeSH) search was conducted for the Cochrane and Pubmed databases.

Cochrane:

MeSH descriptor: [Back Pain] explode all trees and with qualifier(s): [prevention & control – PC, rehabilitation – RH]

MeSH descriptor: [Low Back Pain] explode all trees and with qualifier(s): [classification – CL, diagnosis -DI, pathology – PA, physiopathology – PP]

Chronic non specific low back pain AND definition

Pubmed:

"Back Pain"[MesH] AND "Yoga"[MeSH]

“Aging” [MeSH] AND “Yoga” [MeSH]

"Back Pain"[Mesh]) AND "Exercise Movement Techniques/therapeutic use”

“Aging”[Mesh] AND "Exercise Movement Techniques/therapeutic use”

Grey Literature Searched:

World Health Organization Region Office for Europe (euro.who.int), The National Institute for Health and Care Excellence (nice.org.uk), Gov.co.uk (incorporating Public Health England), the Health and Safety Executive (HSE.gov.uk), the National Health Service (NHS.UK) and Google.co.uk. Open Grey (opengrey.eu) and the British Library (ETHOS.bl.UK) were searched for dissertations.

Appendix II
Yoga Systematic Review Methodology

Literature Search

Table A1.1 *Database Information and Rationale for Selection*

Name/Acronym	Definition	Content	Rationale
CENTRAL	Cochrane Controlled Register of Trials.	Reports of randomised and quasi-randomised controlled trials. Most from bibliographic databases (mainly PubMed and Embase), but also derived from other published and unpublished sources, including ClinicalTrials.gov	High-quality evidence updated monthly. Trusted source for independent evidence to inform healthcare decision making.
CINAHL	Cumulative Index of Nursing and Allied Health Literature	Texts from nursing and allied health journals	Includes literature on rehabilitative therapies under the umbrella of 'Allied Health'
Google Scholar	Google's Scholastic Search Engine	Academic articles, books	To retrieve texts incorrectly cited in other databases, widen the search and reduce risk of publication bias
PUBMED	US National Library of Medicine	Biomedical and life sciences literature	Includes US literature and incorporates Medline biomedical content
PsycInfo	American Psychological Society database	Psychology abstracts and articles	To capture studies with qualitative/QOL outcomes. QOL and psychological aspects considered in this review as a secondary outcome
SCOPUS	Dutch Analytics Company Elsevier’s abstract and citation database	Journals in life sciences, social sciences, physical sciences, and health sciences.	Superior quality and coverage. All included journals reviewed each year to ensure high quality standards are maintained
SPORTSDiscus	SPORTSDiscus	Includes sports, exercise, biomechanics, physical therapy and rehabilitation science literature	Comprehensive database for sports and exercise science, physical fitness and 'exercise for health' perspectives
Web of Science (Core Collection)	Database created by Institute for Scientific Information, now maintained by Clarivate Analytics	Scientific and scholarly research in science, social science and humanities disciplines.	Peer-reviewed, high-quality scholarly journals conference proceedings and book data. Broadens the scope to non-clinical disciplines and beyond journal articles and RCTs

Table A1.2 *Other Internet Sources and Rationale for Selection*

Name/Acronym	Definition	Content	Rationale
ETHOS.bl.UK	British Library	Over 500,000 doctoral theses from British higher education establishments	Dissertations
Opengrey.eu	System for Information on Grey Literature in Europe	Technical or research reports, doctoral dissertations, conference papers, official publications, and other types of grey literature. Science, Technology, Biomedical Science, Economics, Social Science and Humanities.	Unpublished material to ensure against publication bias
Worldcat.org	Union catalogue operated by OCLC Online Computer Library Center, Inc.	Collections of 72,000 libraries in 170 countries and territories that participate in the Online Computer Library Center (OCLC) global cooperative.	Unpublished material to ensure against publication bias International perspective

Studies Excluded After Full Text Assessment

Study	**Primary Reason for Exclusion**	**Notes**
Bonura 2104	Intervention	Chair Yoga
Boschtel 2009	Design	Not RCT
Brenneman 2015	Design	Not RCT
Chen 2008	Population	No MSK Condition
Chen 2009	Population	No MSK Condition
Chen 2010	Population	No MSK Condition
Cheung 2016	Design	Not RCT
Deepeshwar 2018	Intervention	Yoga-based lifestyle (other therapies plus yoga)
Ebenezar 2012_2	Intervention	Co-intervention, Yoga + TENS
Farinetti 2014	Intervention	Co-intervention, Yoga + Calisthenics
Galantino 2012	Intervention	Not RCT
Gautam 2019	Population	Mean age not 50+
Ghesemi 2013	Intervention	Co-intervention, Yoga + Physical therapy
Goncalves 2011	Intervention	Not RCT
Gothe 2014	Population/Outcome	No MSK condition; Fitness and ROM indicators
Grabara 2013	Design	Not RCT
Grabara 2015	Design	Not RCT
Groessl 2018	Population/Outcome	No MSK condition; Short Physical Performance Battery
Hariprasad 2013	Population/Outcome	No MSK condition; Sleep and QOL
Jayabharati 2014	Design	Not RCT
Jorge 2016	Population/Outcome	No MSK Condition; Menopausal symptoms
Kim 2014	Intervention	WiFit yoga not considered comparable to live class
McCaffrey 2017	Intervention	Chair Yoga
Moonaz 2015	Intervention	Chair Yoga
Nambi 2013	Intervention	Yoga and EMG Biofeedback
Noradechenut 2017	Intervention	Thai Yoga not comparable to modern postural yoga
Oken 2016	Population	No MSK Condition
Park 2011	Intervention	Chair Yoga
Park 2014	Intervention	Chair Yoga
Park 2016	Intervention	Chair Yoga
Park 2017	Intervention	Chair Yoga
Reed 2014	Population/Outcome	No MSK Condition; Menopausal symptoms
Saravanakumar 2014	Population/Outcome	No MSK Condition; Balance and Falls
Saravanakumar 2018	Design	Qualitative
Schmid 2018	Population	Diabetes and Neuropathic pain
Schmid 2019	Population	No MSK Condition
Sharma 2019	Not Available	Abstract only. Full study not published or available
Sharpe 2016	Design	Not RCT
Siddarth 2014	Design	Not RCT
Sierpowska 2006	Design	Not RCT
Stirjik 2012	Design	Vitality Intervention; not exclusively yoga
Tew 2017	Population	No MSK Condition
Tiedemann 2013	Population/Outcome	No MSK Condition; Balance and Mobility
Vogler,2011	Design	Not RCT

Studies Excluded After Quality Assessment

Study	**Primary Reason for Exclusion**	**Notes**
Ebenezar 2012	Design	Co-intervention, Yoga + TENS
Groessl 2008	Design	Not RCT
Kolaskinski 2005	Design	Not RCT
Stebbing 2014	Other	Duplicate. (Abstract of Ward 2012)
Tuzun 2010	Design	Not RCT

Risk of Bias Assessment

Table A1.3 shows the risks found in each domain and the overall risk assessment for each study. Table A1.4 shows details of the methodological quality issues affecting in each study.

Table A1.3 *Risk of Bias Summary*

Study	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Overall
Cheung et al., 2014	High	High	Low	Low	Low	***High***
Cheung et al., 2017	Some	Some	Low	Low	Low	***Some***
Dunleavy et al., 2016	High	High	High	High	Some	***High***
Garfinkel et al., 1994	Some	High	High	High	Some	***High***
Greendale et al., 2009	Some	Some	Low	Low	Some	***Some***
Innes et al., 2020	Low	Low	Low	Low	Low	***Low***
Kuntz et al., 2018	Low	Low	Low	Low	Low	***Low***
Pandya 2020	Low	Low	Low	Low	Low	Low
Teut et al., 2016	Some	Some	Low	Some	Low	***Some***
Ward et al., 2018	Low	Low	Some	Low	Low	***Some***
Zacharia et al., 2018	Low	Some	Some	Some	Some	***Some***

Domains
(1) bias arising from the randomisation process
(2) bias due to deviations from intended interventions
(3) bias due to missing outcome data
(4) bias in measurement of the outcome
(5) bias in selection of the reported result

Table A1.4 *Risk of Bias Detail*

Study	Quality Assessment
Cheung et al., 2014	**High Risk**. Randomisation and blinding. Allocation concealment unclear. Participants not blinded.
Cheung et al., 2017	**Some concern**s. Randomisation and blinding. Concealment Unclear, Uneven group sizes Age, osteoarthritis pain level, and fear of falling statistically different among groups at baseline. Participants not blinded.
Dunleavy et al., 2016	**High Risk**. Randomisation, blinding, missing outcome data. Quasi-randomised design. Non-blinded study. High drop-out rate with no intention to treat (ITT) analysis.
Garfinkel et al., 1994	**High Risk.** Risks in all domains. No reporting on blinding, baseline differences not reported, attrition, no ITT analysis, no information on pre-specified plan or trial protocol.
Greendale et al., 2009	**Some Concerns**. Randomisation, blinding, reporting. Baseline differences for group with increased prevalence of vertebral fractures and race. Later corrected in planned ITT secondary analysis re fractures but nor re race. Participants not blinded Additional non-prespecified analysis was added without clear explanation. Also, conclusion states an effect when the stats analysis was not significant. Results cannot therefore be reliably attributed to treatment versus random error or chance, so therefore incorrect conclusion based on findings.
Innes et al., 2020	**Low Risk.**
Kuntz et al., 2018	**Low Risk.**
Pandya 2020	**Low Risk.**
Teut et al., 2016	**Some Concerns**. Randomisation and blinding. Baseline differences highlighted by the researcher and baseline stats comparison not done to show that they were statistically similar therefore possible source of error (lower education level in yoga group & lower households in qigong group). Participants not blinded
Ward et al., 2018	**Some Concerns.** Randomisation, blinding, missing outcome data. Participants not blinded. Baseline differences in educational levels in experimental group and age younger. No statistical test. 1 drop out, but small sample and no ITT analysis.
Zacharia et al., 2018	**Some Concerns.** Blinding, measurement of the outcome, reporting. Participants not blinded. No information on blinding of data assessors. No information on pre-specified plan or trial protocol.

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Results

Table A1.5 *Summary of Individual Study Results – Primary Outcomes*

Study (Colour = Risk of Bias Assessment, A5)	Primary Outcome Measures 1. Pain 2. Physical Function 3. QOL	Effect Size - Mean Difference (CI) at short term 8-12 weeks	*P* values <0.05 = statistically significant effect (in bold)	Summary of Key Results
Cheung et al., 2014 Knee OA women	1. Pain (WOMAC) and single question re: medication usage. 2. Physical function (WOMAC) 3. QOL (SF-12)	1. 2.5 (-4.35, 0.64) 2. 4.2 (-10.57, 2.17) 3a. 1.5 (-1.83, 4.33) (mental component of SF-12) 3b. 0.69 (-2.24, 3.62) (physical component of SF-12)	***P*=0.01** *P*=0.20 *P*=0.39 *P* =0.65	Significant results for pain in yoga group. At 8 weeks WOMAC pain p = .01. **From 4-20 weeks significant treatment and time effects:** WOMAC pain *P*= .03,, function *P* = .01 and total scores *P* = .01. **Changes in QOL were not significant.**
Cheung et al., 2017 Knee OA	1. Pain (WOMAC; VAS) and single question re: medication usage. 2. Physical function (WOMAC) 3. QOL (SF-12)	Versus Control 1. -1.5 (-2.9, -0.0) 2. -7.1 (-11.6, -2.5) 3a. 2.5 (-2.3, 7.2) (mental component of SF-12) 3b. 2.6 (-20, 7.1) (physical component of SF-12) Versus Exercise 1. -1.4 (-2.7, -0.10) 2. -7.6 (-11.9, -3.33) 3a. 1.4 (-3.1, 6.0) (mental component of SF-12) 3b. 2.7 (-1.7, 7.2) (physical component of SF-12)	***P*=0.045** ***P*= 0.003** *P*=0.302 *P* =0.269 ***P*=0.038** ***P*=0.001** *P*=0.528 *P*=0.227	Both yoga and exercise improved pain symptoms and function but **yoga may have superior benefits. Changes in QOL were not significant**
Dunleavy et al., 2016 Chronic mechanical neck pain	1. Pain (NDI) 2. NA 3. NA	Versus Control 1. 4.40 (8.49, 0.30) Versus Pilates 1. 1.30 (-1.84-4.44)	***P*=0.0407** =0.41	NDI decreased significantly in the Pilates and yoga groups, with no change in the control group. Pain ratings also improved significantly. Moderate-to-large effect sizes (0.7 to 1.8) and low numbers needed to treat were found. **There were no differences in outcomes between the exercise groups.**

Table A1.5 *Summary of Individual Study Results – Primary Outcomes (Continued)*

Study (Colour = Risk of Bias Assessment, Table A5)	**Primary Outcome Measures** **1. Pain** **2. Physical Function** **3. QOL**	**Effect Size - Mean Difference (CI) at short term 8-12 weeks**	***P* values <0.05 = statistically significant effect (in bold)**	**Summary of Key Results**
Garfinkel et al., 1994 Hand OA	1. Pain (tenderness of the finger joints measured with an instrument dolorimeter; hand pain on VAS) 2. Physical function (hand function measured by the Stanford Hand Assessment Questionnaire). 3. NA	1a. 1.77 (Hand pain at rest) 1b. 3.29 (Hand pain during activity) 2. 0.31	*P* =0.355 ***P* =0.004** *P* =0.141	Yoga group tenderness of the finger joints for both hands difference was beyond the **0.01** level of significance in each hand. For combined hands variables treatment group improved significantly more than the control group on hand pain during activity. Though differences favoured the treatment group, they were not statistically significant for hand pain at rest or hand function.
Greendale et al., 2009 Adult onset Hyperkyphosis	1. NA 2. Physical function (Debrunner kyphometer assessed kyphosis angle, standing height, timed chair stands, functional reach and walking speed.) 3. QOL (HRQOL).	NI	NI	Yoga group experienced a 4.4% improvement in flexicurve kyphosis angle (*P*=0.006) and a 5% improvement in kyphosis index (*P*= 0.004). **The intervention did not result in statistically significant improvement in Debrunner kyphometer angle, measured physical performance or in self-assessed HRQOL (each *P* >0.1).**
Innes et al., 2020 Restless leg syndrome	1. NA 2. NA 3. QOL SF-36	1. NA 2. NA 3. 3.88 (-7.9,15.05) (SF-36 Mental component score) 4.04 (-12.49,4.43) (SF-36 Physical component score	 *P*=0.44 *P*=0.46	There were no significant group differences for QOL between the yoga group and the educational film control group on the SF-36. Both groups measured significant improvements in mental health component and the control group also in physical health components for this outcome measure.

Table A1.5 *Summary of Individual Study Results – Primary Outcomes (Continued)*

Study (Colour = Risk of Bias Assessment, Table A5)	Primary Outcome Measures 1. Pain 2. Physical Function 3. QOL	Effect Size - Mean Difference (CI) at short term 8-12 weeks	*P* values ≤0.05 = statistically significant effect (in bold)	Summary of Key Results
Kuntz et al., 2018 Knee OA	1. Pain (KOOS; ICOAP) 2. Physical function (self-reported LEFS, function in activities of daily living (ADL) and sport and recreation (SR) subscales of the KOOS). 3.QOL (four-item knee related QOL subscale of the KOOS).	Versus Control 1. 22.9 (6.9, 38.8) 2a. 17.9 (3.8, 32.0) (Function in activities in daily life) 2b. 24.7 (-3.2,52.5) (Function in sports and recreation) 3. 15.2 (-2.0, 32.3) Versus Exercise 1. 11.3 (-5.1, 27.6) 2a. 7.6 (-7.0, 22.2) (Function in activities in daily life) 2b. -6.2 (-34.1,21.8) (Function in sports and recreation) 3. 4.8. (-12.8, 21.6)	 ***P*=0.003** ***P*=0.010** *P*=0.094 *P*=0.095 *P*=0.247 *P*=0.477 *P*=0.925 *P*=0.891	The yoga group demonstrated greater improvements in pain and self-reported physical function compared to no exercise control. **Improvements in these outcomes were similar between yoga and traditional exercise.** No improvement in any outcome was present in control group. **Changes in QOL were not significant.**
Pandya, 2019 Sarcopenia (Women)	1. NA 2. Senior Fitness Test (7 components) 3. NA	1. NA 2. (Senior Fitness Test – 7 components) 2a. 6.91 (6.69,7.12) (chair stand) 2b. 4.43 (4.10,4.75) (arm curl) 2c. 105.49 (98.55,112.42)(6 min walk) 2d. 21.81 (20.59,23.02) (2 min steps) 2e. 3.28 (3.19,3.36) (Chair sit-and-reach) 2f. 3.09 (0.01,3.05) (Back scratch) 2g. -1.49 (-1.52,1.45) (8ft up-and-go) 3. NA	 ***P*=0.00** ***P*=0.01** ***P*=0.02** ***P*=0.04** ***P*=0.03** ***P*=0.02** ***P*=0.01**	**76.29% of the yoga group versus 33.98% of the control group had above-average overall scores for the Senior Fitness test components post-test** (23.71% of yoga and 66.02% of control group had below-average score). (No significant baseline between-group differences pre-test) Researchers note only 6 components of the test but show measurements for 7. Unclear whether 8ft up-and-go was included in this average, as it not referred to when reporting the details of this outcome measure earlier in the narrative.

Table A1.5 *Summary of Individual Study Results – Primary Outcomes (Continued)*

Study (Colour = Risk of Bias Assessment, Table A5)	**Primary Outcome Measures** **1. Pain** **2. Physical Function** **3. QOL**	**Effect Size - Mean Difference (CI) at short term 8-12 weeks**	***P* values ≤0.05 = statistically significant effect (in bold)**	**Summary of Key Results**
Teut et al., 2016 Chronic low back pain	1. Pain (FRI; VAS; medication use) 2. SF-36 QOL Scale; Physical function (back function on FFBRH scale) 3. QOL (SF-36)	Versus Control 1. 17 (-0.43, 0.08) 2a. 1.86 (-2.27, 5.99) (on FfbHR) 2b. 2.05 (-8.04, 3.95) (Physical function on SF-36) 3a. 0.19 (-1.31, 3.70) (SF-36 physical component score) 3b. -0.26 (3.13, 2.61) (SF-36 Mental component score) Versus qigong 1. 0.04 (-0.23, 0.31) 2a. -3.06 (-7.74, 1.64) (on FfbHR) 2b. -4.01 (-10.55, 2.53) (Physical function on SF-36) 3a. -0.77 (-3.64, 2.10) (SF-36 physical component score) 3b. -0.34 (-4.06, 3.38) (SF-36 Mental component score)	 *P*=0.175 *P*=0.377 *P*=0.503 *P*=0.351 *P*=0.877 *P*=0.772 *P*=0.203 *P*=0.230 *P*=0.600 *P*=0.858	**No statistically significant group differences were observed between yoga, qigong and wait list.**
Ward et al., 2018 Rheumatoid arthritis	1. pain (VAS) 2. Physical function (functional disability, using HAQ-DI) 3. QOL (EuroQol EQ-5D-3)	NI	NI	No group effects for outcomes 1, 2, & 3 for yoga compared with usual care.

Table A1.5 *Summary of Individual Study Results – Primary Outcomes (Continued)*

Study (Colour = Risk of Bias Assessment, Table A5)	Primary Outcome Measures 1. Pain 2. Physical Function 3. QOL	Effect Size - Mean Difference (CI) at short term 8-12 weeks	*P* values <u><</u>0.05 = statistically significant effect (in bold)	Summary of Key Results
Zacharia et al., 2018 Lower limb OA	1. Pain (WOMAC) 2. Physical functional performance (CS-PFP 10; WOMAC) 3. NA	NA	NA	Yoga significantly improved pain pre- and post-intervention (no control group comparison) (*P*=<0.001) and physical function (*P*=<0.001), but **the relapse prevention intervention provided no added benefit.**

Key to Abbreviations: ADL=Activities of Daily Living, CI= confidence intervals, FfbRH=Hanover Functional Ability Questionnaire, CS-PFP10= Continuous Scale Physical Function Performance 10, FRI=Functional Rating Index, HAQ-DH=Health Assessment Questionnaire Disability Index, HRQOL=Health related quality of life, ICOAP= Measure of Intermittent and Constant Osteoarthritis Pain, KOOS= Knee Osteoarthritis Outcome Score, LEFS= Lower Extremity Functional Scale, NA=Not applicable, NDI=Neck disability index, NI=No information OA=Osteoarthritis, QOL= Quality of Life, QOL-SF12= Quality of Life Short Form 12, QOL-SF 36=Quality of Life Short Form 36, VAS= Visual Analogue Scale, WOMAC= Western Ontario and McMaster Universities Osteoarthritis Index

Table A1.6 *Summary of Individual Study Results – Secondary Outcomes*

Study (Colour = Risk of Bias Assessment, Table A5)	Secondary Outcome Measures 1. Perception of Intervention 2. Adverse Events	Secondary Outcome Results 1. Perception of Intervention 2. Adverse Events	Adherence
Cheung et al., 2014 Knee OA women	1. Participant rating scale for difficulty and enjoyment. 2. Monitored be research staff/participants at home	1. Average score 9/10 enjoyment, 4/10 difficulty. 100% would recommend programme for OA. 2. No adverse effects	**Yoga group class:** 72% attended 75% of class. **Yoga home practice:** 33% practised yoga at home as prescribed. 70% practised at home but only 36% for 30 minutes at a time as prescribe. Average minutes per week practised = 112 out of 120 prescribed. At 20 week follow-up 74% still practising at home but none 5x a week and/or 30 minutes a day as prescribed.
Cheung et al., 2017 Knee OA	1. 4-point Satisfaction with Programme questionnaire 2. NI	1. No statistically significant differences in program satisfaction between the **yoga** and **exercise control groups** on enjoyment (*P*= 0.18), ease of use (*P*= 0.36), and recommendations of the program to others (*P* = 0.52). 2. 3 non-serious adverse in effects **exercise control group**	**Yoga group class**: 63% of yoga group and 57% of **Aerobic/strength exercise control group** participated in >50% of classes. (p=.67 between group difference) **Yoga home practice**: average number of minutes/week (Y: 79 ± 54 (0–278) out of 120 prescribed vs. ASE: 56 ± 33 (0–126) out of minimum 60, p = .11). Number of days/week (Y: 3 ± 1 (0–6) out of 4 prescribed vs. **ASE**: 3 ± 1 (0–5) out of 5 prescribed, were not significantly different (p+0.28).
Dunleavy et al., 2016 Chronic mechanical neck pain	1. NA 2. NI	1. NA 2. No adverse effects	NR. Reported as drop-outs: **Yoga** 24%, **Pilates exercise control** 41%, **Control** 41%
Garfinkel et al., 1994 Hand OA	1. NA 2. NA	1. NA 2. NA	NA
Greendale et al., 2009 Adult onset hyperkyphosis	1. NA 2. Monthly symptom checklist	1. NA 2. No adverse effects	50% of **yoga** participants attended 80% or more of classes (median 79.9%). 71.1% of **control** group attended at least 4 of 6 sessions.

Table A1.6 *Summary of Individual Study Results – Secondary Outcomes (Continued)*

Study	Secondary Outcome Measures 1. Perception of Intervention 2. Adverse Events	Secondary Outcome Results 1. Perception of Intervention 2. Adverse Events	Adherence
Innes et al., 2020 Restless leg syndrome	1. Credibility/Expectation questionnaire; exit questionnaire 2. Weekly participant and instructor logs	1. Treatment expectancies did not differ between groups, expectations were unrelated to outcomes and adjustment for treatment expectancies did not alter finding, making placebo effect improbable. 2. No adverse effects	30/41 (73%) completed the 12-weeks study (13 yoga, 17 control). No significant attrition rates between groups (P=0.4). **Yoga** and **control groups** attended **81%** and **85%** of sessions, respectively. **Yoga** group completed **81% homework** sessions including 1/9 breathing exercises per non-class day.
Kuntz et al., 2018 Knee OA	1. NA 2. NI	1. NA 2. No adverse effects	Mean ± standard deviation session attendance was **yoga** 3.0±0.75, **exercise control** 2.7±0.52 and **non-exercise control** 2.7±0.62 sessions (out of 3) per week
Pandy 2019 Sarcopenia (women)	1.NA 2.NA	1.NA 2.NA	**85/788** lost to follow-up per yoga and control group over 10 years. **Yoga** group: 31.01% (218) participants attended 90% (468) of the lessons, 40.54% (285) participants attended 80% (416) of the lessons and 28.45% (200) participants attended 60%75% (312-390) of the lessons **Self-reported self-practice diary record** - 59.46% (418) of the treatment group women regularly self-practised and 40.54% (285) of the women did so occasionally Self-practice instructor report - 56.47% (397) treatment group women regularly self-practised and 43.53% (306) treatment group women did so occasionally

Table A1.6 *Summary of Individual Study Results – Secondary Outcomes (Continued)*

Study	Secondary Outcome Measures 1. Perception of Intervention 2. Adverse Events	Secondary Outcome Results 1. Perception of Intervention 2. Adverse Events	Adherence
Teut et al., 2016 Chronic low back pain	1. Credibility and satisfaction scale of 1-10 2. NA	1. Satisfaction: **yoga** group 7.8 ± 2.7, **qigong** group 7.9 ± 2.3. Credibility: **yoga** group 8.2 ± 2.1, **qigong** group 8.2 ± 2.4. Likely to recommend the therapy: **yoga** group mean satisfaction score 8.5 ± 2.2 **qigong** group mean score 8.6 ± 2.2. 2. NR	**Yoga** 71% participated in >75% classes, and 12.9% in 50-75%. **Qigong exercise control group** 72.7% participated in >75% of the classes and 18.2% in 50-75%
Ward et al., 2018 Rheumatoid arthritis	1. Semi-structured questionnaire 2. Adverse Effects (Primary safety outcomes included the type and frequency of adverse events)	1. Yoga 88% very satisfied, 100% preferred group classes to home practice. Preferred practices: relaxation practices (54%), breathing practices (23%) and physical yoga postures (15%) 2. 13 minor events reported related to yoga intervention. 7 related to musculoskeletal pain, 2 "possibly" and 5 "probably" related to intervention, and 6 (all reported by one patient) related to nausea "definitely" related to intervention	**Group class:** 92% attended a median of 7/8 group classes. **Yoga home practice**: 38% adhered to 16/24 home practice sessions. Adherence patterns in both group and home practice were lowest in week 4
Zacharia et al., 2018 Lower limb OA	1. NA 2. NA	1. NA 2. NA	Total minutes per week of yoga relapse prevention practised (out of 120 prescribed) – as Mean (SD). **Yoga**:103.5 ±54.4, **Control** 75.5±26.1 Number of weeks adherence (out of 4 prescribed) **Yoga** 1.7±1.9, **Control** 0.8±1.0

Key to abbreviations: NA=Applicable; NI=No information

Appendix III – Pilates Systematic Review Methodology

Literature Search

Table A2.1 *Database Information and Rationale for Selection*

Name/Acronym	Definition	Content	Rationale
CENTRAL	Cochrane Controlled Register of Trials.	Reports of randomised and quasi-randomised controlled trials. Most from bibliographic databases (mainly PubMed and Embase), but also derived from other published and unpublished sources, including ClinicalTrials.gov	High-quality evidence updated monthly. Trusted source for independent evidence to inform healthcare decision making.
CINAHL	Cumulative Index of Nursing and Allied Health Literature	Texts from nursing and allied health journals	Includes literature on rehabilitative therapies under the umbrella of 'Allied Health'
Google Scholar	Google's Scholastic Search Engine	Academic articles, books	To retrieve texts incorrectly cited in other databases, widen the search and reduce risk of publication bias
PUBMED	US National Library of Medicine	Biomedical and life sciences literature	Includes US literature and incorporates Medline biomedical content
PsycInfo	American Psychological Society database	Psychology abstracts and articles	To capture studies with qualitative/QOL outcomes. QOL and psychological aspects considered in this review as a secondary outcome
SCOPUS	Dutch Analytics Company Elsevier’s abstract and citation database	Journals in life sciences, social sciences, physical sciences and health sciences.	Superior quality and coverage. All included journals reviewed each year to ensure high quality standards are maintained
Web of Science (Core Collection)	Database created by Institute for Scientific Information, now maintained by Clarivate Analytics	Scientific and scholarly research in science, social science and humanities disciplines.	Peer-reviewed, high-quality scholarly journals conference proceedings and book data. Broadens the scope to non-clinical disciplines and beyond journal articles and RCTs

Table A2.2 *Other Internet Sources and Rationale for Selection*

Name/Acronym	Definition	Content	Rationale
ETHOS.bl.UK	British Library	Over 500,000 doctoral theses from British higher education establishments	Dissertations
Opengrey.eu	System for Information on Grey Literature in Europe	Technical or research reports, doctoral dissertations, conference papers, official publications, and other types of grey literature. Science, Technology, Biomedical Science, Economics, Social Science and Humanities.	Unpublished material to ensure against publication bias
Worldcat.org	Union catalogue operated by OCLC Online Computer Library Center, Inc.	Collections of 72,000 libraries in 170 countries and territories that participate in the Online Computer Library Center (OCLC) global cooperative.	Unpublished material to ensure against publication bias International perspective

Excluded Studies with Reasons for Exclusion

Studies Excluded After Full Text Assessment

Study	Primary Reason for Exclusion	Notes
Dsa 2014	Population	Mean age not 50+
Gaskell & Williams 2018	Design	Not RCT
Junges 2012	Intervention	Pilates with apparatus (not exclusively mat-based)
Kofotolis 2016	Population	Mean age not 50+
Patru 2017	Other	Abstract only. Unpublished study not available

Risk of Bias Assessment

Table A2.3 shows the risks found in each domain and the overall risk assessment for each study. Table A2.4 shows details of the methodological quality issues affecting in each study.

Table A2.3 *Risk of Bias Summary*

Study	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5	Overall
Cruz-Diaz 2015	Low	High	High	Low	Low	***High***
Donzelli 2006	Some	Some	Low	Low	Low	***Some***
Dunleavy 2016	High	High	High	High	Some	***High***
Küçükçakir 2013	Some	Some	Low	Low	Low	***Some***
Mazloum 2018	Some	High	High	Low	Low	***High***
Notarnicola 2014	Low	High	High	Low	Low	***High***
Oksuz 2017	Low	Low	Low	Some	Some	***Some***

Domains
(1) bias arising from the randomisation process
(2) bias due to deviations from intended interventions
(3) bias due to missing outcome data
(4) bias in measurement of the outcome
(5) bias in selection of the reported result

Table A2.4 *Risk of Bias Detail*

Study	Quality Assessment
Cruz-Diaz 2015	**High Risk**. Missing outcome data. No intention to treat (ITT) analysis used. Reasons for drops-outs not given and drop-outs not analysed, therefore effect of assignment to intervention imprecise. Also: Intervention favours the outcome measure in terms of function. Not a valid comparison.
Donzelli 2006	**Some concerns**. Randomisation and reporting. No reporting of baseline characteristics No ITT analysis, but all drop-outs occurred before intervention started. No information on pre-specified plan or trial protocol and no reference to ethics approval
Dunleavy 2016	**High Risk**. Randomisation, blinding, missing outcome data. Quasi-randomised design. Non-blinded study. High drop-out rate with no intention to treat (ITT) analysis.
Küçükçakir 2013	**Some concerns.** Randomisation, Missing outcome data. Baseline differences. Pilates group fitter at baseline and multiple exercises more likely to influence sit-to-stand and functional outcomes. Motivational component of being in a class. No ITT analysis but drop-outs unrelated to intervention.
Mazloum 2018	**High Risk**. Missing outcome data. No intention to treat (ITT) analysis used. Reasons for drops-outs cited only as "personal" and drop-outs not analysed so impact of missing data unclear. Also: Insufficient data on baseline levels of function, baseline levels of pain and gender distribution between groups
Notarnicola 2014	**High Risk.** Randomisation Trial was not randomised resulting in significant differences in baseline characteristics. Control group self-selected by defaulting into inactivity group based on lack of interest or motivation to participate in Pilates.
Oksuz 2017	**Some Concerns.** Measurement of Outcome, Reporting of Outcome Use of many outcome measures likely to favour experimental group No information on assessor blinding

References to Included Studies (Pilates Systematic Review)

Cruz-Díaz, D., Martínez-Amat, A., De La Torre-Cruz, M. J., Casuso, R. A., De Guevara, N. M. L., & Hita-Contreras, F. (2015). Effects of a six-week Pilates intervention on balance and fear of falling in women aged over 65 with chronic low-back pain: A randomized controlled trial. *Maturitas*, *82*(4), 371–376. https://doi.org/10.1016/j.maturitas.2015.07.022

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Mazloum, V., Rabiei, P., Rahnama, N., & Sabzehparvar, E. (2018). The comparison of the effectiveness of conventional therapeutic exercises and Pilates on pain and function in patients with knee osteoarthritis. *Complementary Therapies in Clinical Practice*, *31*, 343–348. https://doi.org/10.1016/j.ctcp.2017.10.008

Notarnicola, A., Fischetti, F., Maccagnano, G., Comes, R., Tafuri, S., & Moretti, B. (2014). Daily pilates exercise or inactivity for patients with low back pain: A clinical prospective observational study. *European Journal of Physical and Rehabilitation Medicine*, *50*(1), 59–66. http://www.ncbi.nlm.nih.gov/pubmed/24104699

Oksuz, S., & Unal, E. (2017). The effect of the clinical pilates exercises on kinesiophobia and other symptoms related to osteoporosis: Randomised controlled trial. *Complementary Therapies in Clinical Practice*, *26*, 68–72. https://doi.org/10.1016/j.ctcp.2016.12.001

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Gaskell, L., & Williams, A. E. (2018). A qualitative study of the experiences and perceptions of adults with chronic musculoskeletal conditions following a 12-week Pilates exercise programme. *Musculoskeletal Care*, *17*(1):54-62. https://doi.org/10.1002/msc.1365

Junges, S., Gottlieb, M. G., Baptista, R. R., Quadros, C. B. de, Resende, T. de L., & Gomes, I. (2012). Effectiveness of Pilates method for the posture and flexibility of women with hyperkyphosis. *Brazilian Journal of Science and Movement*, *20*(1), 21–33.

Kofotolis, N., Kellis, E., Vlachopoulos, S. P., Gouitas, I., & Theodorakis, Y. (2016). Effects of Pilates and trunk strengthening exercises on health-related quality of life in women with chronic low back pain. *Journal of Back and Musculoskeletal Rehabilitation*, *29*(4), 649–659. https://doi.org/10.3233/BMR-160665

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Table A2.5 *Summary of Individual Study Results*

Study (Colour = Risk of Bias Assessment, Table E.2)	**Outcome Measures** **1. Pain** **2. Disability** **3. Physical Function** **4. QOL** **5. Strength** **6. Flexibility** **7. Balance**	**Effect Size, Mean Difference 95% Confidence Intervals/** **@ Follow-up**	***P* values ≤0.05 = clinically significant effect in bold** ***Values are versus non exercise control except where noted otherwise***	**Summary of Key Results**
Cruz-Diaz 2015 Chronic Low Back Pain (Women 65+)	1. NRS 2. NA 3. TUG 4. NA 5. NA 6. NA 7. TUG	NI @6 weeks	**1. *P*=0.000** 2. NA **3. P=<0.01** 4-6. NA **7. P=<0.01** all vs. physiotherapy-only control	**Pilates in addition to physiotherapy improved in pain, functional and balance outcomes more than physiotherapy alone.** Both groups improved from baseline.
Donzelli 2006 Chronic Low Back Pain	1. VAS 2. OLBPDQ 3. NA 4-7. NA	NI @6 months	NI	Pilates results comparable to Back School method.
Dunleavy 2016 Chronic mechanical neck pain	1. NDI 2. NDI 3-7. NA	1 .-2.0 (-3.03, -0.96) vs control, -4.0 (-1.40, 0.60) vs yoga 2. -5.70 (-9.44, -1.95) vs control, -1.30 (-4.44, 1.84) vs yoga @ 12 weeks	**1. *P*=0.0006** vs control**,** P=0.44 vs yoga **2. *P*=0.0039** vs control, P=0.42 vs yoga 3-7. NA	**Pain and disability improved in Pilates and yoga groups with no change in control group.** Moderate-to-large effect sizes (0.7 to 1.8) and low numbers needed to treat were found. There were no significant differences in outcomes between the exercise groups.

Table A2.5 *Summary of Individual Study Results (Continued)*

Study (Colour = Risk of Bias Assessment, Table E.2)	**Outcome Measures** **1. Pain** **2. Disability** **3. Physical Function** **4. QOL** **5. Strength** **6. Flexibility** **7. Balance**	**Effect Size, Mean Difference 95% Confidence Intervals/ @ Follow-up**	***P* values <u><</u>0.05 = clinically significant effect (in bold)**	**Summary of Key Results**
Küçükçakir 2013 Postmenopausal Osteoporosis	1. VAS, SF-36 2. NA 3a. 6 mi. walk test, 3b.sit-to-stand test, 3c. SF-36 4a. Qualeffo 41, 4b.SF-36 5-7. NA	1. -2.7 (-3.19, -2.20) on VAS 2. NA 3.17.5 (8.43, 26.5) on SF-36 4. -18.8 (-24.0, -13.5) on Qualeffo-41 5-7. NA @1 year	1. ***P*=<0.001** 2.NA 3abc. ***P*=<0.001** 4ab. ***P*=<0.001** all vs. home exercise control	Both groups showed significant improvement in primary outcomes with **superiority of Pilates in pain, physical function, and quality of life.**
Mazloum 2018 Knee Osteoarthritis	1. Lequesne Index 2. Lequesne Index 3a. Timed walk, sit-to-stand test, stairs,3 b. target knee angle reproduction (Biodex 3) 4-7. NA	1. 2.1 (1.7, 2.6) vs control, 0.6 (0.2,1.1) vs exercise 2. 2.1 (1.7, 2.6) vs control, 0.6 (0.2,1.1) vs exercise 3a. 9.4 (7.2, 11.6) vs control, -3.0 (-2.5,1.8) vs exercise 3b. -1.5 (1.1-1.9) vs control, -0.1 (-0.5,0.2) vs exercise 4-7.NA @8 weeks	1. ***P*=0.000** vs control (**P=0.003** vs therapeutic exercises) 2. ***P*=0.000** vs control (**P=0.003** vs therapeutic exercises) 3a. ***P*=0.000** vs control (p=0.938 vs therapeutic exercises) 3b**.** ***P*=0.000** vs control (P=0.727 vs therapeutic exercises) 4-7. NA	**Significant difference (*P*=<0.001) in both Pilates and exercise groups versus non-exercise control. Pilates was significantly superior for pain and disability (*P*=0.003)**

Table A2.5 *Summary of Individual Study Results (Continued)*

Study (Colour = Risk of Bias Assessment, Table E.2)	Outcome Measures 1. Pain 2. Disability 3. Physical Function 4. QOL 5. Strength 6. Flexibility 7. Balance	Effect Size, Mean Difference 95% Confidence Intervals/ @ Follow-up	P values <0.05 = clinically significant effect (in bold)	Summary of Key Results
Notarnicola 2014 Low back pain	1a. ODLBPQ, SF-36 2a. OLBPDQ, 2b. RMDQ. 3a.SF-36, 3b. SFS 4. SF-36 5-7. NA	1. -11.1 (-19.1, -3.08) on ODLBPQ 2. -1.5 (-4.08, .1.08) on RMDQ 3. 2.0 (-8.7, 12.7) on SF-36 4. No combined result reported @ 6 months	1a. ***P*=0.006**,1b. ***P*=0.0006** 2a. ***P*=0.006** 2b. *P*=0.12 3a. *P*=0.35, 3b. *P*=0.27 4. ***P*<0.05 for pain, health, vitality, role limitations and physical problems, and mental health.**	**Significant improvements in pain, disability and the quality of life domains of pain health, vitality, role limitation and physical problems and mental health in Pilates group versus inactivity.** Significant functional improvements, and improvements in QOL domains of physical/social functioning, vitality and emotional limitations versus baseline.
Oskuz 2017 Osteoporosis	1a. VAS, 1b. SF-McGill,1c. PD, 1d. Qualeffo 41 2.ODI 3a. CSRT, 3b. CSST, 3c. TUG ,3d. HAQ, 3e. Qualeffo-41 4a. HADS, 4b. SLS, 4c. Qualeffo-41 5. CSST 6a. CSRT, 6b. Back scratch test 7. Berg Balance Test	1. -5.55 (-7.66, -3.43) on VAS 2. -9.2000 (-11.63, -6.76) 3. 5.73 (3.69, 7.76) on Qualeffo-41 4. -6.21 (-7.97, -4.44) Qualeffo-41 5. 22.70 (21.85, 23.54) on CSST 6. No combined result reported 7. 1.70 (1.14, 2.25) @ 6 weeks	***P*=<0.05** for all 7 outcomes and all measurements	**Pilates group showed significant improvement in all outcomes compared to the control group.**

Key to Abbreviations: BBT=Berg Balance Test, CSRT=Chair Sit and Reach Test, CSST=Chair Sit and Stand Test, HADS=Hospital Anxiety and Depression Scale, HAQ-DH=Health Assessment Questionnaire Disability Index, NA=Not Applicable, NDI=Neck disability index, NI=No Information NRS=Numerical Rating Scale, ODI=Oswestry Disability Questionnaire, OLBPDQ=Oswestry Low Back Pain Disability Questionnaire, PDI=Pain Disability Questionnaire, Qualeffo-41=Questionnaire of the European Foundation of Osteoporosis, RMDQ=Roland Morris Disability Questionnaire, SF 36=Quality of Life Short Form 36, SFS=Spinal Functioning Sort Questionnaire, SLS= Satisfaction with Life Survey, SF McGill=Short Form McGill Pain Questionnaire, TUG=Timed Up and Go Test, VAS= Visual Analogue Scale

Appendix IV – Yoga and Pilates Participation Questionnaire

Consent form

Thank you for taking part in this survey. Please read and answer the following questions to provide your consent to participating in this study.

* 1. I have read and understood the participant information sheet (v1.0 13/1/20)

Yes

No

* 2. I have had the opportunity to consider the information, and have no questions or have had any questions answered satisfactorily.

Yes

No

* 3. I understand that my participation in completing this survey questionnaire is voluntary.

Yes

No

* 4. I understand that the survey questionnaire is completed anonymously and that no identifying data will be taken.

Yes

No

* 5. I understand that once I have completed the questionnaire I cannot withdraw my responses.

Yes

No

* 6. I understand that my answers will be used to support other research in the future, and may be shared anonymously with other researchers, including in published form.

- Yes
- No

* 7. I understand that there is no compensation or payment for provided for taking part in this survey.

- Yes
- No

* 8. I agree to take part in this study.

- Yes
- No

Tell us about yourself

* 9. What is your date of birth?

Day/Month/Year

DD/MM/YYYY

* 10. Are you

- Male
- Female
- Other gender identity

* 11. Which of the following categories best describes your employment status?

Employed, working full-time

Employed, working part-time

Not employed, looking for work

Not employed, NOT looking for work

Retired

Disabled, not able to work

* 12. Do you have any of the following chronic* conditions (*lasting 3 months or more)

- [ ] Back pain
- [ ] Neck pain
- [ ] Rheumatoid Arthritis
- [ ] Osteoporosis
- [ ] Knee osteoarthritis
- [ ] Other osteoarthritis - please specify in comment box below
- [ ] Other musculoskeletal (muscle, bone or joint) condition(s) - please specify in comment box below

If other osteoarthritis or other musculoskeletal condition, please specify below

Do you attend Yoga classes?

* 13. How often do you currently attend yoga classes?

- Once a week
- Twice a week
- More than twice a week
- Twice a month or less
- Never (please go to question 24)

Yoga and You

14. When did you first start attending yoga classes?

- Less than one month ago
- 6-12 months ago
- 1-2 years ago
- 3-5 years ago
- Over 5 years ago
- Over 10 years ago

15. What time of day do you attend yoga class (check all that apply)

- Before 9am
- Morning after 9am
- Midday
- Afternoon
- Evening
- Monday-Friday
- Weekends

16. What factors influence which yoga class or classes you attend ? (check all that apply)

- ☐ The teacher
- ☐ The style of the class
- ☐ The level of the class
- ☐ The time of the class
- ☐ Other (please specify below)

17. What are your reasons for attending yoga class? (check all that apply)

- ☐ Stress reduction
- ☐ To develop muscular tone and strength
- ☐ To improve flexibility
- ☐ To improve balance
- ☐ To socialise
- ☐ Yoga helps relieve the symptoms of a health condition
- ☐ Other (please provide details below)

18. If yoga helps relieve the symptoms of a health condition, please provide details below.

19. Have you ever sustained an injury during a yoga class?

- No
- Yes
- Not sure

If you answered "YES" or "NOT SURE", please provide details below.

20. Do you feel that group yoga classes cater to your needs?

- Always
- Sometimes
- Rarely
- Never

21. How could group yoga classes better accommodate the needs of adults over 50 years? (check all that apply)

- ☐ Not applicable - my needs are met
- ☐ Provision of classes specifically for older adults
- ☐ More modifications offered by the teacher
- ☐ More classes led by older teachers
- ☐ Smaller class sizes
- ☐ Slower paced classes
- ☐ Other (please specify below)

For those not attending yoga...

22. If you do NOT attend yoga classes, what is the reason? (check all that apply)

☐ Cost

☐ Class time

☐ Class location

☐ Class teacher

☐ Yoga is too physically difficult for me

☐ Yoga is too physically easy for me

☐ Yoga is painful for me

☐ I have a health condition that makes yoga unsuitable ☐

Other (please specify below)

23. If you have health condition that makes yoga unsuitable, please provide details below.

Do you attend Pilates classes?

* 24. How often do you currently attend Pilates classes?

- Once a week
- Twice a week
- More than twice a week
- Twice a month or less
- Never (please go to question 33)

Pilates and You

25. When did you first start attending Pilates classes?

- Less than one month ago
- 6-12 months ago
- 1-2 years ago
- 3-5 years ago
- Over 5 years ago
- Over 10 years ago

26. What time of day do you attend Pilates class (check all that apply)

- [ ] Before 9am
- [ ] Morning after 9am
- [ ] Midday
- [ ] Afternoon
- [ ] Evening
- [ ] Monday-Friday
- [ ] Weekends

27. What factors influence which Pilates class or classes you attend? (check all that apply)

- ☐ The teacher
- ☐ The style of the class
- ☐ The level of the class
- ☐ The time of the class
- ☐ Other (please specify below)

28. What are your reasons for attending Pilates class? (check all that apply)

- [ ] Stress reduction
- [ ] To develop muscular tone and strength
- [ ] To improve flexibility
- [ ] To improve balance
- [ ] To socialise
- [ ] Pilates helps relieve the symptoms of a health condition
- [ ] Other (pleave provide details below).

29. If you Pilates helps relieve the symptoms of a health condition, please provide details below.

30. Have you ever sustained an injury during a Pilates class?

- No
- Yes
- Not sure

If you answered "YES" or "NOT SURE", please provide details below.

31. Do you feel that group Pilates classes cater to your needs?

- Always
- Sometimes
- Rarely
- Never

32. How could group Pilates classes better accommodate the needs of adults over 50 years? (check all that apply)

- [ ] Not applicable - my needs are met
- [ ] Classes specifically for older adults
- [ ] More modifications offered by the teacher
- [ ] More classes led by older teachers
- [ ] Smaller class sizes
- [ ] Slower paced classes
- [ ] Other (please specify)

For those not attending Pilates...

33. If you do NOT attend Pilates classes, what is the reason? (check all that apply)

- [ ] Cost
- [ ] Class time
- [ ] Class location
- [ ] Class teacher
- [ ] Pilates is too physically difficult for me
- [ ] Pilates is too physically easy for me
- [ ] Pilates is painful for me
- [ ] I have a health condition that makes Pilates unsuitable
- [ ] Other (please specify below)

34. If you have a health condition that makes Pilates inaccessible to you, please provide details below.

Your exercise preferences

* 35. Which do you prefer?

- Yoga
- Pilates
- No preference

Please state reasons for your answer

* 36. What other exercise do you participate in at least twice per month? (check all that apply)

- ☐ Gym group exercise other than yoga or Pilates
- ☐ Cycling/indoor cycling
- ☐ Running
- ☐ Swimming
- ☐ Football
- ☐ Martial arts
- ☐ Walking or hiking
- ☐ Dance class
- ☐ Racquet sport (e.g. tennis/badminton/squash)
- ☐ No other exercise
- ☐ Other (please specify)

You're all done

Thank you for completing the questionnaire.

Appendix V – Ethics Approval Documentation

Ethics Documents – Survey

University of Salford MANCHESTER

Yoga & Pilates Participation Survey – Participant Information Sheet (V1.0 13/1/20)

Researcher: Laura Denham-Jones, PhD student at University of Salford School of Health & Society L.Denham-Jones@edu.salford.ac.uk

You are being invited to take part in a research project. Before you decide on whether to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully before you decide whether or not you wish to take part. You are welcome to discuss this project with others if you wish before you make your decision. Please email the researcher at L.Denham-Jones@edu.salford.ac.uk if there is anything that is not clear or if you would like further information.

What is the purpose of the survey?

The purpose of the survey is to gain an understanding of respondents' reasons and motivations for choosing whether to take part in yoga or Pilates (or both) and how well yoga and Pilates group classes suit the needs of participants over the age of 50.

Do I have to take part?

Completion of the survey questionnaire is voluntary. It is up to you to decide whether or not to take part. If you do decide to take part, you should keep this information sheet for reference. In addition, you will be asked to complete a consent form prior to actively participating in the study.

Will my participation in the survey be confidential?

Yes. Confidentiality will be safeguarded during and after the study and will be compliant with General Data Protection Regulation (GDPR). No personally identifying information or contact details will required or taken to complete the survey questionnaire. The questionnaire is anonymous and responses given a research code, known only to the researcher. Data/responses collected will not be shared with any third party.

What is required if I choose to take part?

You will be required to complete an anonymous online survey questionnaire at surveymonkey.co.uk. The questionnaire consists of questions about your current age, exercise habits, musculoskeletal (muscle and bone) health status, and participation in yoga or Pilates classes. Answers will be given in check box or multiple choice form. Some questions include text boxes for you to provide additional information or comments. The questionnaire can be completed on a personal computer, tablet or mobile device and will take approximately 10-12 minutes to complete.

Can I withdraw from the study?

Once the questionnaire is complete you will not be able to withdraw and the responses collect will be used in the research project. However, responses remain anonymous and no identifying information will be taken at any point during this research survey.

How will the survey questionnaire data (responses) be used?

Your questionnaire responses will be used by the researcher and the research supervisors to aid in planning a future comparative trial of yoga and Pilates as part of the larger PhD project. The University may keep the data and use it in future studies. The data gathered from the survey may also be used in written work that may be published. In all cases, you will not be identified in any report or publication. All usage will be anonymised.

How long will the data be stored?

The University of Salford advises that research data should be held for a minimum of ten years after the completion of the research. The actual retention period may be longer where the data is actively used or where otherwise required to retain it as a condition of the research funding.

What are the benefits of taking part in this survey?

The overall aims of the PhD research project is to understand and enhance the way yoga and Pilates are accessed and delivered to meet the needs of adults over 50. As a participant in yoga or Pilates your role in the survey will contribute to this aim, with potential benefits to others in this population.

Who funds or sponsors this research?

The PhD student is self-funded at this time. There is no financial third party sponsor or funding body.

Who can I contact in relation to this study?

If you have a concern about any aspect of this study, you should contact the researcher by email at L.Denham-Jones@edu.salford.co.uk who will do their best to answer your questions.

Following this, if you have any issues or complaints, you may contact the research supervisor Dr Nicola Spence at the University of Salford by email N.Spence@salford.ac.uk or by telephone 0161 295 0700 or Chair or the Ethics committee at the University of Salford, Linda Dubrow Marshall by email l.dubrow-marshall@salford.ac.uk or by telephone 0161 295 6988.

Thank you for taking the time to read this information sheet.

[NOTE: THIS FORM WAS BUILT INTO THE ONLINE SURVEY]

Yoga & Pilates Participation Survey – Participant Consent Form

Researcher: Laura Denham-Jones, PhD student at University of Salford School of Health & Society
L.Denham-Jones@edu.salford.ac.uk

1. I confirm that I have read the information sheet (v1.0 13/1/20) for this study.
   Yes/No
2. I have had the opportunity to consider the information and have no questions or have had any questions answered satisfactorily.
   Yes/No
3. I understand that my participation in completing this survey questionnaire is voluntary.
   Yes/No
4. I understand that the survey questionnaire is completed anonymously and that no identifying data will be taken.
   Yes/No
5. I understand that once I have completed the questionnaire I cannot withdraw my responses.
   Yes/No
6. I understand that my answers will be used to support other research in the future, and may be shared anonymously with other researchers, including in published form.
   Yes/No
7. I understand that there is no compensation or payment for provided for taking part in this survey.
   Yes/No
8. I agree to take part in this study.
   Yes/No

________________________	__________________	__________________
Name of participant	**Date**	**Signature**
________________________	__________________	__________________
Name of person taking consent	**Date**	**Signature**

If you have a concern about any aspect of this study, you should contact the researcher by email at L.Denham-Jones@edu.salford.co.uk who will do their best to answer your questions.

Following this, if you have any issues or complaints, you may contact the research supervisor Dr Nicola Spence at the University of Salford by email N.Spence@salford.ac.uk or by telephone 0161 295 0700 or Chair or the Ethics committee at the University of Salford, Linda Dubrow-Marshall by email l.dubrow-marshall@salford.ac.uk or by telephone 0161 295 6988.

Risk Assessment Form - Survey

Task/Activity/Environment: Online survey	**Location:** Unknown (Online activity)	**Date of Assessment:** 11/12/19

Identify Hazards which could cause harm:		**Identify risks = what could go wrong if hazards cause harm:**	
No.	**Hazard**	**No.**	**Risk**
1	Use of participants' time	1	Inconvenience in taking personal time to complete survey
2	Requiring participants' emotional labour	2	Effort to answer personal questions pertaining to health and exercise may be construed as intrusive
3	Misuse of data	3	Participants may have concerns that personal data will be shared without consent

List groups of people who could be affected: **Participants completing the online survey**	**What numbers of people are involved?**

What risk controls are in place to reduce risks?		**Risk level with risk controls**
No.	**Risk Control**	
1a	Survey is designed to be completed in 10-15 minutes	**Acceptable**
1b	Participants will be informed of approximate required time commitment via participant information sheet	**Acceptable**
2a	Participants will be informed of the general natural of questions via participant information sheet	**Acceptable**
2b	Participants will provide informed consent	**Acceptable**
2c	Completion of the survey is voluntary	**Acceptable**
3a	Participant information sheet will explain how survey information will be use	**Acceptable**
3b	Participants will provide informed consent	**Acceptable**
3c	Survey will be GDPR compliant and secure using Surveymonkey.co.uk	**Acceptable**
3d	No personally identifying information will be taken	**Acceptable**

What additional actions are required to ensure risk controls are implemented/effective or to reduce the risk further?		**Risk level with additional risk controls**
No.		
	N/A	

Is health surveillance required? **NO**	**If YES, please detail:**

Who will be responsible for implementing risk controls: The researcher – Laura Denham-Jones	**By When:** Before, during and after survey recruitment, implementation and analysis

Completed by: **Laura Denham-Jones** **Signed:** Laura Denham-Jones

Record of Annual Review: **……………………………………………**

Risk Rating:

5	10	15	20	25
4	8	12	16	20
3	6	9	12	15
2	4	6	8	10
1	2	3	4	5

Increasing Consequence

Increasing Likelihood

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice
10-16 Tolerable – look to improve within specified timescale
5-9 Adequate – Look to improve at next review
1-4 Acceptable - No further action, but ensure controls are maintained

Guide to using the risk rating table:

Consequences	Likelihood
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening
2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening

Risk Assessment Form Checklist

ALL projects MUST include a risk assessment. If this summary assessment of the risk proves insignificant, i.e. you answer 'no' to all of the questions, then no further action is necessary. However, if you identify any risks then you must identify the precautions you will put in place to control these.

1. What is the title of the project?

Yoga and Pilates participation survey

2. Is the project purely literature based? YES/NO

If YES, please go to the bottom of the assessment and sign where indicated. If NO, then please complete section 3 and list your proposed controls.

3. Please highlight the risk(s) which applies to your study:

Hazards	Risks	If yes, consider what precautions will be taken to minimise risk and discuss with your Supervisor
Use of ionising or non-ionising radiation	*Exposure to radiation* ***YES/NO***	*Obtain copy of existing risk assessment from place of research and attach a copy to this risk assessment summary.*
Use of hazardous substances	*Exposure to harmful substances* ***YES/NO***	*Obtain copy of existing risk assessment from place of research and attach a copy to this risk assessment summary.*
Use of face-to-face interviews *Interviewees could be upset by interview and become aggressive or violent toward researcher*	*Interviewing …* *Own classmates=Low risk* ***YES/NO*** *Other University students=Medium risk* ***YES/NO*** *Non-University personnel=High risk* ***YES/NO***	***NB:*** *Greater precautions are required for medium & high risk activities* ***Consider:*** • *How contact with participants will be made - i.e. do not give out personal mobile number, home number or home email, etc.* • *Location of interviews – to be held in a safe environment, e.g. University building, workplace.* • *What support will be available, i.e. will anyone else be available to assist if you call for help, etc. e.g. a colleague knows where the interview is to take place and will be contacted when completed and safe – and what action to take after a certain time if not contacted*

		• *How to deal with aggressive/violent behaviour, what precautions will be taken to prevent this from happening?*
Use of face-to-face interviews *Participants or interviewees could become upset by interview and suffer psychological effects*	***YES/NO***	***Consider:*** • *What initial and subsequent support will be made available for participants or interviewees?* • *What to do if researcher uncovers information regarding an illegal act?* • *What/who will be used to counsel distressed participants/interviewees, and what precautions will be taken to prevent this from happening?*
Sensitive data	*Exposure to data or information which may cause upset or distress to the researcher* ***YES/NO***	***Consider:*** • *What initial and subsequent support will be available to the researcher*
Physical activity	*Exposure to levels of exertion unsuitable for an individual's level of fitness* ***YES/NO***	***Consider:*** • *Health Questionnaire/ Medical declaration form / GP clearance.* • *Trained First Aid personnel/ Equipment.*
Equipment	*Exposure to faulty or unfamiliar equipment.* ***YES/NO***	***Consider**:* • *Equipment is regularly checked and maintained as per manufacturer's instructions.* • *Operators receive adequate training in the use of.* • *Participants receive induction training prior to use.*
Sensitive issues i.e. Gender/Cultural e.g. when observing or dealing with undressed members of the opposite sex	*Exposure to vulnerable situations/ sensitive issues that may cause distress to interviewer or interviewee* ***YES/NO***	***Consider:*** • *Use of chaperones/translators.* • *What initial and subsequent support will be made available for participants or interviewees?*

Children	***YES/NO***	• *Adhere to local guidelines and take advice from research supervisor.*
Manual handling activities	*Exposure to an activity that could result in injury* ***YES/NO***	• *Adapt the task to reduce or eliminate risk from manual handling activities. Ensure that participants understand and are capable of the manual handling task beforehand.* • *Perform health questionnaire to determine participant fitness prior to recruitment.*

If you have answered 'YES' to any of the hazards in section 3, then please list the proposed precautions below:

Signature of student …… Laura Denham-Jones …… Date ………13/1/20………………..

Signature of Supervisor ………Nicola Jane Spence…………….. Date ……14/1/20……………………

University of Salford MANCHESTER

Research, Enterprise and Engagement
Ethical Approval Panel

Doctoral & Research Support
Research and Knowledge Exchange,
Room 827, Maxwell Building,
University of Salford,
Manchester
M5 4WT

T +44(0)161 295 2280

www.salford.ac.uk

3 April 2020

Dear Laura,

RE: ETHICS APPLICATION–HSR1920-064 – Yoga and Pilates participation survey

Based on the information that you have provided, I am pleased to inform you that application HSR1920-064 has been approved.

If there are any changes to the project and/or its methodology, then please inform the Panel as soon as possible by contacting Health-ResearchEthics@salford.ac.uk

Yours sincerely,

Professor Andrew Clark
Chair of the Research Ethics Panel

Ethics Documents – Trial

A Study of the Benefits of Yoga and Pilates Classes for Adults over 50 Years

Participant Information Sheet

Researcher: Laura Denham-Jones, PhD student at University of Salford School of Health & Society L.Denham-Jones@edu.salford.ac.uk

Study website: yogapilatestrial.co.uk

You are being invited to take part in a research project. Before you decide on whether to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully before you decide whether or not you wish to take part. You are welcome to discuss this project with others if you wish before you make your decision. Please email the researcher at l.denham-jones@edu.salford.ac.uk if there is anything that is not clear or if you would like further information.

What is the purpose of the study?

The purpose of the study is to gain an understanding of the relative benefits of a yoga and Pilates programme designed for middled-age and older adults and assess their effects on physical function, pain and quality of life. Participants will be assigned to either a yoga or Pilates class for eight weeks. This will be preceded and followed up with a measure of physical function, pain and quality of life to record their levels before and after the exercise programme and measure any changes effected by the exercise programme. In additional information about participants' experiences of the classes (such as enjoyment, effects and challenges) will be gathered by anonymous survey in the final week of the exercise programme after the concluding session. One aim is to assess whether one of the programmes yoga or Pilates is more effective than the other for any outcomes. Another is to compare the results to a previous survey of older adults taking place in general Pilates and yoga. This is to assess how well yoga and Pilates group classes suit the needs of participants over the age of 50 and whether this age group can benefit more from the provision of more classes specifically for older people. Secondarily, the research will also assess the feasibility and acceptability of video/hybrid delivery of group exercise, both in conducting a trial and in the "real world".

How do I take part?

Initially you will need to complete a questionnaire to assess your eligibility. If eligible you will continue to the next section of the online registration process to provide informed consent and your contact details.

Who decides whether I take part?

Taking part is voluntary. If selected, it is up to you to decide whether or not to take part. If you do decide to take part, you should keep this information sheet for reference. In addition, you will be asked to complete a consent form and physical activity readiness questionnaire, prior to actively participating in the study. In agreeing to participate in the yoga or Pilates class, you will be agreeing to take part fully in the research including the measures of physical function, pain and quality of life and the questionnaire (unless you request to withdraw – details on withdrawal are below).

Will my participation in the study be confidential?

You will be required to provide your name and contact details in order to participate. Confidentiality will be safeguarded during and after the study and will be compliant with General Data Protection Regulation (GDPR). No personally identifying information, contact details, personal information or data /responses will be shared with a third party. If you attend by Zoom link you will not be recorded. Responses given in pre- and post-trial surveys will be anonymised and known only to the researcher. Any publication of the findings will be anonymised.

What is required if I choose to take part?

You will be required to complete an eligibility questionnaire to determine your eligibility to take part. This is based on your age (which must be 50-75 at the start of the trial) and the absence of any health conditions or difficulties that would make if inappropriate for you to participate.

Involvement in the study requires a minimum of **one hour per week** for **eight weeks**.

If you are selected to take part, you will be randomly assigned either to a yoga group or a Pilates group, notified by email of your allocation, and will take part in eight consecutive weeks of one-hour classes held at North Side Studio, 96 North Side, Wandsworth SW18 2QU. You also have the option to take part by Zoom video link as well as a recording of the session if you are unable to, or chose not to, attend "live". If you chose to attend remotely by Zoom and do not already have a Zoom account, instructions for setting one up will be emailed to you two weeks prior to the first session, and links to the sessions will be emailed on a weekly basis. Participants will not be recorded in the Zoom session. You may interchange between in-person and Zoom sessions if you wish.

Week 1: Prior to the first session, you will be asked to complete a short anonymous online survey (approximately 15 minutes completion time) about your quality of life and rate your current back, knee and shoulder pain levels on a scale.

Week 1-8: You will participate in a one-hour yoga or Pilates class, in person, or by live or recorded video (Zoom) taught by a qualified and insured instructor. A progressive eight-week series of 30-40 minute home practice videos which will be made available online via a private link which should be used twice a week, if possible. You will also be provided a practice log for recording which sessions you completed each week.

Week 8: The online survey conducted in Week 1 will be repeated with an additional section for you to answer some questions to give feedback (for example, on topics of enjoyment, effects, and challenges) about the yoga or Pilates sessions. This process will take approximately 20-30 minutes in total. You will also be asked to submit your practice log by email or post. All data gathered will be anonymised and this material referenced only by the researcher.

Can I withdraw from the study?

In agreeing to participate you will be agreeing to take part fully in the research including the online surveys unless you request to withdraw. **Withdrawal at any stage of the programme will mean that you will no longer be able to attend the group yoga/Pilates classes.** If you are selected for the study following the eligibility questionnaire you can withdraw before or during the trial, up to and including week 8, by contacting the researcher at the email address below. You will be asked to complete a short form. You have the option to provide a reason for withdrawal (This is voluntary, not required. This information, if given, will not be shared with the group or any third parties, and is to help the researcher understand causes of any drop-outs). If you have withdrawn from the group classes (but have attended at least one of them), you can choose whether to consent to your data being use in the final research and opt in or out of the final online surveys in week 8. Following the survey in week 8, data collected up to and including this session cannot be withdrawn. If you do not request to withdraw before or during the 8th (final) week of the trial your anonymised data will be used in the research.

How long will the data be stored?

Data will be stored and archived for a maximum of 6 years. This time period represents the duration of the researcher's course of study (due to expire April 2025) plus 3 years after the graduate award has been made, to allow verification of data from external sources if necessary.

.**What are the benefits of taking part in this study?**

You will receive a free 8-week exercise programme in either yoga or Pilates. Research has shown that both yoga and Pilates can offer a range of benefits including improved strength, mobility and balance, reduced osteoarthritis pain and enhanced well-being. The overall aim of the PhD research project is to understand and enhance the way yoga and Pilates are accessed and delivered to meet the needs of adults over 50. As a participant in yoga or Pilates your role in the study will contribute to this aim, with potential benefits to others in this population.

Who funds or sponsors this research?

The PhD student is self-funded at this time. There is no financial third party sponsor or funding body.

Who can I contact in relation to this study?

A dedicated website for the study is available at yogapilatestrial.co.uk. To take part, or if you have a concern about any aspect of this study, you should contact the researcher by email at l.denham-jones@edu.salford.co.uk who will do their best to answer your questions.

Following this, if you have any issues or complaints, you may contact the research supervisor Dr Nicola Spence at the University of Salford by email N.Spence@salford.ac.uk or by telephone 0161 295 0700 or Chair or the Ethics committee at the University of Salford, Linda Dubrow-Marshall by email l.dubrow-marshall@salford.ac.uk or by telephone 0161 295 6988.

Thank you for taking the time to read this information sheet.

University of Salford MANCHESTER

A Study of the Benefits of Yoga and Pilates Classes for Adults over 50 Years
Participant Eligibility Questionnaire

PLEASE READ THE **PARTICIPANT INFORMATION SHEET** BEFORE COMPLETING THIS FORM

You may submit this form by email to: l.denham-jones@edu.salford.ac.uk or by first class post to:
Laura Denham-Jones, 27 Earlsfield Rd, Flat 3, London SW18 3DB

Name:
Address:
Phone:
Email Address:

1. Date of Birth: (you must be aged between 50 and 75 at the start of the study, to participate. The proposed start date is [TBC]):

2. Age on [study start date, TBC]:

3. Where did you hear about this study:

The Fort Gym ☐ Nuffield Fulham ☐ Online ☐

4. Have you participated in other yoga or Pilates classes or **courses explicitly aimed at the over 50 age group** in the last 12 months? Ye☐ N☐

5. Do you expect to move out of reasonable travelling distance to London SW18 in the next six months? Yes ☐ No ☐

6. Will you be available for to attend a one-hour weekly session for 11 weeks to take place between [dates TBC] at 96 North Side, Wandsworth SW18 2QU?
Yes ☐ No ☐

7. Do you have internet access at home for the viewing of online content? Yes ☐ No ☐

8. Have you had surgery in the past six months? Yes ☐ No ☐

9. Do you expect to have surgery in the next six months? Yes ☐ No ☐

10. Do you experience any of the following? (please check all the apply, otherwise leave blank)
Uncontrolled high blood pressure or unstable heart condition ☐

Acute disc prolapse or protrusion with acute neurological symptoms in the past three months ☐

Easily aggravated pain with exercise, or advice from a doctor not to avoid physical exercise at present ☐

Inability to walk or stand unassisted ☐

Inability to hear or understand verbal cues and see visual demonstration of group exercise ☐

I confirm that the information given is a true and accurate statement. Please be aware that it is your responsibility to inform us if there is a change to any of your answers

Name:	Signature:	Date:

Study of the Benefits of Yoga and Pilates Classes for Adults over 50 Years
Participant Consent Form (Consent is required for all items)

Researcher: Laura Denham-Jones, PhD student at University of Salford School of Health & Society L.Denham-Jones@edu.salford.ac.uk

1. I confirm that I have read and understood the participant information sheet [version and date] for this study. **Yes/No**
2. I have honestly and accurately completed the eligibility questionnaire [version and date] **Yes/No**
3. I have honestly and accurately completed the Physical Activity Readiness questionnaire [version and date] **Yes/No**
4. I have had the opportunity to consider the information and have no questions or have had any questions answered satisfactorily. **Yes/No**
5. I understand that my participation in completing this study is voluntary. **Yes/No**
6. I understand that I participate in the physical activity (yoga or Pilates) sessions, whether face-to-face or by live or recorded video, at my own risk **Yes/No**
7. I agree to notify the instructor in person or by email or phone as soon as possible of any injury or illness that arises during the class or during the trial that I think may affect my ability to participate. **Yes/No**
8. I understand that I may be asked to withdraw from the study should the researcher consider it unsuitable or unsafe for me to continue, a reason for which will be provided. Yes/No
9. I understand that if I am selected for the study after completion of the eligibility questionnaire, I can withdraw by contacting the researcher by email or phone. **Yes/No**
10. I understand that if I request to withdraw I will be asked to fill out a withdrawal form (stating the reason for withdrawal optional) and upon withdrawal I will not be able to attend the group classes **Yes/No**
11. I understand that I cannot withdraw my data from the research once the 8th (final) week has been completed, and that after this point my anonymised data will be included in the study. **Yes/No**
12. I understand that my practice log and comments made on the post-trial questionnaire may be shared anonymously, including in published form. **Yes/No**
13. I understand that there is no compensation or payment for provided for taking part in this study. **Yes/No**
14. I understand that anonymised data from this study will be stored for a maximum of 7 years from the ending week of the trial. **Yes/No**
15. I agree to take part in this study. **Yes/No**

___________________________	____________________	____________________
Name of participant	**Date**	**Signature**
___________________________	____________________	____________________
Name of person taking consent	**Date**	**Signature**

If you have a concern about any aspect of this study, you should contact the researcher by email at l.denham-jones@edu.salford.co.uk who will do their best to answer your questions.

Following this, if you have any issues or complaints, you may contact the research supervisor Dr Nicola Spence at the University of Salford by email N.Spence@salford.ac.uk or by telephone 0161 295 0700 or Chair or the Ethics committee at the University of Salford, Linda Dubrow-Marshall by email l.dubrow-marshall@salford.ac.uk or by telephone 0161 295 6988.

Study of the benefits of Yoga and Pilates Classes for Adults over 50 Years
Withdrawal Form
Please email this form to: l.denham-jones@edu.salford.ac.uk or by first class post to:
Laura Denham-Jones, 27 Earlsfield Rd, Flat 3, London SW18 3DB

Name:

Date of Withdrawal:
OPTIONAL: Reason for Withdrawal (please check all that apply and provide further detail. Leave this section blank if you do not wish to provide this information)

Cannot make time commitment ☐

Injury sustained in the yoga/Pilates class ☐

Injury sustained outside

Illness condition (non-injury) ☐

Other ☐

Do you consent to any data collected from you so far being used in the research? **Yes/No**

If yes:

Do you currently expect to be able to complete final outcome survey online by the end of the week commencing [date]? **Yes/No/Don't know**

I confirm that the information given is a true and accurate statement.

Signature:	**Date:**

Risk Assessment Form

TRIAL RISK ASSESSMENT FORM

Task/Activity/Environment:	**Location:**	**Date of Assessment:**
8-week exercise intervention with pre- and post-intervention survey-based data collection	Yoga studio (and participants' homes by video link)	240122

Identify Hazards which could cause harm:		**Identify risks = what could go wrong if hazards cause harm:**	
No.	**Hazard**	**No.**	**Risk**
1	Physical exercises, which may be unfamiliar to participants	**1**	Injury sustained through exercise
2	Requiring participants' emotional labour during survey	**2**	Requirement to answer personal questions pertaining to health and exercise may be construed as intrusive and discussion of personal issues such as body image, physical fitness and health status may cause distress, offense or harm.
3	Misuse of data	**3**	Participants may have concerns that personal data will be shared without consent
4	Covid-19-related risks	**4**	Risk of exposure to Covid-19

List groups of people who could be affected:	**What numbers of people are involved? 40**
Participants completing the exercise intervention and pre- and post-trial survey	

What risk controls are in place to reduce risks?		**Risk level with risk controls**
No.	**Risk Control**	
1.1	Participants will complete an eligibility questionnaire prior to recruitment, which excludes those at higher risk due to physical or mental limitations. These were compiled based a systematic review of the literature on yoga and Pilates for older adults with chronic musculoskeletal conditions.	**Acceptable**

1.2	A literature review conducted by the researcher found no adverse effects reported for Pilates and a low incidence for yoga. In the systematic reviews of yoga and Pilates completed by the student, no adverse effects were reported in the Pilates studies. In the yoga studies that reported this outcome 5.3% of participants reported non-serious adverse effects. Existing research on the safety of yoga did not find the risk significantly higher than for physical exercise in general: [Cramer, H., Ward, L., Saper, R., Fishbein, D., Dobos, G., & Lauche, R. (2015). The safety of yoga: A systematic review and meta-analysis of randomized controlled trials. *American Journal of Epidemiology*, *182*(4), 281–293. https://doi.org/10.1093/aje/kwv071]	**Acceptable**
1.3	Interventions will be delivered by a qualified and insured instructor.	**Acceptable**
1.4	Interventions will be modified for the population of study using a methodological triangulation comparing quantitative and qualitative findings from the systematic review, survey, and other extant literature on the delivery of yoga and Pilates, injury rates, and age-related contraindications.	**Acceptable**
1.6	Instructor will have undertaken the training and certification for an appointed person for First Aid	**Acceptable**
1.7	Instructor will have public liability insurance for the activities undertaken	**Acceptable**
1.8	Participants will provide informed consent, acknowledging that participation is at their own risk and will complete and sign a Physical Activity Readiness questionnaire (PAR-Q) prior to participation.	**Acceptable**
1.9	Participants will be asked about new or on-going injuries at the start of each class, offered modifications and corrections and feedback will be invited at the end of class.	**Acceptable**
1.10	All participants, including those practising “remotely”, will be asked to immediately report (in person or by email or phone to the researcher) any adverse events occurring during a class or at any point in the trial, where they believe these may affect their participation.	**Acceptable**
1.11	Participants may withdraw from the trial at any time and for any reason	**Acceptable**
2.1	Participants will be informed of the general natural of questions and themes via participant information sheet	**Acceptable**
2.2	Participants will provide informed consent	**Acceptable**
2.3	All data will be anonymised for dissemination	**Acceptable**
2.4	The role of the moderator and expectations of participants will be made clear at the start of the session	**Acceptable**
2.5	The sharing of ideas and information in the qualitative survey is voluntary. To avoid more vocal participants influencing others, the moderator will encourage but not mandate a balanced input from all participants	**Acceptable**
3.1	Participant information sheet will explain how research will be used	**Acceptable**
3.2	Participants will provide informed consent	**Acceptable**
3.3	The researcher has completed the University’s GDPR for Research module – Information Security Smart: GDPR. The General Data Protection Regulation (GDPR) is designed to give individuals better control over their personal data and establish one single set of data protection rules across Europe. A GDPR checklist has been completed and will be observed to ensure that work is in line with guidance issued by the Information Commissioner’s Office (ICO), the Legal and Information Governance team and local School procedures.	**Acceptable**

3.4	A data management plan is submitted to the Ethics Committee as part of the approval process	**Acceptable**
4.1	Should guidelines still be in place regarding Covid-19, the exercise intervention will be delivered within the parameters currently in place at the venue used.	**Acceptable**
4.2	The intervention will switch to remote delivery for some or all participants should government guidelines dictate this due guidelines related to the Covid-19 pandemic.	**Acceptable**

What additional actions are required to ensure risk controls are implemented/effective or to reduce the risk further? N/A

Is health surveillance required? **NO**	**If YES, please detail:**

Who will be responsible for implementing risk controls: The researcher – Laura Denham-Jones	**By When:** Before, during and after survey recruitment, implementation and analysis

Completed by: **Laura Denham-Jones**

Signed: Laura Denham-Jones

Risk Rating:

Increasing Consequence ↑					
	5	10	15	20	25
	4	8	12	16	20
	3	6	9	12	15
	2	4	6	8	10
	1	2	3	4	5
	Increasing Likelihood →				

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice
10-16 Tolerable – look to improve within specified timescale
5-9 Adequate – Look to improve at next review
1-4 Acceptable - No further action, but ensure controls are maintained

Guide to using the risk rating table:

Consequences	Likelihood
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening
2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening

A Study of the Benefits of Yoga and Pilates Classes for Adults over 50 Years

Data Management Plan

1. The researcher has completed the University's GDPR for Research module – Information Security Smart: GDPR. The General Data Protection Regulation (GDPR) is designed to give individuals better control over their personal data and establish one single set of data protection rules across Europe.
2. A GDPR checklist has been completed and will be observed to ensure that work is in line with guidance issued by the Information Commissioner's Office (ICO), the Legal and Information Governance team and local School procedures.
3. Data will be stored electronically on a password-protected computer and password protected secure Salford University F drive which is only accessible to the researcher.
4. All data transported on laptops and USB memory sticks will be anonymous, identified only by a code, and encrypted to protect against loss.
5. Participants will not be recorded in online video Zoom classes.
6. Paper copies of data, including consent forms and practice journals, will be stored in a locked cabinet, accessible only to the researcher.
7. Any publication of data will fully anonymise participants.
8. Data will be stored and archived for a maximum of 6 years. This time period represents the duration of the researcher's course of study (due to expire April 2025) plus 3 years after the graduate award has been made, to allow verification of data from external sources if necessary.

App Ref. 294 – Chair's Instructions following Approval – 17/12/2020

This project can be approved but the project cannot begin.

The current (17D Dec 2021) UK government guidance for indoor physical activity and exercise classes during COVID-19 means that the study is not able to commence. The proposed start date for face-to-face activity, including data collection, in summer 2021 is noted.

IMPORTANT: please contact the panel (stating the application reference number) once indoor physical activities can recommence, with an update on the start date of this project. It may be that subsequent changes to COVID-19 guidelines will mean the application has to be reviewed or amended.

Trial Ethics Committee Approval Confirmation

Amendment Notification Form

Title of Project:			
A study of the benefits of yoga and Pilates classes for adults over 50 years			
Name of Lead Applicant:	**School:**		
Laura Denham-Jones	Health Sciences		
Are you the original Principal Investigator (PI) for this study?			Yes
If you have selected 'NO', please explain why you are applying for the amendment:			
Date original approval obtained:	**Reference No:**	**Externally funded project?**	
17/12/2020	**294**	No	
Please outline the proposed changes to the project. *NB. If the changes require any amendments to the PIS, Consent Form(s) or recruitment material, then please submit these with this form highlighting where the changes have been made:*			
The following changes have been made to facilitate remote/ hybrid delivery of certain aspects of the intervention and data collection in order to accommodate potential changes in Covid-19 mitigation guidelines such as distancing, work-from-home advice or asymptomatic self-isolation requirements, during this phase of research: Use of SF-36 survey to measure physical function rather than the performance-based Senior Fitness Test. Option for participants to attend any of all of the yoga or Pilates class via Zoom link (or recorded version in the scheduled week if unable to attend live). Participants will NOT be recorded in the ZOOM video. Anonymous post-trial open text survey instead of focus group to gather qualitative data.			
Please say whether the proposed changes present any new ethical issues or changes to ethical issues that were identified in the original ethics review, and provide details of how these will be addressed:			

Participants who wish to take advantage of the "remote" delivery option will need to have access to a video streaming device in their practice space and to create a Zoom account. The Zoom option is mentioned at the stage of recruitment, internet access is required in the Participant Eligibility Questionnaire, and the need for a Zoom account is further outlined in the Participant Information Sheet.

Participants will not be recorded if participating by Zoom. This is made clear on the Participant Information Sheet.

Participants will be asked to acknowledge in the consent process that they take part remotely (or in person) at their own risk, and agree to inform the researcher of adverse events that occur (during the intervention or in the course of the trial) either in person, during the live zoom session, or by direct telephone or email contact as soon as possible.

Risk assessments have been revised to reflect the potential implementation hybrid or fully remote delivery as a contingency plan.

Amended recruitment flyer, participant information sheet, consent form, risk assessment forms, and the post-trial survey questions are attached. The changes are highlighted.

Amendment Approved: **YES**	***Date of Approval:***	**15/02/2022**

Chair's Signature:

Once completed, you should submit this form and any additional documentation to ethics@salford.ac.uk

Amendment Notification Form

Title of Project:		
A study of the benefits of yoga and Pilates classes for adults over 50 years		
Name of Lead Applicant:	**School:**	
Laura Denham-Jones	*Health Sciences*	
Are you the original Principal Investigator (PI) for this study?		Choose an item.
If you have selected 'NO', please explain why you are applying for the amendment: *Yes*		
Date original approval obtained:	**Reference No:**	**Externally funded project?**
17/12/2020	**294**	**No**

Please outline the proposed changes to the project. *NB. If the changes require any amendments to the PIS, Consent Form(s) or recruitment material, then please submit these with this form highlighting where the changes have been made:*

Amendment: The addition of one-to-one participant interviews at the end of an 8-week trial of yoga and Pilates. This is being implemented following a suggestion made by the assessors in my Internal Evaluation of March 21st 2022.
Interviews would take place in the two weeks directly following the trial. (Between 9/5 and 22/5/22).
Participants **currently taking part in the trial** will be invited to interview by email in and in person by the researcher, and informed at the same time that interview is optional and voluntarily. Interested participants will be provided (by email or in person by the researcher) with an additional 'Interview Participant Information Sheet and Consent Form.

Please say whether the proposed changes present any new ethical issues or changes to ethical issues that were identified in the original ethics review, and provide details of how these will be addressed:

The original proposal included a focus group which was approved, then removed due to concerns about Covid prevalence and restrictions just prior to the start of the project. The instatement of interviews will present ethics issues similar to the focus group. These are addressed in the attached methodology, recruitment materials, Interview PIS, Interview Consent Form and Risk Assessment. The attached PIS, Consent Form and Risk Assessment are *in addition* to those already submitted and approved and are for interview participants only.

Amendment Approved:	Yes	***Date of Approval:***	14/04/2022

Chair's Signature

:

Once completed, you should submit this form and any additional documentation to ethics@salford.ac.uk

Interview Recruitment Email

Dear XXXX,

Thank you for your continued participation in this eight-week Yoga/Pilates trial.

As an addition to the existing programme, I would like the opportunity to interview some participants about your experiences taking part in this course. This would take the form of a brief (approximately 30-45 minute) phone, Zoom or in-person one-to-one conversation at a time convenient to you between May 9th and 22nd. Taking part in an interview is **entirely optional**.

A detailed information sheet is attached for your information. After reading it, if you would like to be interviewed or have further questions, please reply to this email to let me know, and I will be in touch. You can also speak to me about this in person, before or after your weekly class.

Many thanks,

[Attachment: Interview Participant Information Sheet]

A Study of the Benefits of Yoga and Pilates Classes for Adults over 50 Years

Optional Interview

Participant Information Sheet Addendum

Researcher: Laura Denham-Jones, PhD student at University of Salford School of Health & Society
L.Denham-Jones@edu.salford.ac.uk

You are being invited to take part in a one-to-one interview following your participation in the 8 week yoga/Pilates trial in which you are enrolled. Please take time to read the following information carefully before you decide whether or not you wish to take part in the interview. Please email the researcher at l.denham.jones@edu.salford.ac.uk if there is anything that is not clear or if you would like further information.

What is the purpose of the interview?

The interview is an adjunct to the project that you have already consented to and enrolled in. The purpose of the interview is to gain more depth of feedback about your expectations and experiences taking part in the 8 week yoga or Pilates course. This research, in combination with the data collected from your pre- and post-trial surveys, may help to enhance yoga/Pilates teaching to older adults, improving safety, enjoyment, adherence, and other outcomes such as pain management.

When and where will the interviews take place?

Interviews will take place at a time to be arranged between yourself and the researcher, which will be communicated and confirmed by email. You will be emailed a choice of available time slots. The interview will take place between Sunday May 8th and Sunday May 22nd, 2022. You will have the option of an online Zoom meeting, phone call, or in person meeting at a private meeting room located on Lavender Hill London SW11.

How long will the interview take?

The interview is expected to take about 30 minutes and no more than 45 minutes.

What will I be asked in the interview?

The interview will take the form of a semi-structured informal conversation covering the following topics. You will be welcomed to raise discussion points of your own. **You will not be required or pressured to share or discuss anything involuntarily**. This list is not comprehensive:

- Your expectations of yoga/Pilates in general (depending on which group you were in)
- How you would describe the differences between yoga and Pilates, based on personal knowledge and/or experiences
- Your personal definitions of fitness and well-being (what these terms mean to you)
- Your past and current level of health
- Your physical exercise history

- Your attitude and approach to physical exercise currently
- Your enjoyment or other experience of the 8-week course
- Any physical or mental benefits you experienced that you think may be associated with taking part
- Any challenges you faced performing the exercises and movements in the classes
- Any practical challenges you faced (e.g. time management, maintaining motivation or regular attendance)
- Any intentions you have to continue with yoga or Pilates after the trial ends
- Your experience practising at home between group classes

Who decides whether I take part in the interview?

Taking part is voluntary and entirely optional. You can continue to participate in the 8 week trial with or without opting to be interviewed subsequently.

Will my participation in the interview be confidential?

The identity of participants and their respective responses will be known only to the researcher. The conversation will be recorded (voice only) and will be transcribed, anonymised and referenced only by the researcher. Any further dissemination, including possible publication of the findings, will be anonymised.

How will the data be stored?

Recordings will be transferred to a USB device with a backup on the researcher's University Microsoft Onedrive account, both stored with password protection, with the password known only to the researcher. Data will be stored and archived for a maximum of 6 years. This time period represents the duration of the researcher's course of study (due to expire April 2025) plus 3 years after the graduate award has been made, to allow verification of data from external sources if necessary.

What if I need to change the appointment time?

Please contact the researcher by email to reschedule.

Can I withdraw from the interview?

Yes, you can opt out of the interview at any time before it takes place by contacting the researcher by email or phone (details of which will be available in your email invitation to interview). If you wish to end the interview at any point once it has started, you may do this. After the interview takes place, data cannot be withdrawn.

What are the benefits of taking part in this aspect of the project?

The overall aim of the PhD research project is to understand and enhance the way yoga and Pilates are accessed and delivered to meet the needs of adults over 50. The interview is a chance to give more in-depth and detailed individual feedback about your experiences partaking in a course of yoga and Pilates designed for older adults. As a participant in yoga or Pilates your role in the study will contribute to this aim, with potential benefits to others in this population.

Who funds or sponsors this research?

The PhD student is self-funded at this time. There is no financial third party sponsor or funding body.

How do I take part?

If you would like to be interviewed, please simply reply by email to l.denham.jones@edu.salford.ac.uk. The researcher will then contact you by email to arrange the interview time and date. You will be sent a Participant Interview Consent Form to return to the researcher, either by email at l.denham-jones@edu.salford.ac.uk or in person at your weekly session, by Sunday May 8th, 2022. Interviews cannot take place unless and until the consent form has been completed and returned.

Thank you.

A Study of the Benefits of Yoga and Pilates Classes for Adults over 50 Years

Interview Participant Consent Form

CONSENT

1. I confirm that I have read and understood this participant information sheet.

2. I have had the opportunity to consider the information and have no questions or have had any questions answered satisfactorily.

3. I understand that my participation in completing this interview is voluntary.

4. I understand that I cannot withdraw my data from the research once the interview has been completed, and that after this point my anonymised data will be included in the study.

5. I understand that my comments may be shared anonymously, including in published form.

6. I understand that there is no compensation or payment for provided for taking part in this study.

7. I understand that anonymised data from this study will be stored for a maximum of 6 years from the week of the interview.

8. I agree to take part in this interview.

__________________________ ____________________ ____________________

Name of participant Date Signature

__________________________ ____________________ ____________________

Name of person taking consent Date Signature

If you have a concern about any aspect of this study, you should contact the researcher by email at l.denham-jones@edu.salford.co.uk who will do their best to answer your questions.

Following this, if you have any issues or complaints, you may contact the research supervisor Dr Nicola Spence at the University of Salford by email N.Spence@salford.ac.uk or by telephone 0161 295 0700 or Chair or the Ethics committee at the University of Salford, Linda Dubrow-Marshall by email l.dubrow-marshall@salford.ac.uk or by telephone 0161 295 6988.

INTERVIEW RISK ASSESSMENT **Task/Activity/Environment:** Participant one-to-one interviews following 8 week trial and pre- and post-trial survey	**Location:** Private meeting room or participants' homes by zoon link or phone	**Date of Assessment:** 28/03/22

Identify Hazards which could cause harm:		**Identify risks = what could go wrong if hazards cause harm:**	
No.	**Hazard**	**No.**	**Risk**
1	Requiring participants' emotional labour during interview	**1**	Requirement to answer personal questions pertaining to health and exercise may be construed as intrusive and discussion of personal issues such as body image, physical fitness and health status may cause distress, offense or harm.
2	Misuse of data	**2**	Participants may have concerns that personal data will be shared without consent

List groups of people who could be affected:	**What numbers of people are involved? Up to 24**
Participants completing the exercise intervention and pre- and post-trial survey	

What risk controls are in place to reduce risks?		**Risk level with risk controls**
No.	**Risk Control**	
1.1	Participants will be informed of the general natural of questions and themes via participant information sheet and will not be required or pressured to share or discuss anything involuntarily.	**Acceptable**
1.2	Participants will provide informed consent	**Acceptable**
1.3	The role of the interviewer and expectations of participants will be made clear at the start of the session	
2.1	Participant information sheet will explain how research will be used	**Acceptable**
2.2	All data will be referenced by the researcher only and anonymised for dissemination	**Acceptable**
2.3	The researcher has completed the University's GDPR for Research module – Information Security Smart: GDPR. The General Data Protection Regulation (GDPR) is designed to give individuals better control over their personal data and establish one single set of data protection rules across Europe. A GDPR checklist has been completed and will be observed to ensure that work is in line with guidance issued by the Information Commissioner's Office (ICO), the Legal and Information Governance team and local School procedures.	**Acceptable**
2.4	Recordings will be transferred to a USB device as MP3 files with a backup on the researcher's University Microsoft Onedrive account, both stored with password protection, with the password known only to the researcher.	**Acceptable**

What additional actions are required to ensure risk controls are implemented/effective or to reduce the risk further? **No.**	**Risk level**
N/A	**Acceptable (1-4)**

~~Is health surveillance required?~~	**~~If YES, please detail:~~**

NO	

Who will be responsible for implementing risk controls:	By When:
The researcher – Laura Denham-Jones	Before, during and after survey recruitment, implementation and analysis

Completed by: Laura Denham-Jones

Signature: *Laura Denham-Jones*

Risk Rating:

Increasing Consequence					
	5	10	15	20	25
	4	8	12	16	20
	3	6	9	12	15
	2	4	6	8	10
	1	2	3	4	5
	Increasing Likelihood				

17-25 Unacceptable – Stop activity and make immediate improvements/seek further advice	
10-16 Tolerable – look to improve within specified timescale	
5-9 Adequate – Look to improve at next review	
1-4 Acceptable - No further action, but ensure controls are maintained	

Guide to using the risk rating table:

Consequences	Likelihood
1 Insignificant – no injury	**1 Very unlikely** – 1 in a million chance of it happening
2 Minor – minor injuries	**2 Unlikely** – 1 in 100,000 chance of it happening
3 Moderate – up to three days absence	**3 Fairly likely** – 1 in 10,000 chance of it happening
4 Major – more than three days absence	**4 Likely** – 1 in 1,000 chance of it happening
5 Catastrophic – death or disabling	**5 Very likely** – 1 in 100 chance of it happening