Association Between Chronic Widespread Pain and Physical Activity Behaviour in People with Fibromyalgia

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Declaration of originality

I, Kabir Isah Mayana, declare that this thesis is my original work. None of the content has been presented elsewhere for a degree award, either in part or whole. All literature cited has been referenced.

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Abstract

Background

Fibromyalgia is a prevalent chronic widespread pain condition, affecting 1 in 20 adults in the UK, predominantly women and associated with a significant psychosocial burden. Despite much interest in structured exercise for pain management, resulting in evidence-based guidelines recommending structured exercise as the first line of management for fibromyalgia, adherence to structured exercise remains a huge challenge in this population as factors contributing to exercise intolerance are not adequately explored. The overall aim of this PhD thesis was to explore the impact of biopsychosocial factors on pain and physical activity behaviour in people with fibromyalgia.

Method

Three studies were conducted as part of this PhD. Study-1 examined the literature on the association between non-structured physical activity and pain intensity through a systematic review. Study-2 was a cross-sectional survey to examine the associations between physical activity, physical function and pain, and Study-3 consisted of qualitative interviews. A convergent mixed-method approach was taken to interpret the findings from the quantitative and qualitative studies to gain an in-depth understanding of contextual factors impacting pain and physical activity behaviour in people with fibromyalgia.

Findings

The systematic review revealed that the relationship between pain and physical activity is split. Half of the studies reported a statistically significant association between pain and physical activity categories, and the other half reported no statistically significant associations between physical activity categories and pain. The survey data demonstrated a weak association between pain and physical activity and found that depression, anxiety, and fatigue played critical roles in affecting the relationship between pain and physical activity in this population. The qualitative study findings suggested that people with fibromyalgia did not have appropriate guidance on tailored physical activity, leading to increased pain following exercise and sedentary behaviour. Fatigue was an intermediary factor between physical activity behaviour and pain, and those with access to multimodal therapy and social support reported more positive attitudes such as pacing and less pain following increased physical activities.

Conclusion

A multidisciplinary and multidimensional approach, incorporating patient education with behavioural components, targeting psychosocial factors, is essential to increase adherence to physical activity for people with fibromyalgia. There is also a need to improve public perception of fibromyalgia to facilitate social and workplace support.

List of abbreviation

AAPT	ACTTION-American Pain Society Pain Taxonomy
ACR	American College of Rheumatology
ACSM	American College of Sport Medicine
AHA	American Heart Association
AMPS	Assessment of Motor and Process Skills
ANOVA	Analysis of Variance
APS	American Pain Society
AWMF	Association of The Science Medical Society of Germany
BBAT	Basic Body Awareness Therapy
BMI	Body Mass Index
BPAQ	Baecke Physical Activity Questionnaire
BPI	Brief Pain Inventory
CBT	Cognitive Behavioural Therapy
CHAMPS	Community Health Activities Model Programs for Seniors
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CNS	Central Nervous System
CFS	Chronic Fatigue Syndrome
CPS	Canadian Pain Society
CR	Critical Realist
CRD	Centre for Review and Dissemination
CPM	Counts Per Minutes
EULAR	European League Against Rheumatism
FIQ	Fibromyalgia Impact Questionnaire
FIQR	Fibromyalgia Impact Questionnaire-Revised
FM	Fibromyalgia
FME	Fibromyalgia Education
FSS	Fatigue Severity Scale
GAD	Generalised Anxiety Questionnaire
GDPR	General Data Protection Regulation Policy
GP	General Practitioners
HAQ	Health Assessment Questionnaire
IMMPACT	Initiative on Methods, Measurement, and Pain Assessment in Clinical
IPAQ-SF	International Physical Activity Questionnaire - Short Form
LPA	Lifestyle Physical activity
JBI	Joanna Briggs Institute
METS	Metabolic Equivalents Threshold
NHS	National Health Service
NICE	National Institute of Care Excellence
NSAIDs	NSAIDs
NRAS	National Rheumatoid Arthritis Society
OA	Osteoarthritis
PEDro	Physiotherapy Evidence Database
PHC	Patient Health Questionnaire
PP	Probability Plot
PF	Physical Function
PROMS	Patient Reported Outcome Measures

PSEQ	Pain Self Efficacy Questionnaire
PROMIS	Patient-Reported Outcome Measures Information System
PTSD	Post Traumatic Stress Disorder
QQ	Quantile- Quantile
RA	Rheumatoid Arthritis
RCT	Randomised Control Trial
OMERACT	Outcome Measures in Rheumatoid Arthritis Clinical Trials
SF	Short Form
SFN	Small Fibre Neuropathy
SPECT	Single-Proton Emission Computed Tomography
SPSS	Statistical Package for Social Science
UK	United Kingdom
USA	United States of America
VAS	Visual Analogue Scale
WHO	World Health Organisation
WPI	Widespread Pain Index

Published Abstracts

1. K. Mayana, Y. Prior (2019). Chronic widespread pain and physical activity in fibromyalgia: a systematic review. *Clinical and Experimental Rheumatology 2019; 37 (Suppl. 116): S-116–S-143. Clinical and Experimental Rheumatol.*
2. K. Mayana, Y. Prior (2021). Identifying targets for behavioural interventions in Fibromyalgia: Physical activity behaviour. *European League Against Rheumatism*

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1. Introduction

1.1 Background

Fibromyalgia is a complex, multidimensional chronic widespread pain condition, affecting 1 in 20 people in the United Kingdom (UK), primarily women and associated with symptoms of fatigue, sleep disturbances, anxiety and depression, among other symptoms (Fayaz, Croft, Langford, Donaldson, & Jones, 2016; Wolfe et al., 2016). There is currently no objective biomarker to diagnose fibromyalgia, which results in delayed diagnosis and symptoms invalidation (Armentor, 2016; Huang, Jones, Bennett, Hall, & Lyons, 2018), rapid change of diagnostic criteria (Wolfe et al., 2016; Wolfe et al., 2010), and inconsistent management approach to pain (Annemans et al., 2008; Arnold & Clauw, 2017; Choy et al., 2010; Fitzcharles, 2013a; Häuser, Ablin, Perrot, & Fitzcharles, 2017; Häuser, Thieme, & Turk, 2010; Thieme, Marc Mathys, &Turk, 2017; Wolfe, Walitt, Perrot, Rasker, & Hauser, 2018).

The complexity of fibromyalgia has contributed to enormous economic burdens relating to direct and indirect costs. Financial data from different countries suggest a substantially high health care cost among people with fibromyalgia compared with other chronic pain conditions (Robinson et al., 2012; Silverman et al., 2009; Spaeth, 2009). A total annual direct health care cost was estimated to be over £1000 in the UK and a sick leave cost of about £5000 in people with fibromyalgia (Liedgens, Obradovic, De Courcy, Holbrook, & Jakubanis, 2016).

Research is evolving to unravel the complexity of symptoms to find suitable and sustainable management for pain and symptoms of fibromyalgia (Kia & Choy, 2017; Papadopoulou, Fassoulaki, Tsoulas, Siafaka, & Vadalouca, 2016; Thieme et al., 2017). Pain management in fibromyalgia involves pharmacological and a variety of non-pharmacological treatments (Ablin et al., 2013; Bellato et al., 2012). Drugs such as Amitriptyline, Pregabalin, Milnacipran, and Duloxetine are commonly used in fibromyalgia to treat pain, depression, and anxiety (Calandre & Rico-Villademoros, 2012; Cipriani et al., 2012; Häuser, Petzke, & Sommer, 2010).

Although medications are shown to be effective for pain management, they also contribute to symptoms such as weakness and weight gain for pregabalin (Freynhagen et al., 2016), muscle stiffness and extreme weakness for duloxetine (Cipriani et al., 2012) and sleep problems for milnacipran (Welsch, Üçeyler, Klose, Walitt, & Häuser, 2018). Given the safety concern of prolonged use of medications for pain relief, the evidence-based guidelines for the management of fibromyalgia discouraged drug usage as the first line of management (Ablin et al., 2013; Macfarlane et al., 2017).

Due to the adverse effect of prolonged use of pain medications, there has been a strong emphasis on non-pharmacological management as the first line or complementary to medications (Papadopoulou et al., 2016; Piercarlo Sarzi-Puttini et al., 2011). The National Institute for Health and Care Excellence (NICE, 2021) guidelines for the management of chronic pain, the evidence-based guidelines for the management of fibromyalgia, the European League Against Rheumatism (EULAR) 2017, and the Canadian guidelines for the diagnosis and management of fibromyalgia unanimously encourage non-pharmacological management such as patient education and structured exercise- aerobic/strengthening- as first-line management of fibromyalgia (Fitzcharles, 2013b; Macfarlane et al., 2017). However, adhering to structured exercise remains a massive challenge for people with fibromyalgia due to multiple symptoms associated with fibromyalgia, the cost implication of structured exercise, and psychosocial factors which potentially impact exercise adherence (Dobkin, Abrahamowicz, Fitzcharles, Dritsa, & da Costa, 2005; Russell et al., 2018).

Physical activity and exercise are used interchangeably; however, according to Carspersen (1985), “Physical activity is any bodily movement produced by skeletal muscle that results in energy expenditure”, while “exercise is a subset of physical activity which is planned, structured and repetitive”. Examples of structured exercises are strengthening and aerobic exercises with pre-specified dose, frequency, and intensity. However, physical activity involves any activity that requires energy expenditure, including structured exercises and unstructured exercises, which are primarily unsupervised such as walking, gardening, housework, and stair climbing. Evidence-based guidelines have emphasised structured physical activity such as strengthening exercise, so there is less insight on unstructured physical activity in the evidence-based guidelines (Macfarlane et al., 2017).

Despite the strong recommendation of exercise for pain management over medications, exercise recommendations fell short of addressing critical components of long-term management (Cui, Zhao, Novick, & Faries, 2012). Studies have shown high exercise intolerance, resulting in difficulty adhering to exercise interventions in people with fibromyalgia (Rowe et al., 2019; Sanz-Bañosa et al., 2018). Among several reasons for exercise intolerance in people with fibromyalgia, fear of exacerbating pain and fatigue are standout, making exercise unviable for people with fibromyalgia (Dobkin et al., 2005; Kaleth, Bigatti, Slaven, Kelly, & Ang, 2020; McVeigh, Lucas, Hurley, Basford, & Baxter, 2003).

Fear of exercise among people with fibromyalgia is associated with increased pain following exercise (Russell et al., 2018). Similarly, fatigue and low mood were also reported as barriers to exercise (Dobkin et al., 2005; Sanz-Banos et al., 2017). Due to difficulty adhering to structured physical activity (exercise), studies have explored alternative forms of physical activity such as leisure physical activity- walking, dancing, gardening, and accumulation of short bouts of activities rather than structured physical activity (Fontaine, Conn, & Clauw, 2010; Kaleth, Slaven, & Ang, 2014). Lifestyle physical activity behaviour (brisk walking, stair climbing, dancing) are suggested to provide a sustainable, cheaper, and more comfortable alternative to structured exercise (Mannerkorpi, Nordeman, Cider, & Jonsson, 2010; Sanz-Banos et al., 2017).

There are currently no physical activity guidelines for people with fibromyalgia despite the increasing interest in unstructured physical activity pain management for people with fibromyalgia. The current physical activity guidelines are the National Health Scheme (NHS, 2019) which recommends 150 minutes of moderate physical activity in a week for adults between 19-64 or 75 minutes of vigorous physical activity to stay healthy. Also, the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) recommend five days of 30 minutes of moderate-intensity activity for adults aged 18-65 or a minimum of 20 minutes of vigorous-intensity activity for three days for promoting and maintaining health (Riebe et al., 2015). However, these physical activity guidelines are mainly designed for reducing the risk of cardiovascular and metabolic diseases in healthy adults (Ding et al., 2020). However, physical activity requirements for people with chronic pain conditions fibromyalgia are yet established (Eller-Smith, Nicol, & Christianson, 2018). Although studies have explored various forms of physical activity, structured and unstructured, for people with fibromyalgia, there is still no consensus on appropriate physical activity for people with fibromyalgia.

Studies investigating physical activity and pain in fibromyalgia have not revealed ideal physical activity intensity for pain relief in fibromyalgia. Evidence of exercise on pain modulation and catastrophising have been established (Ellingson, Shields, Aaron Stegner, & Cook, 2012; Ellingson, Stegner, Schwabacher, Lindheimer, & Cook, 2018). Several studies have demonstrated the efficacy of aerobic and isometric exercise protocol on temporal summation of pain, a measure of central excitability (Martins, Siteneski, Ludtke, Dal-Secco, & Santos, 2017; Panza, Taylor, Thompson, White, & Pescatello, 2019; Staud, Weyl, Riley, & Fillingim, 2014; Vaegter, Handberg, & Graven-Nielsen, 2015). However, several chronic pain conditions like fibromyalgia are associated with a loss of pain modulation and increased temporal summation, hypothesised to explain increased pain perception following exercise (Staud, Robinson, Weyl, & Price, 2010; Staud et al., 2014).

A systematic review was conducted (Chapter 3) to investigate the relationship between physical activity and pain. The systematic review was unable to establish the association between categories of physical activity and pain intensity. Four studies reported no relationship between physical activity levels (moderate) and pain intensity. The other half reported a positive relationship between increased physical activity and lower pain intensity. However, variability in study designs and outcome measures might have contributed to the variability of findings. Furthermore, biopsychosocial factors such as mood disorders, social and environmental factors (e.g., family support), which are shown to be associated with physical activity and pain, were not elucidated amongst the studies (Adams & Turk, 2015; Sawa, Sekine, Yamada, Fukazawa, & Hiraku, 2020). Thus, the impact of biopsychosocial factors on pain and physical activity was not clear.

The biopsychosocial model is recognised as the ideal conceptual framework for chronic pain conditions, including fibromyalgia (Turk & Adams, 2016; Van Houdenhove & Egle, 2004). This allows for exploring multidimensional factors documented to drive pain perception (Shuster, McCormack, Pillai Riddell, & Toplak, 2009; Varinen, Kosunen, Mattila, Koskela, & Sumanen, 2017). Given the variability of symptoms and impact of psychosocial factors in pain (Fitzcharles, Perrot, & Häuser, 2018; Häuser, Schmutzer, Brähler, & Glaesmer, 2009; Meeus & Nijs, 2007; Talo & Rytokoski, 2016), the Outcome Measures in Rheumatoid Arthritis Clinical Trials (OMERACT) and the Initiative on Methods, Measurement and Pain Assessment in Clinical Trials (IMMPACT) guidelines recommend including psychological and social domains in pain trials (Chang et al., 2014; Haythornthwaite, 2010; Vincent et al., 2014).

There has been less attention on the influence of personal and contextual factors on physical activity and pain in people with fibromyalgia, given more attention to quantifying the relationship between physical activity and pain (Fontaine, Conn, & Clauw, 2011; Kaleth, Saha, Jensen, Slaven, & Ang, 2013; Kaleth et al., 2014; Merriwether et al., 2018; Segura-Jimenez, Castro-Pinero, et al., 2016; Segura-Jiménez et al., 2017; Soriano-Maldonado et al., 2016). The implication of relying on experimental studies is the potential of relegating other social and environmental factors. The perception and factors leading to exercise intolerance and sedentary behaviour have not been adequately explored. Although few studies have attributed exercise intolerance and sedentary behaviour in people with fibromyalgia to fear increasing pain (de Gier, Peters, & Vlaeyen, 2003; Larsson et al., 2017b; Nijs et al., 2013; Turk, Robinson, & Burwinkle, 2004), mood disorders, contextual and social factors have also been shown to have a huge impact on pain and physical activity behaviour and thus need to be explored (Dailey, Keffala, & Sluka, 2015; Lourenço, Costa, Rodrigues, Carnide, & Lucas, 2015; Malfliet et al., 2017).

1.2 Aims and objectives

The overall aim of this PhD thesis was to investigate the association between physical activity behaviour and pain in people with fibromyalgia.

The specific objectives of the thesis were:

i. To systematically examine the literature on the relationship between physical activity and pain in people with fibromyalgia
ii. To investigate the impact of biopsychosocial factors on the association between physical activity, physical function, and pain in people with fibromyalgia
iii. To explore the perception of physical activity behaviour and pain perception and the impact of psychosocial and the impact of contextual and environmental factors on physical activity behaviour and pain perception

1.3 Thesis structure

1. **Introduction**

This chapter summarises the background of the thesis, summary of literature review and the conceptual framework that guided this thesis, aims and objectives and the thesis structure with chapter summaries.

2. **Literature review**

This chapter depicts the background literature review conducted to evaluate the current evidence behind multidimensional factors impacting pain perception and physical activity behaviour in people with fibromyalgia to identify specific aims of the thesis and relevant keywords to design an effective and comprehensive search strategy for the systematic review reported following chapter.

3. Systematic review

A systematic review was conducted to examine the literature on the relationship between unstructured physical activity and pain experience in people with fibromyalgia, given the dearth of data on unstructured physical activity highlighted in the previous chapter, where a broader literature review was reported (Chapter 2). The findings of the systematic clarified the thesis aims and informed the methodological approach, including the choice of outcome measures to investigate the impact of multidimensional factors impacting physical activity and pain experience in people with fibromyalgia.

4. Methodology

Chapter 4 describes the philosophical stance, ontology and epistemology, rationale for the convergent mixed-method approach, and the cross-sectional study design. This chapter expands on the rationale for adopting a critical realist perspective to interpret the qualitative interviews, exploring the impact of the biopsychosocial, contextual, and environmental factors impacting physical activity behaviour and pain in people with fibromyalgia.

5. Quantitative Study (Study-1)

Chapter 5 presents the quantitative component of the mixed method approach, study rationale, methodology, statistical analysis, and discussion summary. The aim of the study was to investigate the association between physical activity and pain and the impact of biopsychosocial factors on the relationship between pain and physical activity in people with fibromyalgia.

6. Qualitative Study (Study-2)

Parallel to the survey, semi-structured telephone interviews were conducted with people with fibromyalgia recruited via social media. This chapter describes the qualitative methods and methodologies used to obtain lived experiences of individuals with fibromyalgia from a widespread sociodemographic to acquire an in-depth understanding of the factors determining the relationship between pain and physical activity behaviour.

7. Combined discussion and conclusion

This chapter discusses the combined findings of the qualitative and quantitative studies, the limitations of the combined findings, recommendations, implications for future research and the conclusion.

2 Literature review

2.1 Introduction

This chapter describes a brief historical journey that shaped the understanding of fibromyalgia and the research trends that have guided this thesis. This chapter also presents epidemiology and literature on biopsychosocial factors driving pain perception and physical activity in people with fibromyalgia.

2.2 Historical perspective of fibromyalgia

Fibromyalgia is a complex, multidimensional chronic widespread pain condition associated with fatigue, sleep disturbances, and depression, anxiety as core symptoms (Wolfe et al., 2010). Fibromyalgia has undergone rapid evolution, especially over the past two decades, with rapid changes in diagnostic criteria (Fitzcharles, 2013a; Wolfe et al., 2018). Diffuse chronic musculoskeletal pain (fibrositis) was the term used to describe chronic muscular widespread pain (Inanici & Yunus, 2004). The focus on muscular involvement in pain perception changed following biopsy studies showing no evidence of muscle involvement as the source of pain (Yunus, 2012). Subsequent studies demonstrated CNS involvement as the source of pain (Alciati, Cirillo, Masala, Sarzi-Puttini, & Atzeni, 2020; Brummett & Clauw, 2018; Cagnie et al., 2014). Since then, extensive research has helped shape the understanding of fibromyalgia from a typical muscular pain condition to a broader systematic condition (Meeus & Nijs, 2007; Turk & Adams, 2016; Van Houdenhove & Egle, 2004). However, despite the extensive studies published to date investigating various aspects of fibromyalgia, the aetiopathogenesis, diagnosis, and management of fibromyalgia are still vaguely comprehended (Bellato et al., 2012; Mease, 2005).

2.3 Epidemiology

2.3.1 Prevalence of fibromyalgia

The prevalence of fibromyalgia in the general population is reported at 2% and 5% in the UK population (Jones et al., 2015). The prevalence of fibromyalgia is higher in the UK than in European countries and the world (Branco et al., 2010; Fayaz et al., 2016; Jones et al., 2015). The diagnosis of fibromyalgia is mainly contingent on the diagnostic criteria used for the diagnosis of fibromyalgia. The American College of Rheumatology (ACR) 1990 criteria was the first diagnostic criteria that require tender spot examination in 11 out of the 18 areas of the body (Wolfe et al., 2010). However, the 2010/2011 criteria adopted subjective method and appraisal of widespread pain and other symptoms or a combination of both (Wolfe et al., 2010). The main criticism of the 1990 criteria is that its practical implementation was practically challenging as a tender point examination is needed in about 11 areas of the body to confirm the diagnosis (Bellato et al., 2012). Other symptoms associated with fibromyalgia were not recognised in the 1990 criteria resorted to the criticism of potential underdiagnosis (Bellato et al., 2012).

2.4 Biopsychosocial factors associated with pain and physical activity in fibromyalgia

The World Health Organisation (WHO) recommended the biopsychosocial (BPS) framework within the International Classification of Functioning (ICF) framework (ICF, 2003) to investigate and management of chronic pain conditions. Figure 2-1, the ICF framework emphasises integrating various aspects of health from biological, individual, and social perspectives to explain the disability process (Talo & Rytökoski, 2016). This stems from the idea that functioning and disability result from the interaction between the body functions and structure, health conditions and contextual factors (Talo & Rytökoski, 2016). Pain and physical activity are driven by a combination of multiple factors such as physical, psychological, or social state, making the biopsychosocial model ideal for identifying critical factors for target intervention (Buskila, 2003b; Turk & Adams, 2016; Yaghmaian & Miller Smedema, 2019).

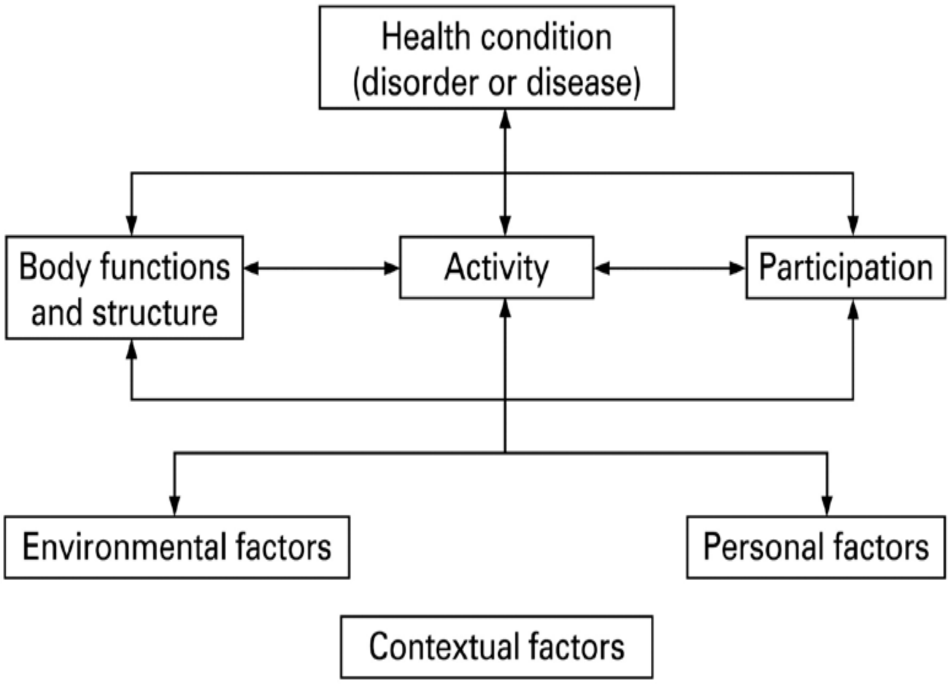

Figure 2-1- ICF Framework Source: WHO 2001

2.4.1 The biopsychosocial model

The BPS model was first proposed by Engel (1977) to incorporate multidimensional factors against the traditional reductionist biological model (Renjith, Pai, Castalino, George, & Pai, 2016). The BPS model theorises that pain perception is influenced by the interaction between biological, psychological, and social factors (Gatche, 2007). The BPS model's most critical characteristic is its resolution that these diverse sets of factors interrelate to form the pain experience and be explored (Fillingim, 2017). This model offered an ideal framework for a comprehensive approach to chronic pain conditions and recommended fibromyalgia trials (Borrell-Carrio, Suchman, & Epstein, 2004; Buskila, 2003a; Gur, 2003; Meeus & Nijs, 2007; Talo & Rytokoski, 2016).

The ACTTION-American Pain Society Pain Taxonomy (AAPT) suggests that the classification of chronic pain conditions should incorporate information on biopsychosocial mechanisms and consequences (Fillingim et al., 2014). Similarly, the Initiative on Methods, Measurement and Pain Assessment in Clinical Trial (IMMPACT 2008) consensus recommends four core domains consisting of psychosocial domains in reporting efficacy and effectiveness of clinical trials in chronic pain (Dworkin et al., 2008; Fillingim et al., 2014).

2.5 Clinical guidelines for the management of fibromyalgia

The need for treatment guidelines was necessary based on the variety of treatment approaches. The treatment approaches have been inconsistent, primarily associated with unknown etiopathogenesis, comorbidities and variability of symptoms (Ablin et al., 2013; Papadopoulou et al., 2016). Given the need to standardise treatment in fibromyalgia, evidence-based guidelines were drafted to summarise research on the efficacy of treatments on core symptoms of fibromyalgia such as pain, sleep, psychological symptoms, and physical function. The most recent guidelines are the EULAR, American Pain Society (APS) (CS, 2005), the Canadian Pain Society (CPS), and the Association of the Scientific Medical Societies of Germany (AWMF 2012) (CS, 2005; Fitzcharles, 2013a; Kia & Choy, 2017; Macfarlane et al., 2017).

Although both guidelines were supported by quality research evidence to support recommendations, few discrepancies were noticed between the guidelines for pharmacological and non-pharmacological interventions. This may perhaps be attributed to the inclusion criteria set for selecting studies, the committee's composition and the weight given to the studies. The committee's composition differed between the APS, the CSP, and the AMWF committees were more diverse than the EULAR committee. The APS committee comprises thirteen medical and allied health professionals, psychologists, patient advocates, rheumatologists, and nurses serving as panel members. The AWMF also consisted of 13 members drawn from various health professionals engaged in fibromyalgia management and two members representing the fibromyalgia largest German self-help group. The Canadian fibromyalgia guideline committee consisted of 11 relevant health care professionals, including a physiotherapist, nurse, chiropractors, patient representative, international observer, and a research coordinator. The EULAR committee has a larger composition (eighteen), mostly Rheumatologist, drawn from twelve European countries. The committee is chaired by an epidemiologist nominated by EULAR (Macfarlane et al., 2017). The committee's composition was criticised for being very narrow in selecting medical health care professionals (Thieme et al., 2017).

Both guidelines also presented strong recommendations for exercise and CBT except the EULAR guidelines that rated CBT as "weak for" despite all five reviews included showing better outcome for pain than placebo and controls (Fitzcharles, 2013a; Häuser et al., 2010; Thieme, Mathys, & Turk, 2017). The possible explanation for the weak recommendation may be due to the poor studies' quality, and only one review was rated as medium quality. In response to the guidelines underplaying CBT, there is a suggestion that the guidelines overlooked the effectiveness of CBT due to the variability of the composition of committees (Thieme et al., 2017).

Another discrepancy between the management guidelines was the choice of studies that informed the recommendation of treatment. The EULAR committee only considered systematic reviews with or without metanalysis, while the AMWF and the CSP included both systematic reviews, with or without a meta-analysis and control trials. This has resulted in obtaining higher quality evidence against other guidelines that used systematic reviews and poorly controlled studies, but that also means having fewer studies to work with, as is the case for the EULAR with fewer studies than the APS the CPS guidelines. Despite the variability in committee composition and methods used, both guidelines (APS, AWMF, and CPS) showed similarities regarding pharmacological interventions and non-pharmacological interventions.

2.5.1 Pharmacological treatment

The EULAR guidelines provide a detailed drug recommendation based on the evidence, including meta-analysis and systematic reviews for the efficacy of various drugs on pain management (Macfarlane et al., 2017). These drugs include pain modulators, drugs acting on hormones, antidepressants, muscle relaxants and anticonvulsants—some of the medications like Amitriptyline, Pregabalin and Duloxetine show encouraging results on pain reduction (Papadopoulou et al., 2016). Amitriptyline was recommended with an A rating by both guidelines. However, other fibromyalgia symptoms like fatigue, sleep disturbances, and disability often aggravate at different rates following Amitriptyline, Pregabalin, and Duloxetine medication (Yelland, 2017). In contrast, medications such as Cyclobenzaprine, Non-steroidal anti-inflammatory drugs (NSAIDs), and potent opioids were not recommended due to detrimental efficacy and safety profile (Macfarlane et al., 2017).

An updated Cochrane systematic review evaluated the efficacy, safety, and tolerability of Serotonin noradrenaline reuptake inhibitors compared with other active medications or placebo people with fibromyalgia. Eight new studies were added to the meta-analysis, which comprises 18 studies. Although the studies added had an unclear or high risk of bias, the systematic review's findings indicate that Duloxetine and Milnacipran show a clinically relevant benefit for pain relief- more than 30% compared with placebo (Welsch et al., 2018). However, there was no clinically relevant benefit on fibromyalgia symptoms such as fatigue, sleep, and health-related quality of life (Welsch et al., 2018).

Increasing evidence for cannabinoids to manage chronic pain is emerging (Guillouard, Authier, Pereira, Soubrier, & Mathieu, 2021; Brian Walitt, Klose, Fitzcharles, Phillips, & Häuser, 2016; Yassin, Oron, & Robinson, 2019). The effect of Cannabinoids is exerted through the interaction of the cannabinoid type 1 receptor (CB1-R) expressed by the neural cells and cannabinoids type 2, which is present in the cells of the immune system (Chaves, Bittencourt, & Pelegrini, 2020; Crestani, 2018). The psychoactive components in Cannabis, like tetrahydrocannabinol (THC), helps to improve cognition, increased motor function and reduce pain perception (Berger et al., 2020; Chaves et al., 2020). Despite the well-documented mechanism of cannabis to modulate pain and mood, there is still a reluctance to prescribe cannabis for pain management in fibromyalgia due to potential addiction and safety issues (Cameron & Hemingway, 2020; Guillouard et al., 2021; Kurlyandchik, Tiralongo, & Schloss, 2021; Sagy, Bar-Lev Schleider, Abu-Shakra, & Novack, 2019; Brian Walitt et al., 2016; Ware, Fitzcharles, Joseph, & Shir, 2010).

The use of opioids in the management of fibromyalgia has shown delusive results. Although tramadol has shown moderate effects on pain reduction, Naltrexone, an opioid antagonist, has shown remarkable pain reduction for people with fibromyalgia. The action mechanism is described through the transient blockade of the opioid receptors in the CNS (Metyas et al., 2018). The considerable variability in clinical presentations and symptoms of fibromyalgia usually necessitates a combined therapeutic approach, whether pharmacological or non-pharmacological. A Cochrane systematic review evaluated the effect of combination therapy and safety associated with a combination of drug therapy and one drug treatment or placebo on pain. The study included 16 studies with 1474 participants (Häuser et al., 2017; Sarzi-Puttini et al., 2011). The authors concluded that combination therapy has a better pain outcome than single-drug treatment and a mild side effect. However, the study's effect only showed a moderate effect and heterogeneity in study designs (Häuser et al., 2017; Sarzi-Puttini et al., 2011).

2.5.2 Non-pharmacological treatment

The non-pharmacological therapies were recommended by both guidelines based on a significant impact on the quality of life, symptoms and lower side effects compared to pharmacological interventions (Häuser et al., 2017). Virtual reality is an advanced technology used for different purposes like military simulation, gaming experience, and most recently reported to have a modulating effect on pain, which was explained by influencing attention by distracting the patient — thereby helping the patient concentrate. The mechanism of pain modulation was explained through concentration and emotion rather than acting through the nociceptive pathway of pain (Garcia-Palacios et al., 2015).

Virtual reality has been demonstrated to improve pain, depression, and coping mechanisms in people with fibromyalgia (Garcia-Palacios et al., 2015). Subsequent studies also advocated using virtual reality in multidimensional symptoms, especially in pain catastrophising and positive emotional effects (Garcia-Palacios et al., 2015; Morris, Grimmer-Somers, Spottiswoode, & Louw, 2011).

Basic Body Awareness Therapy (BBAT) is shown to increase body awareness by teaching patients how to move in space and time correctly. An RCT conducted to investigate the effect of BBAT on pain reduction and anxiety randomised 41 people with fibromyalgia. Twenty were allocated to the BBAT group, and 21 were allocated to the control group. People with fibromyalgia randomised to the BBAT significantly reduced pain and anxiety than those in the control group (Bravo, Skjaerven, Espart, Guitard Sein-Echaluce, & Catalan-Matamoros, 2019). Similar positive findings were recorded in a qualitative study that explored people's perception of fibromyalgia following a BBT intervention (Bravo et al., 2019). Few studies investigated the efficacy of BBAT on fibromyalgia symptoms, so it is still early to ascertain the efficacy of the treatment in pain and physical activity.

Cognitive Behavioural Therapy is one of the highly effective non-pharmacological treatments in fibromyalgia. CBT is recommended by the CSP, AMWF, APS, and EULAR recent guidelines for managing pain, depression and coping in people with fibromyalgia (Fitzcharles, 2013a; Kia & Choy, 2017; Macfarlane et al., 2017). CBT counters mood disorders and disabilities by influencing coping strategies and emotional control (Bennett & Nelson, 2006; McCrae, Curtis, Miller, et al., 2020). Biological studies have shown that eight weeks of CBT reverse atrophic changes of grey matter areas of the brain in people with fibromyalgia (McCrae, Curtis, Craggs, et al., 2020). A recent update of a systematic review conducted by Bernady (2018), published in 2018, analysed the results of 29 RCTs which included 2509 participants. The review findings showed that people with fibromyalgia that had CBT reported a remarkable 50% improvement in pain compared with controls (active non-pharmacological agents, attention control, standard treatment, and waiting list). With the significant effect that CBT has shown on physical, emotional and well-being in people with fibromyalgia, it could be plausible to recommend CBT as the first line of treatment immediately after diagnosis. This could also help slow the integration of physical activity behaviour.

Psychological support through online platforms was explored for a potential remedy for sustainable symptom management. One of the major concerns in the management of fibromyalgia is adherence to treatment due to the chronicity of fibromyalgia (Dobkin et al., 2006; Huyser, Buckelew, Hewett, & Johnson, 1997). A large RCT of people with fibromyalgia, 140 participants, reported a high retention rate, 94%, and symptom coping in 12 months of online psychological interventions. Also, the study reported greater cost-effectiveness than those with no internet intervention (Caballol Angelats et al., 2019). Another result from a meta-analysis of online-delivered therapy reports a significant improvement in mood and disability following six months of intervention. However, pain relief was not observed compared to those on the waiting list (Monti, Drefahl, Mussino, & Härkönen, 2020). As the findings of Anderson (2019), a systematic review of an online-based CBT in people with fibromyalgia and other chronic disease shows a higher effect on symptoms of depression and anxiety.

2.5.3 Self-management of fibromyalgia

The need for self-management is becoming very critical, considering the limitations of available treatment options for managing pain (Bourgault et al., 2015; Cedraschi et al., 2004; Sandstrom & Keefe, 1998). The pharmacological treatment options have shown a moderate effect on pain and adverse effect while adhering and sustaining structured exercise is not practical for people with fibromyalgia. Several Self-management approaches have suggested managing psychological symptoms to help better cope with pain and lifestyle adjustment, including adopting a lifestyle physical activity (Poole & Siegel, 2017; Rasmussen et al., 2017).

2.6 Role of physical activity in pain management

Aerobic exercises/strengthening exercises are recommended as the first line of management by both guidelines based on the quality of evidence that supports the efficacy of exercises on core symptoms of fibromyalgia-like pain, fatigue, mood, and physical function. The EULAR 2016 committee recommended "strong for" for aerobic exercises only and suggested non-pharmacological intervention (Patient's education and Exercise) as the first line of management (Macfarlane et al., 2017). Notwithstanding the safety of exercise, which informs the strong recommendation, systematic reviews show that although exercise interventions were more favourable than the control groups, the effect size is small and far below clinical relevance. Bush et al. (2007) were the most extensive systematic reviews that evaluated the efficacy of various exercise training, including 34 studies, on fibromyalgia symptoms (Busch, Barber, Overend, Peloso, & Schachter, 2007b). Pain reduction between exercise and control groups was only 13%. Similarly, another Cochrane systematic review involving 13 trials indicates that aerobic exercise only slightly decreased pain intensity with an estimate size of 11%. Interestingly, none of the systematic review trials reported improvement more significant than 30% to suggest clinical relevance (Busch et al., 2013).

In addition to a cumulative small effect size on pain intensity among studies, exercise intervention was characterised by inconsistent exercise dose and withdrawals from exercise. Exercise interventions in the systematic review reported an average drop out of 22% in patients assigned to the aerobic exercise groups compared with 10 % for the control group (Busch, Barber, Overend, Peloso, & Schachter, 2007a). Furthermore, the dose of exercise is not well documented in some of the exercise interventions.

The underlying mechanism, exercise-induced analgesia, has been well investigated in different pain populations (Villafaina, Borrega-Mouquinho, Fuentes-García, Collado-Mateo, & Gusi, 2019). Previous studies suggested higher intensity exercise influenced systemic naloxone, which influences the opioid system in the human body (Eller-Smith et al., 2018; lvin et al., 2016; Roland Staud et al., 2010; Staud et al., 2014). However, in some people with fibromyalgia, there seems to be a dysfunction of the endogenous system following exercise, evident from the report of severe pain after exercise (Malfliet et al., 2017). There is evidence of genetic abruption of the endogenous system in cohorts of people with fibromyalgia (Baek et al., 2016; Bjersing, Dehlin, Erlandsson, Bokarewa, & Mannerkorpi, 2012). This could explain why the subgroup of people with fibromyalgia often refrains from doing exercise. Several mechanisms of treatments such as the bio-physiological model explaining the rationale for physical activity on pain, impact of physical activity on psychosocial factors have been proposed to explain the potential mediating and moderating impact of various factors and symptoms of fibromyalgia affecting the relationship between physical activity and pain perception in people with fibromyalgia. Exploring these factors could help identify barriers to target physical activity intervention.

2.6.1 Pain mechanisms and impact of physical activity

The mechanism and origin of pain in fibromyalgia is still a subject of debate. Chronic widespread pain is the hallmark symptom of fibromyalgia; however, several authors have varied arguments on pain perception in fibromyalgia, with predominant arguments supporting the theory of pain originating from the CNS (Top-down) (Alciati et al., 2020; Schrepf et al., 2020). However, other arguments suggest that pain perception originates from the periphery and is exaggerated at the CNS (Bottom-Up) (Affaitati et al., 2011; Brietzke et al., 2019). Similarly, there are suggestions both theories apply (Talo & Rytokoski, 2016; Turk & Adams, 2016; Van Houdenhove & Egle, 2004). The most accepted theory for pain sensitivity in fibromyalgia is the central sensitisation theory (de la Coba, Bruehl, Galvez-Sánchez, & Reyes Del Paso, 2018; Staud et al., 2014). Each of these arguments is supported by evidence to support the rationale for the treatment approach (Arnold, 2009; Gormsen, Bach, Rosenberg, & Jensen, 2012).

2.6.2 Muscle as a potential nociceptive input

A growing body of literature shows the role of muscle tissue as a source of pain in fibromyalgia. Although earlier hypotheses of pain processing implicate muscle as a source of pain, muscle biopsy studies comparing people with fibromyalgia and healthy controls proved the contrary (Ruggiero, Manganelli, & Santoro, 2018). However, recent studies suggest variability in muscle fibre size and decreased capillary density in women with fibromyalgia compared to women without fibromyalgia (Ruggiero et al., 2018; Srikuea et al., 2013). Other findings suggest that physical performance in fibromyalgia results from impaired muscle metabolism and microcirculatory disorder (Gerdle et al., 2013). Similarly, a study found significantly lower (about 30%) phosphocreatine concentrations in people with fibromyalgia compared with control (Gerdle et al., 2014). These findings could explain the widely reported pain experienced by people with fibromyalgia after exercise. However, metabolic alterations and decreased capillary density in muscle fibres may be associated with reduced physical activity, commonly observed in people with fibromyalgia and people who are not active (Olausson, Ghafouri, Ghafouri, & Gerdle, 2016).

Another hypothesis of muscular involvement in pain is the evidence of decreased blood flow, lower levels of Adeno triphosphate and phosphocreatine, and dysfunction in pro-inflammatory cytokines (Gerdle et al., 2013). However, the hypothesis of dysregulation of inflammatory cytokines in the muscle of people with fibromyalgia could not be confirmed based on the variability in study designs (Góes et al., 2012). However, evidence of reduced blood flow in people with fibromyalgia compared with healthy controls suggests an ischaemic change that explains frequent reports of pain following exercise in people with fibromyalgia (Elvin, Siosteen, Nilsson, & Kosek, 2006)

Muscle pain in people with fibromyalgia has been hypothesised to be associated with muscle ischemia following exercise (Alciati et al., 2020). The hypothesis that pain perception originates from an abnormal muscle structure and altered sympathetic nerve activity was later modulated with evidence suggesting an absence of any muscle pathology that could explain the pain reported by people with fibromyalgia (McIver et al., 2006). Some findings have reported no indication of altered sympathetic nerve activity in people with fibromyalgia compared with healthy controls. However, other studies have shown decreased muscle blood flow during dynamic movements in people with fibromyalgia compared to healthy controls (McIver et al., 2006; Umeda, Corbin, & Maluf, 2015a). Smaller sample sizes and various hypotheses primarily categorise these findings.

2.6.3 Central sensitisation and implication to higher pain and lower physical activity

The central sensitisation theory is proposed as the leading mechanism responsible for pain sensitivity in fibromyalgia. Central sensitisation theory proposes a CNS involvement in pain through increased activation of nociceptive neurons of the spinal cord with or without input from the muscle tissue (Alciati et al., 2020). A systematic review conducted to summarise the evidence of changes in the brain measured by Functional Magnetic Resonance Imaging (fMRI) shows evidence of changes in the areas of the brain in people with fibromyalgia, suggesting abnormal brain processing in fibromyalgia cohorts compared with healthy controls (Cagnie et al., 2014). This is in addition to evidence of constant abnormal firing of the neurons, which creates a phenomenon termed hyperalgesia and allodynia, both of which are characteristics of central sensitisation (Ablin, 2017; Yüksel, Nazıroğlu, Şahin, & Çiğ, 2017). Hyperalgesia is an abnormal excessive pain perception following a mild painful external stimulus such as mild pressure that is not supposed to be that painful, and allodynia is the perception of non-painful stimuli like touch to be painful (Chandran et al., 2012; lvin, Sluka, & Clauw, 2016; Potvin, Paul-Savoie, Morin, Bourgault, & Marchand, 2012).

Another fundamental phenomenon involved in the centralisation sensitisation theory is the wind-up. The windup phenomenon illustrates neuroplasticity due to repeated noxious stimulation, leading to increased neural responsiveness to pain (Staud et al., 2014). This phenomenon is commonly heightened in people with fibromyalgia compared with control (Staud, Robinson, Weyl, & Price, 2010). These changes explain the increased appraisal of painful stimuli (hyperalgesia) and mild stimuli sensitivity to be excruciating (Vecchio et al., 2020). People with fibromyalgia have shown increased sensitivity to pain following non-noxious stimuli like stress, noise, and weather which also explains the increase and sustained pain perception following physical activity (Gupta & Silman, 2004; Van Houdenhove & Egle, 2004).

People with fibromyalgia display all the typical characteristics of central sensitisation: allodynia (Perrot et al., 2012), hyperalgesia (Araya-Quintanilla et al., 2020), temporal summation and after sensations to different stimuli like pressure, heat or cold, and auditory stimulus (Bosma et al., 2016). Although central sensitisation is considered the primary mechanism of pain in fibromyalgia (Sarzi-Puttini, Atzeni, Diana, Doria, & Furlan, 2006), other chronic pain conditions are now thought to be driven by abnormal brain processing suggesting the central nervous system involvement in the amplification of pain Figure 2-2 (Brennan et al., 2012; Timmermans, 2014). All central sensitisation characteristics are presently seen and reported in nociceptive or neuropathic conditions like osteoarthritis (OA) (Timmermans, 2014). Given that fibromyalgia is associated with considerable pain, mental health, and other conditions associated with central sensitisation, distinguishing fibromyalgia's contribution with other commodities remains a challenge.

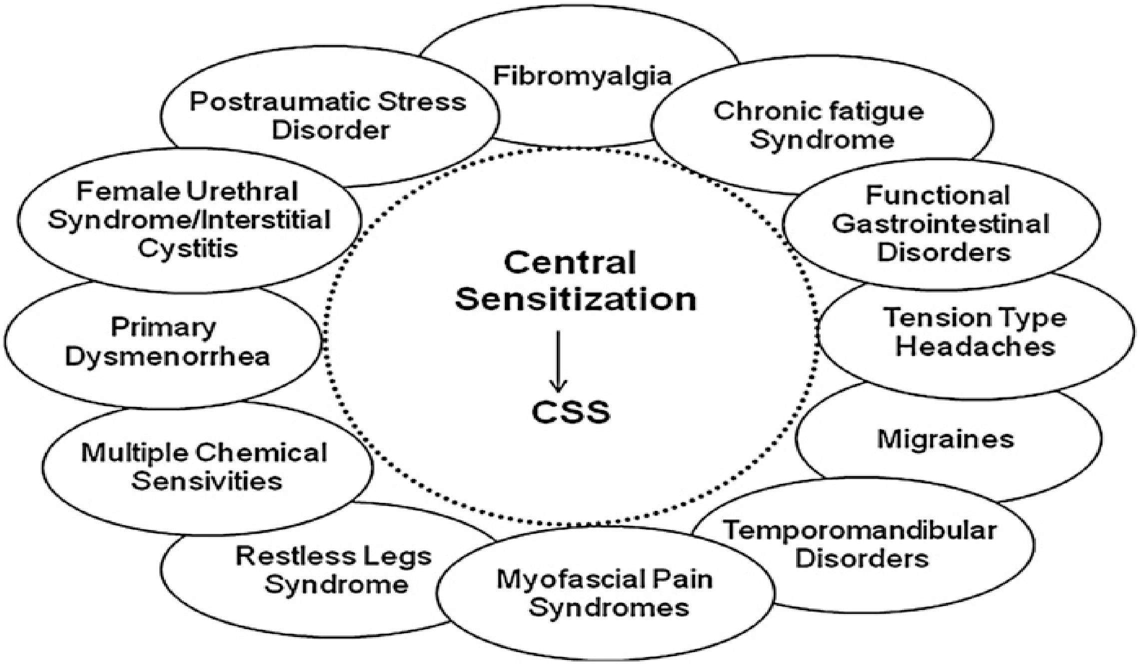

Figure 2-2- Central sensitisation in multiple conditions - Source: Yunus et al., (2008)

2.6.4 Peripheral pain and implication to increased pain perception and lower physical activity

The second hypothesis of pain origin in fibromyalgia is peripheral sensitisation. Peripheral pain is categorised into neural damage and secondary peripheral nociception (Geneen et al., 2017b). Neural damage results from systemic conditions such as RA, OA, diabetes neuropathy, cancer, or drugs (Sarzi-Puttini et al., 2006). Neuropathic pain often occurs due to peripheral nerve damage (Geneen et al., 2017b). Pain stimuli are perceived and conveyed through the nociceptors existing in all parts of the human body and convey stimuli, i.e., painful sensation (painful pressure, tissue squeeze), thermal sensation like hot and cold, and harmful chemical stimulations to the brain (Caballol Angelats et al., 2019).

A recent study demonstrated heightened pain sensation, observed in people with fibromyalgia, originates from activation of nociceptors in the muscles and dense vascular structures, which periphery partakes in the pathophysiology of central sensitisation (Vecchio et al., 2020). Given that various chronic musculoskeletal pain conditions evolve from traumatic or degenerative changes that trigger the local nociceptive pathway, the CNS modulates the somatosensory system's sensitivity; this theory remains relevant in fibromyalgia (Staud et al., 2010; Vecchio et al., 2020). Given that most people with fibromyalgia also have other conditions and underlying pathologies involved in peripheral sensitisation, it would be difficult to distinguish central or peripheral involvement (Kleykamp et al., 2020; Lichtenstein, Tiosano, & Amital, 2018; Mease, 2017).

2.6.5 Neuropathic pain

Recent evidence is emerging to support the incidence of Small Fibre Neuropathy (SFN) in developing pain in people with fibromyalgia, with a meta-analysis showing evidence of SFN in half of the people diagnosed with fibromyalgia (Grayston et al., 2019). SFN is a peripheral nerve disorder that affects small somatic fibres, leading to changes in sensory perception and autonomic dysfunction (Baek, Seok, Koo, & Kim, 2016; Lacout et al., 2020). Pain and burning sensation in fibromyalgia are induced by damage to small nerve fibres, commonly seen in people with fibromyalgia (Roland Staud et al., 2010). Other symptoms exhibited by SFN are hyperalgesia and allodynia (de la Coba, Bruehl, Moreno-Padilla, & Reyes Del Paso, 2017). However, SFN is also associated with other medical conditions such as Diabetes Mellitus, Vitamin B12 Deficiency, Parkinsonism (Fasolino et al., 2020; Martínez-Lavín, 2018; Popescu, 2019; Thaisetthawatkul, Lyden, Americo Fernandes, & Herrmann, 2020). These symptoms need to be ruled out to ascertain whether small fibre neuropathy is strongly associated with fibromyalgia. The implications of these findings are heightened pain sensation following physical activity.

2.6.6 Multiple mechanisms associated with pain perception and physical activity

The multiple mechanisms propose a combination of central and peripheral and psychological factors. The multiple mechanism theory argues that amplification and maintenance of pain, commonly seen in people with fibromyalgia, is a result of a combination of the peripheral input and increased excitability of the spinal neurons (de la Coba et al., 2017; Eller-Smith et al., 2018; Meeus & Nijs, 2007). This theory argues that psychological factors play a significant role in pain sensitisation, evident from higher psychological instability and repeated episodes of persistent pain displays without evidence of peripheral sensitisation (Bustan et al., 2018; Meeus & Nijs, 2007; Simons, Elman, & Borsook, 2014).

2.6.7 Genetic factors

Studies have been inconsistent on genetic involvement in the aetiology of fibromyalgia. Previous studies have explored various candidate genes in fibromyalgia, focusing on neurotransmitters such as serotoninergic, adrenergic, and dopaminergic pathways (Park et al., 2015; Park & Lee, 2017). An experimental study comparing 270 healthy people found a significant association between the IL-4 gene in 300 people with fibromyalgia (Yigit et al., 2013). Similar findings demonstrate a genetic pattern identified to be involved in the inflammation process, mood disturbances and nociception in people with fibromyalgia compared to healthy control (Smith et al., 2012). However, other studies found that pain is not associated with genetic components such as Val 158Met polymorphism in fibromyalgia (Fernández-de-Las-Peñas, Ambite-Quesada, Gil-Crujera, Cigarán-Méndez, & Peñacoba-Puente, 2012). Although other fibromyalgia symptoms such as depression, anxiety was associated with genetic factors regulated by physiological variables (Fernández-de-Las-Peñas et al., 2012). It is still unclear how genetic factors influence the aetiology of fibromyalgia, judging from the contrasting findings. Given the variability of hypotheses in genetic studies (Angelats et al., 2019; Park et al., 2015), it is difficult to ascertain the impact of genetic predisposition in fibromyalgia.

2.6.8 Impact of epigenetics on pain and physical activity behaviour

The interaction between humans and the environment is an emerging area of interest in the pathogenesis of fibromyalgia (D'Agnelli et al., 2019; Polli, Godderis, Ghosh, Ickmans, & Nijs, 2020). Epigenetic concepts describe how genes and the environment interact to explain changes in chronic pain (Low & Schweinhardt, 2012). Recent findings have established a link between gene expression, determined by the Deoxyribonucleic acid (DNA) and the environment, suggesting the impact of genetic expression in fibromyalgia (D'Agnelli et al., 2019). The primary mechanism that supports the epigenetic concept is evidence of methylation (Ciampi de Andrade et al., 2017).

2.6.9 Health factors and implications to pain and physical activity

Because many other health issues frequently accompany fibromyalgia, it can be difficult to distinguish between the effects of fibromyalgia and other disorders on pain. (Bateman et al., 2016; Bou Khalil, Khoury, & Richa, 2018; Gore, Tai, Chandran, Zlateva, & Leslie, 2012). Fibromyalgia may occur independently, but it is often co-morbid with other conditions such as Rheumatoid Arthritis (RA), lupus, hypothyroidism, and infections such as Lyme disease and other chronic pain conditions such as Irritable Bowel Syndrome (IBS) (Yang et al., 2015), spondylarthrosis (Mease, 2017), and migraine (de Tommaso et al., 2009). These conditions may trigger fibromyalgia symptoms and contribute to the increased pain appraisal and lower physical activity behaviour (Bou Khalil et al., 2018; Tommaso et al., 2017; Gore et al., 2012; Lichtenstein et al., 2018). Identification and substantiating the impact of these diseases and other comorbidities associated with pain and physical activity behaviour is critical for identifying targets for intervention.

2.6.10 Sleep disturbances and nociception

Sleep disturbance is a common problem reported by more than 75% of people with fibromyalgia (Wu, Chang, Lee, Fang, & Tsai, 2017). Sleep complaints in people with fibromyalgia are commonly reported in the form of lower sleep quality, unrefreshed sleep, and difficulty falling asleep (Roth, Bhadra-Brown, Pitman, Roehrs, & Resnick, 2016; Theadom & Cropley, 2010). Experimental studies have suggested dysfunction in the descending inhibitory pathway that controls pain management, impaired by sleep deprivation (Caballol Angelats et al., 2019). Systematic reviews and experimental studies have indicated a strong relationship between sleep problems and pain (Hamilton et al., 2012; Iacob, Hassett, Neikrug, & Okifuji, 2017; Keskindag & Karaaziz, 2017). Similarly, sleep problems are strongly linked with exercise or physical activity intolerance (Dolezal, Neufeld, Boland, Martin, & Cooper, 2017).

Recent findings have shown a strong link between sleep disturbances and pain (Keskindag & Karaaziz, 2017). The impact of psychological symptoms such as depression, mood and anxiety are strongly suggested to mediate the relationship with pain and physical activity (Andrade, Vilarino, et al., 2018; Caballol Angelats et al., 2019; Diaz-Piedra et al., 2014; Kothari, Davis, Yeung, & Tennen, 2015). The extent to which sleep problem mediates pain intensity and physical activity behaviour is still vague considering the interrelationship between core symptoms of fibromyalgia and sleep (Dolezal et al., 2017; Hamilton et al., 2012; Keskindag & Karaaziz, 2017).

2.6.11 Impact of fatigue on pain and physical activity behaviour

Fatigue is among the most debilitating symptoms of fibromyalgia, which affects pain and physical activity, typically characterised as a prolonged feeling of exhaustion associated with rising pain and decreased physical activity (Merriwether et al., 2018). Approximately 70% of people with fibromyalgia report fatigue, often reported as more disabling than pain (Lyons, Jones, Bennett, Hiatt, & Sayer, 2013). Research conducted in the UK showed a decline in chronic fatigue syndrome diagnosis since 2001 by over 38% and increasing fibromyalgia diagnosis by over 40% (Collin, Bakken, Nazareth, Crawley, & White, 2017). Physical fatigue has been linked with decreased muscle contraction due to an impaired energy reserve (Bachasson et al., 2013) and cognitive impairment (Dailey et al., 2015). Evidence suggests that fatigue is associated with severe pain, sleep disorders, and depression (Segura-Jimenez, Castro-Pinero, et al., 2016). A study comparing gene profiles in fatigued women with fibromyalgia reported preliminary evidence of physiological involvement in women reporting fatigue (Lukkahatai, Walitt, Espina, Gelio, & Saligan, 2016). The implications of these studies are the impact potential impact of fatigue on pain and physical activity intolerance.

2.7 Psychological factors

A growing body of evidence is emerging to support psychological clusters in fibromyalgia. Although the ACR criteria for diagnosing fibromyalgia did not distinguish individuals with fibromyalgia based on symptom clusters, growing evidence suggests heterogeneity of people with fibromyalgia based on common clinical symptoms (Yavne, Amital, Watad, Tiosano, & Amital, 2018). Psychological symptoms are influential given their impact on the severity of pain and other fibromyalgia symptoms (Giesecke et al., 2003; Hoskin, Whipple, Nanda, & Vincent, 2018). Systematic reviews show that pain and psychological symptoms are strongly associated (Galvez-Sánchez, Reyes Del Paso, & Duschek, 2018). Psychological factors, i.e., perceived control, self-efficacy, fear, depression, and anxiety, have all been shown to influence pain perception and behavioural modifications (Beal, Stuifbergen, & Brown, 2009; Buckelew et al., 1994; García-Martínez, De Paz, & Márquez, 2012; Peñacoba Puente et al., 2015).

2.7.1 Impact of depression on pain and physical activity

Depression is a debilitating symptom of fibromyalgia, with a reported prevalence ranging from 62-86% (Fuller-Thomson, Nimigon-Young, & Brennenstuhl, 2012; Gracely, Ceko, & Bushnell, 2012). Symptoms of depression include low mood, disengaging from health-protective activities, loss of interest in engaging and a general decline in functioning (Singh & Kaul, 2018). Longitudinal studies have shown a robust reciprocal relationship between pain and depression (Kroenke et al., 2011; Steiner, Bigatti, 2015). This is corroborated by neurobiological studies suggesting that depression and pain share similar neurotransmitters (serotonin, norepinephrine, and glutamate) (Goesling, Clauw, & Hassett, 2013). Given the overlapping mechanism and bidirectional relationship, pain management impacts depression symptoms and vice versa (Singh & Kaul, 2018). Depression has an adverse influence on physical activity behaviour (Steiner et al., 2015). Few studies have suggested a mediating effect of depression on the relationship between physical activity behaviour and pain (Soriano-Maldonado et al., 2016). Although depression is a critical symptom of fibromyalgia, its impact and contextual information on pain and physical activity have not been adequately explored.

2.7.2 Impact of anxiety on pain and physical activity

Anxiety is a pervasive symptom in fibromyalgia that increases pain appraisal and lower physical activity(Alciati et al., 2020; Consoli et al., 2012; Diaz-Piedra et al., 2014; Kayhan et al., 2016). Anxiety is independently associated with a sedentary lifestyle (McDowell, Cook, & Herring, 2017a). Genetic studies have linked familial aggregation with anxiety in fibromyalgia-suggesting family involvement in the development of anxiety (Fernández-de-Las-Peñas et al., 2012). However, various factors are shown to contribute to anxiety in people with fibromyalgia, given the uncertainties surrounding fibromyalgia, especially the challenges surrounding diagnosis and the low efficacy of medications and treatments for managing pain (Winfried Häuser & Fitzcharles, 2018; Krasselt & Baerwald, 2018). The association between anxiety and pain and physical activity behaviour makes anxiety assessment critical for physical activity behavioural interventions and pain management.

2.7.3 Personal factors and nociception

Personal factors such as gender, ethnicity, and culture influence pain perception (Fillingim, 2017). Studies have shown that people with fibromyalgia have negative views of themselves and society (Beal et al., 2009; De Roa, Paris, Poindessous, Maillet, & Héron, 2018; Josefsson, Lindwall, & Archer, 2014), which contributes to negative illness perception (Skaer & Kwong, 2017). However, a systematic review concluded that when depression is controlled, there was no difference in personality traits in people with fibromyalgia compared with control (Conversano et al., 2018). Potential reasons for personality traits could be related to the legitimacy of symptoms and social challenges relating to family and occupation (Glazer, Buskila, Cohen, Ebstein, & Neumann, 2010). Personal traumatic events (i.e., death of loved ones, child abuse, relationships) are also associated with developing pain behaviour and isolation (D'Aoust et al., 2017). Substantiating the impact of personality on pain intensity and physical activity behaviour is essential in managing pain, as demonstrated through CBT (Bennett & Nelson, 2006). The impact of personality on pain behaviours and physical activity has not been widely investigated as outcome measures for fibromyalgia have not emphasised the impact of personal factors on pain.

2.7.4 Self-efficacy and pain control

Low self-efficacy is a common challenge in chronic pain management, affecting coping and treatment behaviour (Di Tella et al., 2015; Moyano et al., 2018). Studies have shown that perceived control on pain substantially impacts pain rating (Moyano et al., 2018). A positive belief in pain control has shown better outcomes; likewise, a contrary belief in pain control was associated with worse pain outcomes (Hardin-Fanning & Ricks, 2017; Santoro et al., 2014). Few studies have reported self-efficacy as a mediator for the relationship between pain and physical functioning in fibromyalgia (Segura-Jimenez, Estevez-Lopez, et al., 2016; A. Soriano-Maldonado et al., 2015). Although previous studies have investigated the role of self-efficacy in pain rating and physical activity (García-Martínez et al., 2012; Jones, Rutledge, Jones, Matallana, & Rooks, 2008; Peñacoba Puente et al., 2015), there is a dearth of contextual data to identify the social factors driving self-efficacy.

2.7.5 Catastrophising

The severity of pain in fibromyalgia is commonly associated with catastrophising. Catastrophic thinking is a set of negative cognitive effect which tends to exaggerate pain perception and coping strategy (Lami, Martínez, Miró, Sánchez, & Guzmán, 2018). Catastrophising in fibromyalgia has been associated with multiple factors, including genetic (Malfliet et al., 2017), Kinesophobia (Malfliet et al., 2017) and environmental factors (Ravesloot, Berendts, & Schiwal, 2017). Research suggests that catastrophising is related to increased pain perception and an indicator of poor physical functioning in fibromyalgia (Eller-Smith et al., 2018). Similarly, catastrophising changes were shown to alter pain perception in people with fibromyalgia (Ellingson et al., 2018; Franceschelli et al., 2017; Lami et al., 2018; Quartana, Campbell, & Edwards, 2009). Psychological interventions aimed to decrease catastrophising were also shown to reduce pain perception (Turk & Adams, 2016). Studies have investigated catastrophising using questionnaires and thus neglect the experience shaping catastrophic thinking in fibromyalgia to enable targeted intervention.

2.7.6 Social stigma

The consequence of living with an invisible and contested illness as described due to unknown factors often leads to invalidation symptoms (Armentor, 2016). People with fibromyalgia frequently report experiencing social stigmatisation from friends, families, and health care workers (Huang et al., 2018). The consequence of social exclusion from family and friends often results in unexplained pain perception and mood disturbances that can negatively affect self-confidence, well-being, and increased psychological instability (Taylor, Adelstein, Fischer-White, Murugesan, & Anderson, 2016). This has increased to socio-economic burden among people with fibromyalgia.

Financial constraints and low socioeconomic status have a significant impact on pain management and contribute to pain appraisal. Studies have shown that people with less income are more prone to severe pain perception than middle income and higher-income (Grol-Prokopczyk, 2017; Janevic, McLaughlin, Heapy, Thacker, & Piette, 2017). A study investigated the role of economic hardship on 250 women with OA, RA, and fibromyalgia and found that patients who were not employed or had more financial burden reported more pain severity than their counterparts (Reisine, Fifield, Walsh, & Feinn, 2003). The severity of pain and other symptoms is more likely to keep people with fibromyalgia out of work than their counterparts with similar chronic pain conditions (Reisine et al., 2003).

2.7.7 Fibromyalgia: Diagnosis

Due to an unreliable biomarker to diagnose fibromyalgia, diagnosis is complicated by various classifications and diagnostic criteria. The ACR were the first to develop a diagnostic criterion for fibromyalgia. From the first criteria developed in 1990 by ACR, two other criteria followed- 2010/ 2011 and the 2016 criteria (Wolfe et al., 2010). The rapid change of criteria's for diagnosing fibromyalgia, i.e., the American College of Rheumatology 1990 was based on tender point examination and widespread pain, the ACR 2010/2011 abolished the tender point examination and widespread pain by adding symptom severity, and the revised 2016 criteria reemphasised on chronic widespread pain have led to the potential under-diagnosis and overdiagnosis of fibromyalgia (Wolfe et al., 2016). Virtually, patients undergo a tedious medical screening process to rule out other potential diseases before obtaining a diagnosis. These uncertainties in diagnostic criteria have triggered debates on the legitimacy and lack of confidence in the diagnostic criteria, especially in the primary health care settings (Arnold, 2008; Mease, 2005). The implications for these uncertainties have resulted in a non-uniform treatment approach, invalidating symptoms that severely affect the sufferers.

2.7.7.1 American College of Rheumatology Criteria 1990

The ACR 1990 was the first criteria developed to diagnose fibromyalgia, but the challenge for diagnosing fibromyalgia was prominent with the ACR 1990 criteria. The ACR 1990 requires a history of widespread pain in at least 11 out of 18 points in defined areas of the body, and tenderness must be present for more than three months (Wolfe et al., 2010). The diagnosis must also be carried out by a skilled rheumatologist trained in digital palpation to provide approximately 4kg of pressure. People with fibromyalgia are primarily seen in the primary healthcare set-up, where many physicians are not trained to conduct the tender point assessment (Buskila, 2003a). Another criticism of the 1990 criteria was not recognising other prevalent symptoms common in fibromyalgia, considering the high prevalence of sleep disturbances, fatigue and other psychological symptoms like depression and anxiety in people with fibromyalgia (Vugts, Joosen, van Bergen, & Vrijhoef, 2016). These agitations lead to new diagnostic criteria conducted through a multicentre study (Wolfe et al., 2010).

2.7.7.2 American College of Rheumatology Criteria 2010

The ACR 2010 criteria was developed to address the limitations of the ACR 1990 (Wolfe et al., 2010). The ACR 2010 was established through a multicentre study to supplement the tender point dependent criteria for diagnosing fibromyalgia by recognising other prevalent fibromyalgia symptoms (Wolfe et al., 2010). The study recruited 829 people diagnosed with fibromyalgia and controls- defined as patients with an unconfirmed diagnosis of OA or RA Physicians with knowledge of fibromyalgia, and tender point examinations were also selected from a rheumatologist list to conduct the first phase of the examination. The finding suggests that more than 80% of people with fibromyalgia do not require a tender point examination, and the Widespread Pain Index (WPI) and symptom severity scale are enough to diagnose fibromyalgia. The 2010 ACR criteria recommend eliminating the tender point examination in the diagnosis of fibromyalgia, a major controversial area of the ACR 1990 criteria, with self-reported widespread pain instead. Other sets of criteria were introduced; Widespread pain index score (≥7), and Symptom Severity Scale (≥5) or widespread pain index (3-6) and symptom severity (SSS ≥ 9). Like the 1990 ACR criteria, symptoms should also be present for more than three months, and the patients should not have any disease or disorder that would perhaps elucidate pain (Wolfe et al., 2010).

2.7.7.3 Canadian guidelines for management and diagnosis of fibromyalgia

The Canadian 2012 fibromyalgia guidelines recommend a more simplified criterion than the ACR 1990 and 2010/11 criteria. Contrary to the 1990 and 2010 ACR criteria that required a specialist, rheumatologist, to diagnose fibromyalgia, the Canadian guideline recommends diagnosis to be made by a primary care provider. The guidelines further argue the viability of tender point examination in clinical set up; that tender point examination is subjective and not necessarily needed to confirm fibromyalgia diagnosis. Furthermore, the guidelines recommend simple investigations to rule out conditions that mimic fibromyalgia symptoms like hyperthyroidism, rheumatic diseases, and neurological diseases. One possible criticism of this simplistic approach in the Canadian guidelines is the increased chance of misdiagnosis or fibromyalgia overdiagnosis (Fitzcharles, 2013a).

2.8 Burden of fibromyalgia

The complexity of fibromyalgia symptoms and the uncertainty surrounding the diagnosis of fibromyalgia are potential sources for the massive burden in people with fibromyalgia. Unlike many chronic pain conditions, i.e., OA and RA that have an objective clinical biomarker, fibromyalgia is not associated with a definitive biomarker and is accompanied by additional complex symptoms that could be devastating to physical, social, and psychological wellbeing (Chinn, Caldwell, & Gritsenko, 2016; Wolfe et al., 2018). Because of an unidentifiable biomarker and various diagnostic criteria to diagnose fibromyalgia, the process of diagnosis is often delayed ruling out other conditions (Ablin, Neumann, & Buskila, 2008; Bellato et al., 2012).

The impact of symptoms has contributed immensely to the working conditions of people with fibromyalgia. Quality of life in people with fibromyalgia is significantly lower than other chronic pain conditions (Birtane, Uzunca, Tastekin, & Tuna, 2007; Yilmaz et al., 2007). People with fibromyalgia scored lower in all Short Form 36 domains when compared with the healthy population and other chronic pain conditions such as OA, RA., and Systemic Lupus Erythema (SLE) (Verbunt, Pernot, & Smeets, 2008). Similarly, people with fibromyalgia are shown to have more challenges with work reporting to be more absent from work when compared to their peers with OA and RA (Kivimaki et al., 2007). Compared to other chronic pain conditions that are widely recognised to be impairing, people with fibromyalgia had the worse overall health status (Robinson et al., 2012), scoring less on the physical function domains of the SF-36: fibromyalgia=55 compared with OA =67, RA= 62 and are characterised by higher disease burden, comorbidities, pain medications, inferior health status, lower physical function, inadequate sleep, lower work productivity, and higher healthcare and medications expenditure (Schaefer et al., 2016).

In addition to the enormous burden on the health-related quality of life, financial data from different continents demonstrate a substantially high health care cost and significant health care utilisation among people with fibromyalgia (Robinson et al., 2012; Silverman et al., 2009; Spaeth, 2009). A total annual direct health care cost was estimated to be over £1000 in the UK and a sick leave cost of about £5000 (Liedgens, Obradovic, De Courcy, Holbrook, & Jakubanis, 2016). In the US, data from an annual report examining the health care expenditure in people with fibromyalgia and other randomly selected patients on the US health insurance register reported a three times higher health care cost in people with fibromyalgia, $9573 when compared to matched control $3291 on the register (Martinez et al., 2015). Similarly, a trend of high healthcare cost was reported in France €7,900 and the Netherlands €7100, comprising direct and indirect costs (Perrot et al., 2012). A similar trend was reported in Canada where $3804 (Canadian dollars) was estimated as an annual direct cost associated with medication taking the higher percentage, followed by consultation fee (Lacasse, Bourgault, & Choinière, 2016), and Japan (¥2,826,395 vs ¥1,201,547) which incurred twice more indirect cost and nearly six times six times higher in indirect cost (¥1,941,118 vs ¥335,140) (Perez-de-Heredia-Torres, Huertas Hoyas, Sanchez-Camarero, Perez-Corrales, & Fernandez de-Las-Penas, 2016).

2.9 Summary

- Pain is the hallmark symptom of fibromyalgia and is still a subject of debate. Although CNS has been implicated for pain in fibromyalgia, pain can be expressed in various dimensions, i.e., sensory, emotional, and cognitive. Cognitive and emotional factors are shown to have a critical influence on pain perception (Borg et al., 2018; Di Tella et al., 2015; Ekici et al., 2010; Ellingson et al., 2018; Lami et al., 2018; Martinez et al., 2015; Peñacoba Puente et al., 2015) and investigation of pain should incorporate these multidimensional constructs to provide a clearer picture.
- Most studies have attempted to understand the mechanism of pain through the biological model, which has been inconclusive. The biological model is engrossed in the biomedical causes of pain, i.e., identifying objective findings to explain pain perception (Meeus & Nijs, 2007). The biological model fails to recognise other critical aspects that drive pain perception without an underlying biochemical abnormality or objective finding. Despite the biomedical model's apparent inconsistency, it remains the primary determinant informing diagnosis and treatment guidelines in various pain conditions.
- Evidence-based guidelines for management have provided separate recommendations for pharmacological and non-pharmacological treatments. Although non-pharmacological treatments such as exercises are encouraged and recommended as the first line of management given the adverse effect of prolonged use of medications, adherence to structured exercise remains a massive problem in people with fibromyalgia. The alternative for structured exercises is a non-structured physical activity that does not involve supervision and structure. An example of non-structured exercises is leisure physical activity like dog walking, gardening, and dancing. Like

exercise, physical activity also has recommended intensity. The general guidelines for physical activity recommend moderate physical activity in the adult population. It is unclear whether these recommendations will be suitable for people with fibromyalgia, considering the pain severity. These factors need to be established.

3 Association between physical activity and pain: a systematic review

3.1 Background of systematic review

Pain is the primary symptom of fibromyalgia accompanied by fatigue, sleep disturbances, and depression (Wolfe et al., 2010). Among various treatment approaches, pharmacological and non-pharmacological, exercises have been recommended as the first line for managing pain (Macfarlane et al., 2017). However, adhering to structured physical activities such as strengthening and aerobic exercise remains an enormous challenge for people with fibromyalgia (Rowe et al., 2019; Sanz-Bañosa et al., 2018). Findings from a meta-analysis suggest more adherence to non-structured physical activity such as walking programs than supervised exercise for people with fibromyalgia (Sanz-Baños et al., 2018; Schachter, Busch, Peloso, & Sheppard, 2003). Due to the difficulties of exercise adherence in people with fibromyalgia, non-structured exercise such as lifestyle physical activity are needed as an alternative to structured exercise.

Although non-structured physical activity has been suggested as an alternative to structured exercise, the intensity of physical activity for fibromyalgia is unclear. There is a growing recognition that physical activity guidelines are not a one-size-fits-all recommendation as various conditions may have specific physical activity needs (Zhao, Veeranki, Magnussen, & Xi, 2020). The recent physical activity guidelines released by the UK chief medical officer (2019) recommend moderate to vigorous physical activity for improving and maintaining health in adult populations. Moderate physical activity can be achieved through approximately 150 minutes of weekly activities like brisk walking, stair climbing, gardening, Pilates, yoga and Taiichi. Moderate physical activity can also be achieved through 75 minutes of vigorous physical activity such as strengthening exercises, swimming, cycling, running, or combining both (Ding et al., 2020). The choice of approach to physical activity could depend on personal choices, availability, feasibility and most importantly, the ability to sustain the required physical activity to derive benefit. The question of whether people with fibromyalgia can benefit from the general physical activity guidelines or whether adjustments are needed for people with fibromyalgia or a particular group of people with fibromyalgia is not well established.

The challenge is identifying a suitable physical activity intensity to guide physical activity intervention for people with fibromyalgia. Literature investigating the relationship between physical activity categories and pain in fibromyalgia has not provided much insight into suitable physical activity for fibromyalgia. Although moderate to vigorous-intensity exercises are shown to impact lower pain intensity in other populations (Eller-Smith et al., 2018; lvin et al., 2016; Roland Staud et al., 2010; Staud et al., 2014), this is not clear for people with fibromyalgia. Thus, this systematic review examines the literature on the relationship between physical activity categories (low, light, moderate and vigorous) and pain in people with fibromyalgia.

3.2 Methods

This systematic review is registered with the Prospero number CRD 42018090219 and reported using the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines (Page et al., 2021b). The main objective of the PROSPERO is to register a study protocol for peer review to decrease replication of similar reviews and to enable transparency in the review process (Page et al., 2021a).

3.2.1 Eligibility criteria

Participants

Studies were only involved if they examined the adults' population (≥18 years), using a published criterion for the diagnosis of fibromyalgia (e.g., ACR criteria), were eligible for inclusion in the systematic review (Wolfe et al., 2016; Wolfe et al., 2010).

Types of intervention

This systematic review examined all types of study designs such as the RCTS, case-control, cohorts, and cross-sectional reporting the association or relationship between subjectively or objectively measured physical activity categories (sedentary behaviour, low physical activity, moderate physical activities, vigorous physical activity) and pain intensity in people with fibromyalgia. Only the studies conducted in the English language were included in the systematic review.

Comparison/exposure

This systematic review only involved studies that define categories of physical activity (low, light, moderate and vigorous) and reported the association between these categories of physical activity and pain intensity. Studies that investigated the difference between physical activity categories following long bout, non-structured physical activity were also included. This excluded any structured exercise (strengthening exercise), or which is short bout aerobic exercise.

Table 3-1: Eligibility Criteria

Criteria	Inclusion	Exclusion
Time period	1990- 2019	Before 1990
Language	English Language	Other Languages
Studies	Studies involving the adult population investigating the effect or relationship between lifestyle physical activity behaviour and pain, classified as low, moderate, or high with defined criteria	Studies involving structured exercise only
Types of studies	Primary studies- Qualitative and Quantitative	Reports, commentaries, narrative reviews, letters

3.2.2 Information Sources

To capture studies that were published to date, studies were retrieved via a computerised search of Cochrane Library, Medical Literature Analysis and Retrieval System Online (MEDLINE), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Psychological Information Database (Psych Info), Web of Science, Physiotherapy Evidence Database (PEDro). Only papers published in English were included in the study.

3.2.3 Search strategy

All searches were done between March 2018 to December 2018 (updated in 2021). Search strategies Table 3-1 were developed for physical activity, pain intensity, and fibromyalgia. The search terms were developed and piloted for sensitivity and relevance (Bramer, de Jonge, Rethlefsen, Mast, & Kleijnen, 2018; Kamdar, Shah, Sakamuri, Kamdar, & Oh, 2015). The rationale for starting the search from 1990 was to capture studies from when fibromyalgia was named a syndrome, and diagnostic criteria were formed (Inanici & Yunus, 2004). Search results for each database, documents obtained, and search dates are presented (see *Appendix 1)*

Table 3-2: Search Strategy

No	Keyword	Search strategy
1	Fibromyalgia (SI)	Fibromyalgia*
2	Physical Activity (S2)	*physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg*
3	Pain (S3)	Pain*, chronic widespread pain, *pain
4	Combine	SI AND S2 AND S3

3.2.4 Selection process

Abstracts of papers retrieved that meet the eligibility criteria were entered in an excel sheet for the second review and the supervisor for evaluation. Screening of abstracts was finalised in an arranged meeting to discuss the rationale for inclusion and exclusion of abstracts for synthesis, and decisions were recorded. A final meeting was arranged to agree on the final papers included in the synthesis (Büchter, Weise, & Pieper, 2020).

3.2.5 Data collection process

Data extraction was done with the guide of the lead supervisor. After identifying the keywords through the preliminary literature review, the search was piloted to ensure comprehensiveness and sensitivity. All articles retrieved were title screened and selected according to their relevance and objective of the systematic review (Büchter, Weise, & Pieper, 2020). The PhD candidate and the lead supervisor conducted a title review, and a consensus meeting was set to discuss any discrepancies to decide the papers selected for abstract screening.

3.2.6 Data items

Data extraction from articles retrieved includes the names of the authors, year, country, participants, sample size, study design, outcome measures, intervention, results and conclusion for each study included in the review was collected and presented in Table 3.5 for the primary outcomes (pain intensity and physical activity categories) (Büchter et al., 2020; Bui, Del Fiol, Hurdle, & Jonnalagadda, 2016; Norman, Leeflang, & Névéol, 2018).

3.2.6.1 Primary outcomes

Pain is the hallmark symptom of fibromyalgia, and thus all fibromyalgia studies assess pain as the primary outcome and other core symptoms of fibromyalgia such as depression and anxiety (Wolfe., 2010).

3.2.6.1.1 Pain Intensity

This review only reported one aspect of the pain experience (pain intensity) as pain intensity is the most common outcome for fibromyalgia studies and is also contained in the FIQR (Mease et al., 2009). When more than one measure of pain intensity is reported in one study, one outcome was extracted, i.e., FIQR pain intensity scale, Brief Pain Inventory (pain intensity), Mc Gill pain VAS, and the SF-36 bodily pain and pain severity scale. Primarily most of these questionnaires measure the severity of pain using single-item scales.

3.2.7 Secondary outcomes

The secondary outcomes for this review are the core symptoms domain defined by the ACR and the OMERACT consensus criteria for the diagnosis of fibromyalgia and are described below (Borrell-Carrio et al., 2004).

3.2.7.1.1 Depression

Depression is a core symptom of fibromyalgia and is recommended as a core outcome in fibromyalgia (Mease et al., 2009). This review reported the findings of the relationship between depression and physical activity categories. Changes in depression using the FIQR or other outcome measures used to assess depression in fibromyalgia were reported.

3.2.7.1.2 Fatigue

Fatigue is a core symptom of fibromyalgia and is recommended as a core outcome in fibromyalgia (Lukkahatai et al., 2016; Mease et al., 2009). All aspects of fatigue (physical, mental, and general) measured using the fatigue severity scale and other outcome measures that assess fatigue in fibromyalgia and relationship with physical activity category were reported in a separate table.

3.2.7.1.3 Anxiety

Anxiety is a core symptom of fibromyalgia and is recommended as a core outcome domain in fibromyalgia (Thieme, Turk, & Flor, 2004). This review reported anxiety intensity measured using the fibromyalgia Impact Questionnaire or other outcome measures commonly used to assess anxiety in fibromyalgia such as Patient Health Questionnaire-9 (PHQ-90) or the Beck Depression Inventory and the relationship with physical activity behaviour.

3.2.8 Assessing the risk of bias within studies and methodological quality

A procedure to assess the risk of bias recommended in the Cochrane handbook for systematic review was used in this study (Higgins et al., 2011; Jørgensen et al., 2016; Viswanathan et al., 2018). The Joanna Briggs Institute (JBI) appraisal tools were used to assess the risk of bias. Studies were grouped into study designs to assess the studies' methodological quality, i.e., experimental studies, mainly RCTs, observational studies, and mainly cross-sectional studies. The JBI contains a separate appraisal checklist for the experimental and observational studies. In this review, the studies were best categorised as RCTs and Observational studies and two separate checklists were used to assess methodological quality for experimental *(Appendix 2)* and observational studies *(Appendix 3).* While the JBI does not provide a scoring system for evaluating the quality of studies, it provides a systematic evaluation of the general validity of the analysis by identifying weaknesses in the studies that could have resulted in bias (Carlson, 2016; Vardell & Malloy, 2013).

3.3 Data synthesis

A narrative synthesis was conducted due to the heterogeneity between the included studies (Siddaway, Wood, & Hedges, 2019). The synthesis of the findings was conducted in a thematic breakdown of studies reporting similar findings (Siddaway, Wood, & Hedges, 2019). Studies reporting a positive relationship between physical activity categories and pain intensity were grouped and synthesised. Similarly, studies reporting a non-significant relationship between physical activity categories and pain intensity were grouped and synthesised. Likewise, the studies reporting the link between physical activity categories and fatigue or depression were grouped.

3.4 Results

3.4.1.1 Study selection

The literature search identified 15342 records, with 3,852 duplicates. After screening the titles, 11438 were further excluded, and the remaining 52 abstracts were screened. Eleven studies were not retrieved as these were only published abstracts. Forty-one papers were assessed for eligibility, and only ten papers were included in the final synthesis. The summary of selection is presented in the Prisma chart Figure 3-1- Prisma flow Chart (Page et al., 2021b)

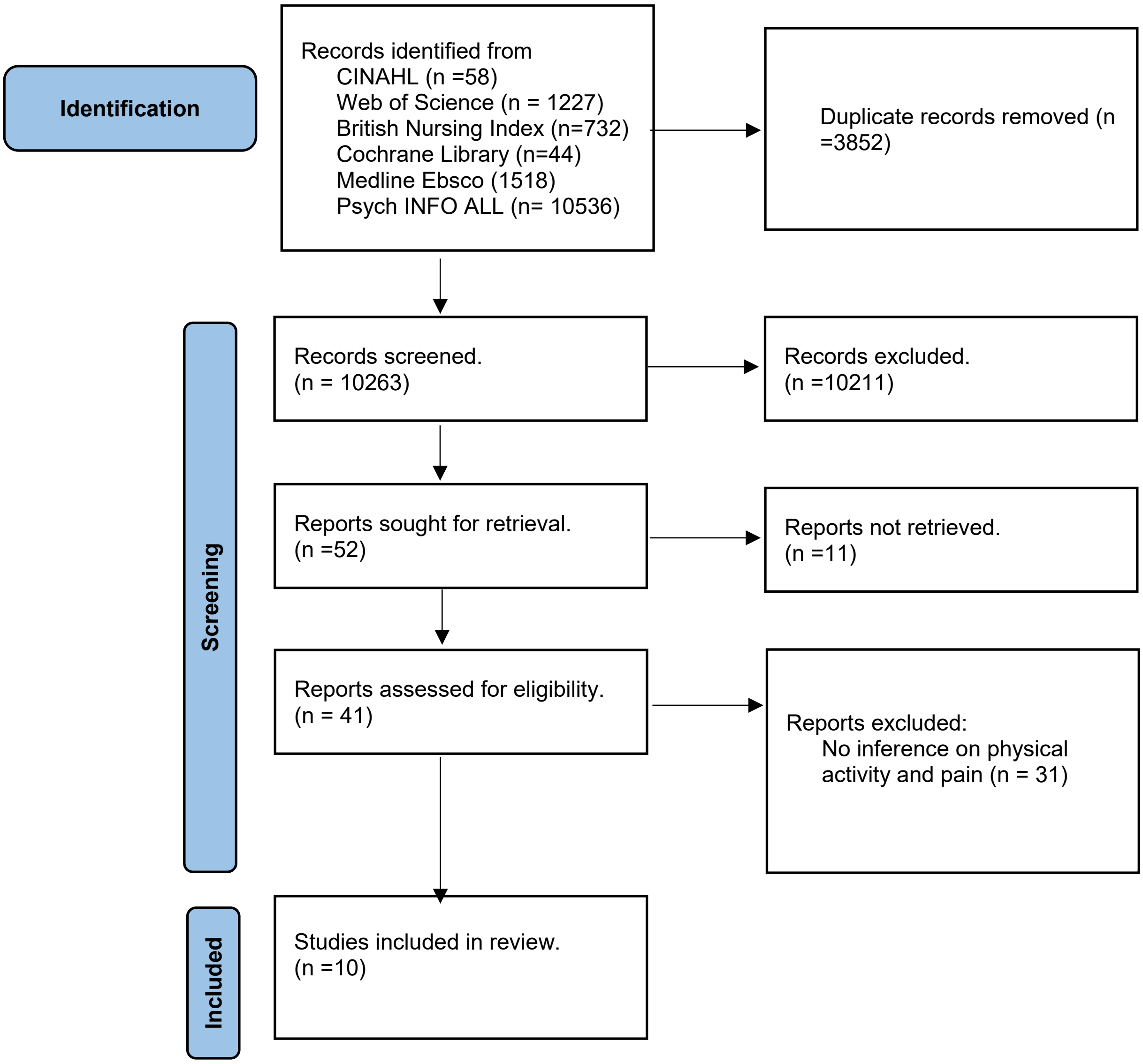

Figure 3-1- Prisma flow Chart

3.4.2 Description of studies

Ten studies were included in the final synthesis of the systematic review. Five of the studies were RCTs, and five were observational studies involving analytic cross-sectional designs and longitudinal studies. Most of the studies (six) were conducted in the USA. The description of studies, including author and year publication, study design, age, gender, outcome measures, results, and conclusion, is presented in Table 3-3.

3.4.3 Outcome measures used in studies

3.4.3.1 Pain measurement

Several outcome measures were used to measure pain intensity in the studies involved in the narrative synthesis. This involves single item severity scales measured with VAS, Fibromyalgia Impact Questionnaire pain scale, The Brief Pain Inventory (BPI) questionnaire, the Mc Gill questionnaire, and the pain self-efficacy questionnaire were all used to measure pain intensity.

3.4.4 Physical activity measurement

Several outcome measures, including objective measures and PROMS, were used to quantify physical activity categories in studies involved in the narrative synthesis. For the RCTs, the Community Health Activities Model Programs for Seniors (CHAMPS) questionnaire was used in two studies, other studies used the FIQR Physical Function scale (FIQ-PF), 6 minutes' walk test, Assessment of Motor and Process Skill (AMPS), and one study used an objective measurement ACTi Graph to classify physical activity. Similarly, the cross-sectional studies also used various outcome measures to quantify physical activity. The SF 36 physical function scale, Baecke Physical Activity Questionnaire (BPAQ), International Physical Activity Questionnaire - Short Form (IPAQ-SF) were used, and the objective measure, the ACTi Graph accelerometer-based device, was used in three observational studies.

3.4.5 Sleep measurement

Three studies used different outcome measures to quantify sleep disturbance. Pittsburgh Sleep Quality Index questionnaire, ACTi Graph accelerometer-based device and electronic interviewer of sleep quality were used to measure sleep disturbances.

Table 3-3: Extraction table for included studies on pain intensity and physical activity categories

S/No	Reference	Design	N	Gender	Age	Outcome measures	Result	Conclusion
1.	Fontaine et al. 2007 USA	RCT	34	F	50.5 ± 9.1	Physical performance: (distance covered in 6 minutes) Pain: VAS-FIQR	The relationship between lifestyle physical activity and fibromyalgia education group on pain intensity was negative p= 0.060	Moderate physical activity achieved through lifestyle physical activity was not associated with less pain.
2.	Fontaine 2010 USA	RCT	84	F and M	46 ±11.6 - 49 ± 10.2	Physical Activity: FIQ PF scale Pain Intensity	The Lifestyle Physical Activity group had an increase in an average daily step by 54% when compared to the fibromyalgia education group and had significantly less pain intensity compared with fibromyalgia Education p= .006	Accruing 30 minutes of moderate physical activity throughout the day is associated with less pain.
3.	Kaleth et al. 2013 USA	RCT	170		45.9± 10.9	Primary outcome: FIQ PI score, Secondary outcome: Pain intensity (pain severity), PA Assessment: CHAMPS	Sustained physical activity group reported a substantial improvement in pain severity compared to the LO-PA group ($P < 0.05$)	Increased and sustained physical activity is associated with lower pain compared to non-increase.
4.	Kaleth 2014 USA	RCT	199	95 % women	46.14 ± 11.19	Physical Activity assessment: Actigraphy Pain Intensity: BPI	Additional steps were not associated with pain intensity improvement p. 0.89 after 12 weeks	Additional steps per day were NOT associated with less pain intensity
5.	Rasmussen-2017 Denmark	RCT	187	Women	44.3	Physical Function: Assessment of Motor and Process Skills (AMPS), SF-36 PF subscale Pain: FIQ VAS	Individual changes in pain self-efficacy were not associated with changes in observed activity: AMPS motor p 0.27 and process p 0.11) No differences in pain self-efficacy and intensity were observed between the	An increase in physical function was not associated with less pain intensity

							rehabilitation group and controls P = 0.24	
6.	Steiner 2015	Secondary analysis of RCT	216	96.7% Women	46.39 ± (11.60)	Physical Activity: CHAMPS Pain Intensity: BPI	Univariate tests showed that the interaction between pain and physical activity group was significant for pain $p \leq 0.05$.	Activity increasers had lower pain compared to the non-increasers.
7.	Segura-Jiménez 2017 Spain	Cross sectional	419	Women	51.7 ± 7.6 years	Physical activity/Sedentary Time: Actigraphy Clinical pain: FIQR Fatigue severity: Multidimensional Fatigue Inventory (MFI-S)	A lower level of sedentary time was associated with lower pain intensity $p = 0.001$ Vigorous physical activity was associated with lower pain intensity $p = 0.002$. Moderate physical activity was not associated with lower pain $p = 0.27$	Lower sedentary time and Vigorous PA were associated with lower pain on SF 36, FIQ Pain subscale A positive relationship between lower sedentary time, vigorous - physical activity and pain No association between Moderate physical activity and pain intensity
8.	Segura-Jiménez 2017 Spain	Cross sectional	386	Women	51.2 ± 7.6	Physical Activity: triaxial accelerometer GT3X+ (ACTi graph, Pensacola, FL, USA) Physical fitness: The chair sits and reach test: lower body flexibility. The arm curl test: upper-body muscle strength Clinical pain: (SF-36) pain sub-scale The impact of fibromyalgia: (FIQR)	Light PA was associated with lower pain $p = 0.01$ and vigorous physical activity $p = 0.002$. However, lower pain was not associated with moderate physical activity $p = 0.214$ and moderate to vigorous physical activity $p = 0.15$	Light physical activity and vigorous physical activity were more beneficial for lower pain intensity. Moderate physical activity is not associated with lower pain intensity
9.	Umeda 2015 USA	Cross-sectional		Women	45.5 ± 12.2	Physical Activity levels: x Pain Intensity: VAS	BPAQ and VAS were positively associated p= < 0.01	More recreational physical activity is beneficial for reduced pain intensity.

10.	Meriwether USA	Cross-sectional	171	Women	49.3 ± 11.5	Physical Activity: IPAQ Accelerometer (ACTi graph) Pain Intensity: BPI Pain Intensity scale	There was a negative relationship between moderate to vigorous physical activity with pain intensity p= 0.87	Maintaining moderate physical activity does not reduce pain intensity.

3.5 Data analysis

A narrative synthesis of the studies was conducted due to the methodological variations between the studies (Siddaway et al., 2019). According to the guidance on narrative synthesis (2006), a narrative synthesis uses words and text to summarise and explain findings and study characteristics to gain greater value from multiple studies than just one. Narrative synthesis is popular in systematic reviews, including Cochrane reviews, especially when meta-analysis is not practical (Siddaway et al., 2019). In contrast to using words and text to summarise data, a meta-analysis uses statistical synthesis for combining and pooling effect sizes of studies through forest plots to gain an overall effect size (Andrade, 2020; Israel & Richter, 2011; Shorten & Shorten, 2013). A meta-analysis requires study uniformity, which includes statistical and methodological homogeneity. Methodological heterogeneity, for example, can be defined as the inclusion of RCTs and non-RCTs and the variety of continuous and binary outcomes (Andrade, 2020; Israel & Richter, 2011).

In this systematic review, there was variability in the study designs. The experimental studies were mainly RCT design, and the observational studies mainly were cross-sectional and longitudinal designs. The intervention studies compared the efficacy of unstructured physical activity with the control group, which also received treatment/ intervention. In addition to the variability of methodology, there was also variability in the outcome of interest. Therefore, a meta-analysis was not feasible.

3.5.1 A significant relationship between physical activity and pain intensity

Four studies included in this review reported a significant association between a moderate to vigorous physical activity category and reduced pain intensity in people with fibromyalgia Table 3-4. Fontaine (2010) investigated whether an accumulation of 30 minutes of lifestyle physical activity is associated with pain reduction. Participants were randomised to either the lifestyle physical activity group, where 30 minutes of moderate-intensity physical activity is accumulated or the fibromyalgia education group, where only education is delivered. The findings indicate that people with fibromyalgia in the lifestyle physical activity group increased their activity by 54 % compared to the fibromyalgia Education group. Most importantly, they had a significant decrease in pain intensity levels compared to the control group. Similar findings were reported by Umeda 2015, Kaleth et al., (2013) and Segura Jimenez et al., (2017) and Steiner (2015). The variability between these studies makes it difficult to make inferences on the findings. At the same time, Kaleth et al. (2013) and Fontaine et al. (2010) compared lifestyle physical activity intervention and fibromyalgia education. Steiner et al. (2014) compared participants that improved their physical activity from baseline to those that did not improve their physical activity. Similarly, the quantification of physical activity differed between the studies that reported a positive relationship between physical activity and pain intensity. Two studies used a CHAMP questionnaire (Kaleth et al., 2014; Steiner et al., 2015). The other two used the BPAQ questionnaire and six-minute walk test, which all have limitations in measuring physical activity behaviour (Rasmussen et al., 2017; Fontaine et al., 2007). Their validity to classify physical activity levels is vague.

Table 3-4: Summary of studies (pain and physical activity)

Author	Description and summary of findings
Kaleth et al. (2013)	This study evaluated if sustaining moderate to vigorous physical activity was associated with lower pain intensity. Among the 170 females recruited in the study, only 27 participants, representing 15%, sustained moderate to vigorous physical activity for over 24 weeks. In addition, 40% of the participants increased their physical activity initially but then decreased over time, while the remaining 44% did not increase their physical activity at all. Comparing these groups, those that increased and sustained their physical activity levels at moderate to vigorous intensity had lower pain intensity than the other groups that did not sustain their physical activity level. **The study limitation** is measuring and classifying physical activity using the CHAMPS questionnaire, primarily designed for older adults to assess physical activity level over one week. Given the length of study, 24 weeks, and cognitive problems in people with fibromyalgia, recall bias could affect the validity of physical activity classification.
Steiner et al. (2015)	This study investigated whether changes in physical activity maintenance through motivational interviewing and the attention control group. Comparing the two groups, there was no difference in physical activity between the two groups, so participants were divided into those that increased their physical activity from baseline and did not increase their physical activity. A univariate test found a significant association between pain intensity and those that increased their physical activity compared to those that did not increase their physical activity from baseline at 24 weeks p= <0.05. **The limitation** is using the CHAMP questionnaire to quantify physical activity over 36 weeks, and observations were taken at baseline, 24 weeks, and 36 weeks.
Umeda et al. (2013)	This study investigated the association between physical activity and daily function to determine the impact of pain, depression, and body mass. Twenty-three adults with fibromyalgia were recruited in this observational study and completed the self-reported physical activity, pain intensity and other variables. The study showed that pain intensity mediates the association between physical activity and daily function. The main limitations are the small sample size in this study and the Baecke Physical Activity Questionnaire (BPAQ) to quantify physical activity.

Fontaine et al. (2010)	This study evaluated the effects of accumulating 30 minutes of physical activity on pain intensity and other fibromyalgia symptoms. The study recruited 84 participants and was randomised into a lifestyle physical activity group. Participants received a build-up of 30 minutes of moderate physical activity and a fibromyalgia education group. The participants only received educational intervention on diagnosis, causes, and treatment approaches in Fibromyalgia. The study found that people with fibromyalgia allocated to the lifestyle physical activity group had significantly less pain than those assigned in the fibromyalgia education group. This study's limitation is using a 6 minutes' walk test to measure physical activity behaviour.

3.5.2 No significant relationship between moderate physical activity/physical function and pain intensity

In this review, four studies reported no significant association between moderate to vigorous physical activity and pain intensity in people with fibromyalgia described in Table 3-5. Among the four studies that reported no relationship between participants that increased from a sedentary lifestyle to moderate physical activity and pain intensity, three RCTs compared participants that increased their physical activity levels to those that did not correlate with pain intensity. However, the comparison group also had an education intervention which is also helpful for pain management. These studies found a positive association between physical activity and reduced pain intensity also have varied study designs and outcome measures employed to assess physical activity.

Table 3-5: Description of the studies reporting a nonsignificant association between moderate physical activity and pain intensity

Author	Description and summary of findings
Fontaine et al. (2007)	This RCT is conducted to examine the effects of lifestyle physical activity, a target of 30 minutes of moderate-intensity physical activity, and fibromyalgia education on pain intensity and other symptoms. In this study, a smaller sample of thirty-four participants was recruited and allocated into the lifestyle physical activity group or the fibromyalgia education group. The findings of the study showed that an increase in lifestyle physical activity was not significantly associated with decreased pain intensity compared with the fibromyalgia education group.
Kaleth et al. (2014)	This study investigated the association between the number of steps taken per day and pain intensity in adults with fibromyalgia. The study recruited 199 adults with fibromyalgia, primarily women, within a sedentary lifestyle, with an average of 4,091 steps per day. The study showed that increasing over 1,000 steps per day was not associated with P= 087 with decreased pain intensity. The strength of this study is using the Actigraphy accelerometer to quantify physical activity.
Rasmussen et al. (2017)	This study examines whether changes in pain self-efficacy was associated with an increase in physical activity. The study recruited 187 women randomised to the rehabilitation group, tailored intervention to improve physical activity, and the control group. The finding of the study did not report a significant relationship between the rehabilitation group and the control group on pain intensity p= 0.24. The limitation of this study is the assessment of physical activity. Physical function in this study was measured using the AMPS, where the therapist observes and score the ability to perform a motor and process skill. The validity and reliability of this measure are not reported in people with fibromyalgia.
Meriwether et al. (2018)	This study investigated the relationship between lifestyle physical activity and multiple symptoms of fibromyalgia, including pain intensity. The study recruited 171 women with fibromyalgia, and physical activity was assessed using the subjective IPAQ-SF and objective measure ACTi Graph monitor on the wrist. Interestingly, both subjective and objective measurements were correlated. Among the 171 participants recruited, only 57 participants were within a moderate, physically active lifestyle. The relationship between moderate to vigorous physical activity with pain intensity were negative p= 0.87.

3.5.3 Lower and higher physical activity was associated with lower pain intensity, and moderate physical activity was not associated with reduced pain

Two studies in this review by Segura Jimenez et al. (2017) reported that light physical activity behaviour, 200-2689 counts per minute, was associated with less pain reduction than moderate physical activity behaviour 2690-6167. These are different findings considering most studies in this review compared moderate physical activity as moderate physical activity is the recommended dose of physical activity for healthy populations.

Table 3-6: Description of the studies reporting a significant association between lower physical activity and pain

Author	Description and summary of findings
Segura Jimenez et al. (2017)	This study was conducted to investigate the independent association between physical activity levels and pain intensity. The study recruited 386 people with fibromyalgia, and physical activity was classified as low, moderate, and vigorous. Low physical activity was classified as 200-2689 counts per minute, moderate physical activity was classified based on 2690-6167, while vigorous physical activity was classified as equal to or more than 6167 counts per minute. In this study, light physical activity was associated with lower pain intensity p= 0.001 and vigorous physical activity was not associated with lower pain intensity p= 0.072. Surprisingly, moderate physical activity was not associated with lower pain intensity p= 0.304.
Segura Jimenez et al. (2017)	This study examined the association between sedentary time and physical activity levels in women with fibromyalgia. The study recruited 419 women and was classified into sedentary and light physical activity, moderate and vigorous physical activity based on the accelerometer data recorded over seven days. Sedentary was classified based on physical activity vector magnitude cut point as 0-199, light physical activity 200-2689, moderate physical activity 2690- 6166, while vigorous was classified as having over 6167. The study's findings revealed that sedentary time and lower physical activity were associated with lower pain intensity p= 0.001, vigorous physical activity was also associated with lower pain intensity. In contrast, moderate physical activity was not associated with lower pain intensity.

3.5.4 Relationship between moderate to vigorous physical activity behaviour and depression

The relationship between physical activity and depression was inconsistent in this review. Considering the variability between the studies and methodological variation in measuring depression, this review could not ascertain the impact of physical activity on depression as some studies report a significant difference between those that improved their physical to those that did not improve their treatment, other studies also report the difference between moderate physical activity behaviour and depression. Table 3-7 summarises results from studies that reported the relationship between physical activity categories and depression. Four out of six studies reported the association between depression and physical activity categories and reported no significant improvement in depression.

Table 3-7: Summary of studies reporting an association between physical activity and depression

Author	**Summary of finding**
Kaleth et al. (2014)	This study found that an increase in 1000-5000 steps per day was associated with improved depression score P=<0.001. Depression was measured using the Patient Health Questionnaire 8-items for depression.
Kaleth et al. (2013)	In this study, increased physical activity and sustaining physical activity were not significantly associated with decreased depression. Depression was measured using the Patient Health Questionnaire 8-items for depression.
Steiner et al. (2015)	This study suggested that depression is a mediator in the relationship between physical activity and pain intensity.
Rasmussen et al. (2017)	There was no difference between the rehabilitation group with moderate physical activity and a control group for depression p=0.64. Depression was measured using the Major Depression Inventory.
Umeda et al. (2013)	This study reported that depression did not mediate the relationship between physical activity increase and pain intensity.
Fontaine et al. (2010)	There was no difference between the lifestyle physical activity group and fibromyalgia education group on depression measured using the Centre for Epidemiological Depression Scale p=0.88.

3.5.5 Relationship between physical activity behaviour and fatigue

The relationship between fatigue and physical activity is reported in five studies Table ***3-8***. Two experimental studies found no difference between an increase in physical activity and fatigue. Similarly, two cross-sectional studies reported a significant difference between vigorous and light physical activity and fatigue among the three observational studies. One study did not find a relationship between moderate physical activity behaviour and fatigue in people with fibromyalgia.

Table 3-8: Summary of findings reporting the association between physical activity and fatigue

Author	Description
Merriweather et al. (2018)	This study reported that lifestyle physical activity was not related to fatigue intensity p=0.69, movement fatigue p=0.45 and multidimensional fatigue p= 0.99
Fontaine et al. (2010)	This study found no difference between the lifestyle physical activity and fibromyalgia education groups on Fatigue Severity Scale (FSS) p= 0.07.
Fontaine et al. (2007)	This study found no difference between the lifestyle physical activity group, which accumulated 30 minutes of moderate-intensity physical activity and the fibromyalgia education group on FSS p= 0.85.
Segura Jimenez et al. (2017)	This study reported that vigorous physical activity and physical function are independently associated with lower general fatigue except for mental fatigue p<0.0001.
Segura Jimenez et al. (2017)	In this study, higher levels of physical activity (vigorous) were associated with lower general and physical fatigue p<0.001

3.6 Discussion

This systematic review aimed to summarise evidence on the relationship between physical activity and pain intensity in people with fibromyalgia. This review did not establish strong evidence on the relationship between physical activity categories (sedentary, light, moderate and vigorous) and pain intensity in people with fibromyalgia. While half of the studies reported lower pain intensity following an increase in physical activity, the other half reported a non-significant decrease in pain intensity following an increase in physical activity.

The hypothesis that a higher level of physical activity is associated with lower pain reduction was not corroborated in this systematic review. Previous studies have demonstrated that activation of endogenous systems such as the opioidergic, serotonergic, endocannabinoidergic, and inflammatory cytokines endogenous systems are responsible for pain modulation following physical activity in people with fibromyalgia (lvin et al., 2016). Ellington et al. (2012) also demonstrated an increased brain activity in different brain areas responsible for pain modulation in higher active fibromyalgia patients compared to sedentary people with fibromyalgia. These findings imply that people with fibromyalgia who engage in moderate to vigorous physical activity will have less pain perception than participants who lead a sedentary lifestyle. However, this systematic review did not corroborate the hypothesis that higher physical activity is associated with lower pain. Half of the studies did not find a statistically significant association between physical activity categories or increased physical activity and pain.

Four studies were in line with the hypothesis that increased physical activity is associated with lower pain intensity. Fontaine et al. (2010) investigated whether an accumulation of 30 minutes of lifestyle physical activity affects pain reduction and other fibromyalgia symptoms. People with fibromyalgia were randomised to either the lifestyle physical activity group, where 30 minutes of moderate-intensity activity is accumulated or the fibromyalgia education group, where only education is delivered. The findings indicate that people with fibromyalgia in the lifestyle physical activity group increased their activity by 54% compared to the fibromyalgia education group and, most importantly, had a significant decrease in pain intensity levels compared to the control group. Similar findings were reported by Umeda et al., (2015), Kaleth et al., (2013) and Segura Jimenez et al., (2017) and Steiner et al., (2015). Surprisingly, Segura Jimenez et al., 2017, found that light physical activity was associated with lower pain; however, moderate physical activity was not. Given the multiple symptoms associated with fibromyalgia, it is hard to directly link physical activity behaviour and pain intensity without controlling other known mediating factors.

This systematic review shows an indication that most people with fibromyalgia are leading a sedentary lifestyle. A few studies have suggested that people with fibromyalgia are less active than their aged-matched control (Ellingson, Shields, Stegner, & Cook, 2012). This systematic review also indicates that most people with fibromyalgia are within the low physical activity category. Among the 170 females recruited by Kaleth et al. (2013), only 27 participants, representing 15%, sustained moderate to vigorous physical activity over 24 weeks. Also, 40% of the participants increased their physical activity but declined over time, and the other 44% did not increase their physical activity. Similarly, Kaleth et al. (2014) showed that among the recruited 199 adults with fibromyalgia, primarily women, live a sedentary lifestyle, with an average of 4,091 steps per day. The study by Fontaine et al. (2007) also showed that people with fibromyalgia are minimally active.

The inconsistency of the relationship between physical activity and pain could be due to the variability of outcome measures and physical activity measurement. Physical activity and physical functioning were used interchangeably across studies even though physical activity and physical functioning concepts are entirely different (Caspersen, Powell, & Christenson, 1985). While physical activity measures the amount of time and intensity spent on doing any movement such as brisk walking, gardening, walking from the parking lot to the office, and stair climbing, physical function, on the other hand, relates to the performance and ability in doing these tasks, i.e., muscle performance, strength, and endurance. Although physical activity is a predictor of physical function in people with fibromyalgia (Merriwether et al., 2018), sometimes that might not be the case as very functional people are not always the most physically active. In this systematic review, some studies, Fontaine et al. (2007) and Rasmussen et al. (2017), measured physical activity using physical function outcomes like performing on a six-minute walk or physical function scale. This would be problematic comparing physical function outcomes and physical activity outcomes.

3.6.1 Limitations

I. The experimental studies used a longitudinal design, and the observational studies mostly used a cross-sectional design. The experimental studies compared physical activity increase with the control group, which also received treatment/ intervention. Therefore, methodological variations between the studies may explain the inconsistent findings.

II. Variability in outcome measures used for quantifying physical activity may have affected the reliability of physical activity categories.

III. A narrative synthesis was conducted due to the variability between the studies. Narrative synthesis does not distinguish studies based on effect size estimates, and thus, all studies, irrespective of their weight, were equally counted.

3.6.2 Implication for further studies and selection of outcome measures

Studies investigating physical activity patterns and links with symptoms of fibromyalgia are scarce in the UK population. Although physical activity guidelines unanimously recommend 75−150 minutes of vigorous-intensity physical activity or 150−300 minutes of moderate-intensity physical activity in a week (Ding et al., 2020), different physical activity patterns are observed in various populations. For example, the UK physical activity guidelines indicate that over 65% of men and 61% of females met the physical activity recommendations (UK chief medical officer report 2019). Similarly, the AHA reports that only 53% of the adult population in the USA meets the physical activity guidelines, which is 10% less than the UK and other reports suggesting 80% of the adult and adolescence not meeting the guidelines (Riebe et al., 2015; Piercy, Troiano, Ballard, et al. 2018). Looking at the physical activity patterns in the UK and the US, it is reasonable to suggest that people with fibromyalgia are less physically active and potentially more sedentary behaviour than the healthy population. The study characteristics, shown in the synthesis, indicates that most studies were conducted in the US, and thus a UK data will be essential given the variability in physical activity patterns.

In addition to the dearth of data on physical activity in the UK population, most studies investigating physical activity have adopted a positivist paradigm. Thus, the impact of biopsychosocial factors such as beliefs, perceptions, experience, coping strategy and interpersonal factors are not explored. The dearth of data on personal experiences and perspectives on physical activity behaviour and pain has rendered physical activity interventions hard to implement in practice. Given that pain and physical activity are associated with multidimensional factors such as emotion (Lumley et al., 2011), perception (Habiger, Flo, Achterberg, & Husebo, 2016), an individual difference (Fillingim, 2017), and biopsychosocial factors (Lourenço et al., 2015), makes it very complex. The role of psychosocial, environmental and contextual factors on pain and personal experiences and perspectives leading to exercise intolerance and sedentary behaviour is unclear. Therefore, a qualitative approach complementing quantitative data will enable a broader understanding of factors impacting this relationship between pain and physical activity behaviour.

Measuring physical activity was inconsistent between studies in the systematic review. While objective measures in the review used the accelerometer to quantify physical activity behaviour, the subjective measures used various questionnaires to quantify physical activity behaviour. Although both methods intend to quantity the same activity construct, i.e., time spent on physical activity and intensity of the physical activity (Lynch et al., 2019; Mannerkorpi & Hernelid, 2005; Strain, Milton, Dall, Standage, & Mutrie, 2020), the difference between the accelerometer-based and self-reported assessments is not well established in fibromyalgia. Merriweather (2018) quantified physical activity using the accelerometer and IPAQ- SF, and the measurements were moderately correlated for classifying physical activity behaviour in people with fibromyalgia.

Physical activity and physical functioning were used interchangeably across studies even though physical activity and physical functioning concepts are entirely different (Caspersen et al., 1985). While physical activity measures the amount of time and intensity spent on doing any movement such as brisk walking, gardening, walking from the parking lot to the office, and stair climbing, physical function, on the other hand, relates to the performance and ability in doing these tasks, i.e., muscle performance, strength, and endurance. Although physical activity is a predictor of physical function in people with fibromyalgia (Merriweather et al., 2018), further studies need to establish the pattern of association between physical activity and pain and physical function and pain separately to guide interventions.

Pain intensity was used in this review as the primary outcome measure given the widespread use of the pain intensity scales such as the Numeric Rating Scale, VAS and FIQR single-item pain severity scales, which all fundamentally measures pain severity. Although other outcome measures are used in measuring multidimensional constructs of pain, these are not as common given their length potentially. A multidimensional pain outcome measure is needed to explore the difference between pain intensity scales and multidimensional pain and physical activity constructs.

3.7 Conclusion

The association between increased physical activity and decreased pain intensity varied across studies. The association may be impacted by other symptoms associated with fibromyalgia or variability in measuring physical activity and physical function. Given that most studies investigating pain and physical activity have not fully captured the impact of biopsychosocial factors such as contextual factors, psychological factors such as depression and anxiety and social factors such as employment and living status, which are shown to have an impact on pain and physical activity as shown in the literature review (2.6) (Arnborg Lund, Kongsted, Bäcker Hansen, & Myburgh, 2020; Hanson et al., 2021; Mun et al., 2017; Sawa et al., 2020), there is need to explore the impact of these factors on the association between pain and physical activity.

4 Methodology

4.1.1 Introduction

This chapter will describe the rationale for the philosophical stance, ontology and epistemology, data collection method and rationale for the mixed-methods design, quantitative and qualitative approach and analysis for each approach. As a recap, the systematic review conducted (Chapter 3) to investigate evidence on the association between pain and physical activity did not establish the association between physical activity categories and pain in people with fibromyalgia. The association between pain perception and physical activity is shown to be driven by multiple factors such as biological, psychological, social and contextual (Bannon, Greenberg, Mace, Locascio, & Vranceanu, 2021; Li, Liu, Hu, & Meng, 2020; Quiton et al., 2020; Ziadni, You, Johnson, Lumley, & Darnall, 2020). Expert consensuses suggest using contextual frameworks to understand issues associated with fibromyalgia and unravel targets for intervention (Bustan et al., 2018; Lourenço et al., 2015; Whitburn, Jones, Davey, & Small, 2017).

4.1.2 Philosophical paradigm

The emergence of mixed-methods research provides an option to integrate two methodologies to enhance understanding of a complex problem in health, social and behavioural sciences (de Haan, van Eijk-Hustings, & Vrijhoef, 2021). The mixed method combines qualitative and quantitative philosophies to broaden the research problem (van Griensven, Moore, & Hall, 2014). According to the Health Services Research UK, there has been an increased interest in mixed-methods research compared to the previous decades (O'Cathain, Murphy, & Nicholl, 2007). This is in line with the WHO recommendation for a holistic approach to investigating chronic pain conditions, which involves incorporating social and personal perspectives to enhance understanding and management (ICF, 2003). The mixed method is derived from a pragmatic philosophy that argues that research is contextual and proposes the use of multiple methods deemed appropriate to answer the research question against strict philosophical assumptions (Allmark & Machaczek, 2018; Bravo et al., 2015; O'Cathain et al., 2007; Tariq & Woodman, 2013; van Teijlingen, Douglas, & Torrance, 2008).

4.1.3 The rationale for the mixed-methods approach

Researchers have paid less attention to the influence of personal and contextual factors on physical activity and pain in people with fibromyalgia and given more attention to quantifying the relationship between physical activity and pain (Álvarez-Gallardo et al., 2019; Breda et al., 2013; Fontaine et al., 2011; Fontaine & Haaz, 2010; Mannerkorpi et al., 2010; Racine et al., 2018; Víctor Segura-Jiménez et al., 2019; Segura-Jimenez, Soriano-Maldonado, et al., 2017). The implication of relying on experimental studies is the potential to miss other social and environmental factors that equally play a role in driving pain perception and participation in physical activity. Although several studies have attributed exercise intolerance and sedentary behaviour in people with fibromyalgia to fear of increased pain (Carbonell-Baeza et al., 2011) and fatigue (Dailey et al., 2015; Malfliet et al., 2017), the role of psychosocial, environmental and contextual factors on pain and physical activity in fibromyalgia is not clear.

The systematic review conducted to investigate pain and physical activity did not provide sufficient evidence to establish the impact of psychosocial factors on the relationship between pain intensity and physical activity. Pain perception and physical activity are also driven by social factors such as family support, working environment and contextual factors, which could impact emotions, experiences and expectations of living and coping with pain (Bannon et al., 2021; Li et al., 2020; Quiton et al., 2020; Ziadni et al., 2020). Given the impact of context on pain, several expert consensuses suggest using contextual factors to understand fibromyalgia pain (Bustan et al., 2018; Lourenço et al., 2015; Whitburn et al., 2017). The need to investigate and manage chronic pain conditions using a comprehensive approach is recommended by the ICF framework (Talo & Rytokoski, 2016).

This thesis aims to explore the influence of contextual and biopsychosocial factors on pain and physical activity. A mixed-methods approach was more appropriate to provide additional depth to the quantitative data (O'Byrne, 2007; Tariq & Woodman, 2013). Hence, a mixed-methods approach was utilised to quantify the association between pain and physical activity while controlling for biopsychosocial factors' impact and gaining a more in-depth understanding of people with fibromyalgia's perspectives by examining their narratives. These questions need to be answered through a large-scale dataset to obtain a complete picture of the links between pain and physical activity in people with fibromyalgia and identify more specific targets for interventions.

4.1.4 The positivist ontology

Quantitative research aims to produce empirical evidence through a rigorous procedure to obtain objective findings (Carminati, 2018). The concept of quantitative studies is derived from the positivist perspective, which relies on gathering and analysing numerical data to describe, explain and predict variables of interest (Claydon, 2015). Researchers inclined toward the positivist paradigm consider that truth is susceptible to discovery through empirical observation (Blease, 2018). In this regard, the positivist theorist does not consider contextual factors in research because of the potential bias of the researcher or the participant. Therefore, data are collected through experiments and surveys using statistical techniques to establish associations and causal relationships between independent and dependent variables (Kelley-Quon, 2018; Watson, 2015).

4.1.5 The rationale for the survey

Among several quantitative studies, RCTs sits on the top of the hierarchy of evidence, informing policymaking and clinical guidelines (Katz et al., 2019; Vere & Gibson, 2020). Evidence hierarchy is used to rank research based on evidence quality (Merlin, Weston, & Tooher, 2009). Because RCTs are designed to minimise bias, using random sampling and blinding of participants and control confounding factors, their validity and reliability are reported to be superior to observational studies (Sullivan, 2011). Observational studies, such as cohort, cross-sectional, and case-control, are ranked lower because of their potential for bias (Corrao, Rea, & Mancia, 2021; Park, 2020; Sedgwick, 2015). Most clinical guidelines, including the guidelines for managing fibromyalgia recommended only systematic reviews and RCTs to develop treatment recommendations (Macfarlane et al., 2017).

Despite RCTs' strength and perceived superiority to generate objective findings, their scope is limited to answering questions of effectiveness (Deaton & Cartwright, 2018; Zurita-Cruz, Márquez-González, Miranda-Novales, & Villasís-Keever, 2018). Exploring experience is critical to finding treatment adherence in clinical practice is equally important (Rosen, 2015). A researcher may be more interested in understanding the acceptance of treatment to identify ways of improving the intervention (Rosen, 2015). Observational studies as can identify categories of people and patterns of physical activity to guide treatment approaches. This may help identify factors resulting from fear and intolerance to exercise in people with fibromyalgia (Lonberger et al., 2016; Nijs et al., 2013).

Observational studies are non-interventional designs used to investigate disease conditions' prevalence, patterns, and risk (Song & Chung, 2010). Observational studies include case-control, cohorts and cross-sectional studies (Boyko, 2013). The primary criticism for the observational studies is the potential bias associated with the study design (Faraoni & Schaefer, 2016). Confounding is universal in observational studies because participants are not randomised into groups, so the chance of confounding factors influencing the result will be higher (Jager, Zoccali, Macleod, & Dekker, 2008). Observational studies could also be prone to information bias and transient human nature, i.e. mood state and response style, affecting variability between the predictor and outcome of interest (Song & Chung, 2010).

A cross-sectional analytic survey was adopted as the design for the quantitative study to investigate the association between pain and physical activity. Generally, cross-sectional studies have a one-time dimension, there is no time interval between the exposure and outcome, so causal inference cannot be made (Boyko, 2013). This enables data gathering on events of interest, examining multiple outcomes and trajectories and determining disease rates in exposed and unexposed groups (Song & Chung, 2010). Although cohorts and longitudinal studies are more potent than cross-sectional studies, they involve logistic challenges, such as time, expenses and a high attrition rate compared with cross-sectional studies, which only need one-time data collection (Boyko, 2013). The prospect of multiple observations, a longitudinal design, was explored for this thesis. The plan was to collect data at multiple points to examine the trajectory of the association between physical activity, pain, and other symptoms of fibromyalgia at multiple time points. This was to enable establishing a cause-and-effect relationship. However, given the time frame of the PhD and the challenges anticipated with recruitment and the possibility of attrition rates, a cross-sectional survey was utilised along with qualitative inquiry to enhance rich data.

4.1.6 Interpretive philosophy

The two most common philosophies used in primary research are the interpretive and the positivist (Altmann, 2007). The interpretive philosophy was developed based on the criticism of positivism philosophy dominance (Mitchell & Cody, 1992). Interpretivism is based on the idealist philosophy, which constitutes a wide range of approaches, including phenomenology and social constructionism (Chessick, 1993). Interpretivism asserts that the meaning of the world can be interpreted in various ways (Levers, 2013). The interpretivism philosophy is linked to idealist philosophy, including social constructionism, phenomenology and hermeneutics, which focuses on the meaning of the world that the individual creates (Walsham, 2017).

The critical realist is a relatively new philosophy developed in the 1970s to address the dominance and limitations of the positivist philosophy in social sciences (Bhaskar, 2013). Evolving from two distinct philosophies, positivist and idealist (Modell, 2009; Vaujany, 2008), critical realism applies both schools of thought to address the complex inquiry process (Fletcher, 2016). The critical realist criticises the positivist and idealist philosophies for absolutist and universalist claims (Shipway, 2015). Critical realism Integrates these two approaches to be a more comprehensive philosophy of enquiry (Fletcher, 2016).

In this research, a critical realist perspective enables an in-depth analysis to understand the impact of multiple factors affecting pain and physical activity behaviour, given the impact of the biopsychosocial dimensions of pain and physical activity. Previous phenomenological studies have identified themes that include social dimensions of physical activity participation and behaviour towards their attitudes to exercise (Madden, 2010; Shaefer, 1995; Soderberg, 1999). Applying the critical realist philosophy, interpretive accounts, by phenomenological studies, could be subjected to multiple realities, and patients' pain experiences could be exaggerated beyond their descriptions. The critical realist approach identifies causal mechanisms and interactions between multiple mechanisms and contextual factors to explain how things act and why (Williams, Rycroft-Malone, & Burton, 2017).

4.1.7 Critical realist ontology

The distinct feature of the critical realist philosophy is the concept of stratified ontology. The critical realist argues that ontology is not reducible to epistemology; our knowledge of truth is not necessarily the reality but could be closer to reality (Bhaskar, 2013). In this regard, the critical realist deviates from both the positivist and idealist philosophies. Critical realist (Modell, 2009) criticised the positivist philosophy for its reductionist approach to epistemology and limiting reality to empirical inquiry. In the same way, he criticised the constructivist for viewing reality through human knowledge. Interpretivism is based on the relativist ontology that the existence of human knowledge is related to their society and culture, and knowledge is not absolute as these factors shape our realities (Levers, 2013).

There is an increase in studies adapting the critical realist perspective to understand health and social problems better. Critical realism is described as the ‘emancipatory potential’ in mental health care research with the potential to unravel the complexities of gender and mental health (Bergin, Wells, & Owen, 2008). Methodologies such as ethnography, case study and grounded theory are based on relativist ontology (Levers, 2013). According to the critical realist, the pitfall of these philosophies is that people’s culture and society naturally shape their experience and knowledge (Stevens, 2020; Toye, Jenkins, & Barker, 2020). Therefore, describing social events based on accounts of human experience could be subjective and lacking depth. The application of critical realist will enable the identification of social mechanisms, given the complexity of multidimensional factors involved, where pain management may be subjected to multiple realities.

4.1.7.1 Truth has multiple layers

The difference between the critical realist philosophy and other philosophies is the concept of stratified ontology. While the positivist argues that truth is reducible to human experience and perception regardless of mechanisms, interpretivism argues that reality is independently or socially constructed, which can only be done by analysing meanings (Scotland, 2012). In contrast to both philosophies, the critical realist seeks to identify empirical data structures to infer causal mechanisms (Williams et al., 2017). The critical realist philosophy argues that empiricism, knowledge based on experience, is deficient and often misleading as social events go far beyond human description, experience and perceptions (Bunt, 2016; Levers, 2013). In people with fibromyalgia, their agony due to the invalidation of symptoms from multiple facets of society could have a different interpretation. It may be subject to personal context and multiple realities. Figure 4.1 shows an example of how the root determines the actual and what is observed.

Bhaskar's (1975) early work proposed this ontological peculiarity; he argued that natural and social phenomena do not fully represent the truth. In this regard, critical realism deviates from the positivist and constructivist perspectives in the quest for ontology. Hence, the ‘three layers of truth’ was proposed (Fletcher, 2016). Figure 4-1 depicts stratified ontology with the first layer (root) representing the empirical which is derived from the positivist concept where social events are measured empirically to investigate human experience and perceptions of social events. The second level of reality is the actual, where the experience of certain phenomena is obtained without filtering the data to ascertain the reason for given perception, which could contradict the empirical data obtained in the first stage (Dyson & Brown, 2005). The third stage of stratification is the real stage. This describes the causal mechanism of the empirical and the real stage (Fletcher, 2016).

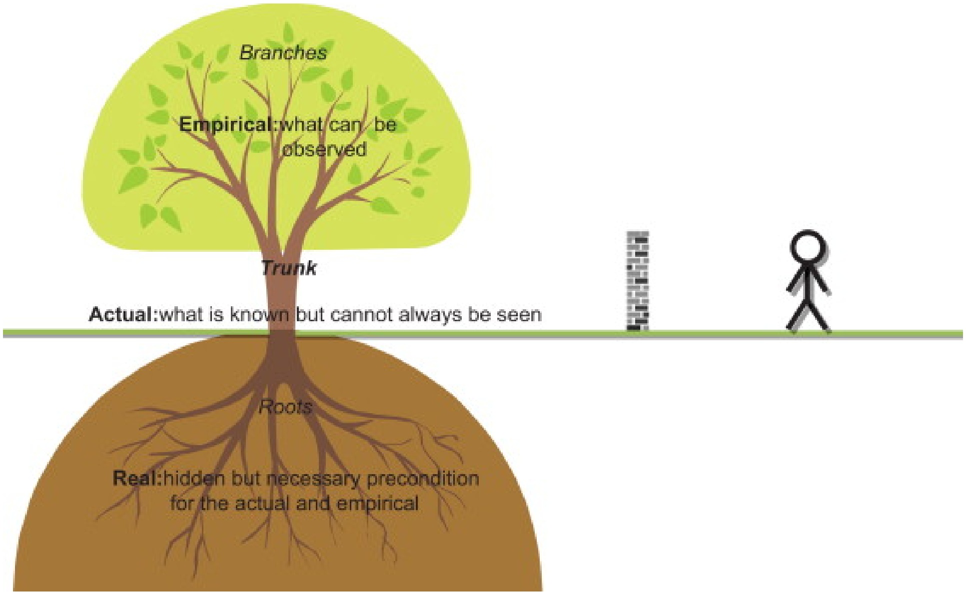

Figure 4-1- Stratified ontology adapted from Dyson and Brown (2005)

4.1.8 Epistemological assumptions of critical realism

The assumption of knowledge from the critical realist perspective is distinctive from other philosophies due to ontology. Critical realism's epistemology is related to the ontological assumption, where one's knowledge of truth is not necessarily the truth (Nairn, 2012; Scotland, 2012; Shipway, 2015; Walsh & Evans, 2014). Based on the critical realist perspective, scientific knowledge has two significant dimensions that do not necessarily form a reality: transitive and intransitive (Fletcher, 2016). Intransitive knowledge deals with our understanding based on experience and sense of the independent world (Fletcher, 2016). The transitive dimension is ascribed to our knowledge of the independent world based on theories and empirical data (Shipway, 2015). In other words, the idea that our knowledge of the independent world does not necessarily form a reality makes knowledge fallible.

To form an actual reality based on a critical realist perspective, an explanation of a mechanism is used to generate knowledge of an event (Fletcher, 2016). Through this explanation, the factors presumed to cause a specific event are explored to understand the meaning behind experiences and perceptions (Yin, 2003). The critical realist believes that identifying a single event as the mechanism for an event will be impossible because of the interactions between factors (Scotland, 2012; Walsh & Evans, 2014; Williams et al., 2017). Critical realism emphasises explaining mechanisms rather than predictions, which requires absolute control to predict outcomes correctly (Bunt, 2016; Easton, 2010; Fletcher, 2016). Therefore, the primary aim of using the philosophical underpinning of the critical realist is to provide an explanation or possible mechanisms as to why people with fibromyalgia lead a sedentary lifestyle and explore the impact of psychological symptoms and social factors such as family and work on their experience or events.

4.1.9 Design

After establishing the need for mixed-methods research, it is crucial to decide on a suitable design for the research aim (Creswell & Plano Clark, 2007). An important consideration before choosing a design is to evaluate the intent, procedure, and challenges of each design and, most importantly, the suitability of the design to answer the research question (Creswell, 2013). Creswell (2013) described four types of the mixed-methods approach to summarise the various types reported in the literature. Within these four types are subvariants. Another important consideration is timing, weighing, and mixing the two methods associated with this approach.

Table 4-1 describes common types of mixed methods designs and adopted from Creswell, Plano Clark et al. (2003).

4.1.10 The rationale for the convergent design

This study adopts a convergent mixed-methods design consisting of two separate phases: quantitative and qualitative (Creswell et al., 2003). In this study, both quantitative and qualitative data were collected and analysed separately then combined for discussion to enhance the in-depth data (Sunderji & Waddell, 2018). The quantitative results, which quantify the association between physical activity and pain and the association between physical activity behaviour and psychological variables, were joined with the findings of the qualitative research, where the perception of physical activity behaviour and psychological factors was explored to help explain and elaborate on the results of the quantitative study. The rationale for this approach is that the quantitative data analysis provides a general understanding of the strength of the links between physical activity behaviour with pain and psychological symptoms, while the qualitative data explains the statistical findings of the quantitative phase by exploring participants' views in more depth (Creswell et al., 2003; Morse, 1991)

According to Creswell et al. (2013), the triangulation mixed methodology enables "*concurrent data collection, quantitative and qualitative, giving equal priority to both methods*". This design aims to collect different but complementary data to address the quantitative and qualitative method. The timing of data collection is concurrent, unlike the explanatory or exploratory design, which takes sequential data, then analyses the results separately and converges them for corroboration to better understand the research problem (Creswell et al., 2013). Among the variants of triangulation, the convergent design is the most popular of these methods (Morse, 1991).

Other mixed-methods designs were explored for their suitability to answer the research questions and feasibility within the PhD time frame. However, the convergent mixed-methods design is more suitable as it provides the depth and corroboration of two philosophies to understand the quantitative findings. When selecting a mixed-methods design, a decision on timing, weighing, and mixing must be made along with the research design's suitability to answer the question. Each design has its timing, weighing, and mixing shown in Table 4-1, adapted from (Creswell & Plano Clark, 2007)

4.1.11 Embedded mixed methods design

An embedded mixed-methods design is employed when a study aims to answer a research question within one large study. For example, if a study is dominantly quantitative or qualitative and wants to answer a question best answered using an alternative method, the second method becomes an alternative. This design is beneficial when a single method is insufficient for answering a research question.

The challenge with this method is integrating the results of the two methods, as they answer different questions. However, Creswell et al. (2003) argued that, as the intent is not to triangulate the two methodologies' findings because one method only plays a supportive role, that would not be a problem. The advantage of an embedded design is time constraints, which is essential if there is a lack of resources and time to collect qualitative and quantitative data concurrently or serially. This method is unsuitable for this study aim, as qualitative findings are essential to understanding the quantitative result.

4.1.12 The explanatory design

The explanatory mixed-methods design or sequential design is a double phase mixed-methods design that enables collecting quantitative data and subsequent qualitative data collection to help understand any unexplained results in the quantitative study (Morse, 2015). This method usually emphasises the quantitative data, as qualitative data is collected secondary to explain the quantitative data (Draucker, Rawl, Vode, & Carter-Harris, 2020). According to Creswell (2003), this method is the most straightforward of all mixed methods approaches because it is simple to conduct, analyse and interpret. However, the challenge of this method is time, as the two methods must be conducted one after the other. It is possible that participants who were part of the quantitative study may not be available for the qualitative study. This thesis does not suit the research aim as corroboration and expansion are needed to enhance the research question.

4.1.13 The exploratory method

The exploratory design is also a two-phase mixed-methods approach that enables collecting data using the qualitative approach followed by a quantitative approach (Greene et al., 1989). The main use for this method is exploring participants' views to develop an instrument, formulate an unknown variable or develop a framework or theory (Creswell, Plano Clark et al., 2003). Like the explanatory mixed-methods design, this is also straightforward to conduct, interpret and report as triangulation or corroboration is unnecessary. However, the disadvantage of this method is time constraints, as qualitative data will be collected, analysed and interpreted before the commencement of the quantitative method (Creswell & Clark, 2007). This design is not suitable for answering the research aim as it does not seek expansion and corroboration.

Table 4-1: Types of mixed methods approaches adapted from Creswell (2007)

Design Type	Variants	Timing	Weighting	Mixing	Notation
Triangulation	Convergence Data transformation Validating quantitative data Multilevel	Concurrent: quantitative and qualitative at the same time	Usually, equal	Merge the data during the interpretation or analysis	QUAN + QUAL
Embedded	Embedded experimental. Embedded correlational	Concurrent or sequential	Unequal	Embed one type of data within a larger design using the other type of data	QUAN (qual) or QUAL (quan)
Explanatory	Follow-up explanations Participant selection	Sequential: quantitative followed by qualitative	Usually, quantitative	Connect the data between the two phases	QUAN (qual)
Exploratory	Instrument development Taxonomy development	Sequential: qualitative followed by quantitative	Usually, qualitative	Connect the data between the two phases	QUAL (quan)

5 Impact of biopsychosocial factors on the association between physical activity and pain in fibromyalgia–Cross-sectional survey

5.1 Introduction

This chapter presents the study background, methods, and findings of the quantitative element of this thesis, which is conducted through online questionnaires. This survey investigates the association between physical activity and pain and the impact of biopsychosocial factors on the relationship between pain and physical activity in people with fibromyalgia using a cross-sectional survey design.

5.2 Study background

The efficacy of structured physical activities such as exercise in fibromyalgia has been well established through experimental designs, mostly RCTs, investigating various forms of exercise on pain perception and other symptoms of fibromyalgia (Busch et al., 2007a; Busch et al., 2007b; Busch et al., 2013; Hauser et al., 2010; McDowell, Cook, & Herring, 2017b; Segura-Jiménez et al., 2013; Wang et al., 2018; Wilson, Spencer, & Kortebein, 2012). Although these studies have guided exercise recommendations for people with fibromyalgia, adherence to structured exercise for sustainable benefits, especially for long-term conditions such as fibromyalgia, remains a concern and thus, other forms of unstructured physical activity such as walking interventions are explored (Macfarlane et al., 2017; Pastor-Mira et al., 2020; Peñacoba, Angeles Pastor-Mira, López-Roig, Sanz, & Velasco, 2019; Russell et al., 2018; Sanz-Banos et al., 2018; Wallin, Mattsson, & Olsson, 2016; Wang et al., 2018).

There is a paucity of data investigating the impact of biopsychosocial factors such as age, gender, conditions, depression, anxiety, fatigue, and contextual factors on the association between pain and physical activity. There is evidence of a reciprocal relationship between psychosocial factors with pain and physical activity, suggesting evidence of potential confounders (Adams & Turk, 2015; Di Tella et al., 2017). However, most studies investigating the association between pain and physical activity have not explored the impact of the psychosocial factors on pain and physical activity (Kaleth et al., 2013; Segura-Jimenez et al., 2015; Víctor Segura-Jiménez et al., 2019).

As a recap, the systematic review (Chapter 3) found variability in outcomes measures assessing physical activity. Some studies used physical activity and physical functioning interchangeably, even though physical activity and physical functioning concepts are entirely different (Caspersen et al., 1985). While physical activity measures the amount of time and intensity spent on doing any movement such as brisk walking, gardening, walking from the parking lot to the office, and stair climbing, physical function, on the other hand, relates to the performance and ability in doing these tasks, i.e., muscle performance, strength and endurance (Caspersen et al., 1985). Although physical activity is a predictor of physical function in people with fibromyalgia (Merriwether et al., 2018), there is a need to establish the pattern of association for physical activity and physical function on pain separately to guide interventions.

Furthermore, the pain intensity scale was the primary outcome in the systematic review. All the studies reported pain intensity scores on the relationship between physical activity categories. Although the pain intensity scale is commonly used and widely accepted, it does not detail multidimensional pain constructs (Tan, Jensen, Thornby, & Shanti, 2004; Williams & Arnold, 2011; Williams & Kratz, 2016). This survey investigates the association between physical activity and physical function, pain intensity and interference, and the impact of biopsychosocial factors on the relationship between pain and physical activity in people with fibromyalgia.

The objectives of the survey are to:

1. Determine the association between physical activity, physical function with pain and psychological (depression and anxiety) and clinical symptoms (sleep, fatigue, disease impact).
2. Determine the impact of biophysiological factors (age, Body Mass Index (BMI), underlying conditions, and medications), psychosocial factors (depression, anxiety, employment and living status) on the relationship between pain and physical activity.
3. Compare between physical activity categories (low, medium, high) and pain (intensity and interference)

5.3 Ethical Approval

Ethical approval was sought from the University of Salford Health Research Ethics committee and obtained (reference number–HSR1819-025) *(Appendix 4)*

No identifiable information was taken to ensure participants' identities remained anonymous and confidential.

Data will be stored at the secure University server and archived for a minimum of 5 years after the graduate award has been made to verify data from external sources if necessary or more prolonged if used for further research.

General Data Protection Regulation Policy (GDRP), outlining the usage, storage, and sharing of data, was clearly stated and accessible online by all participants before the data collection and informed consent stages.

5.4 Methods

5.4.1 Participants and Settings

Participants were mainly recruited online through fibromyalgia organisations, fibromyalgia special interest groups, and fibromyalgia charities based in the UK. Fibromyalgia organisations contacted included the official UK fibromyalgia organisation, the Fibromyalgia Action UK (fibromyalgia.fmauk.org), Fibromyalgia Research UK, Versus Arthritis UK (fibromyalgia.verusarthritis.org), National Rheumatoid Arthritis Society (NRAS) UK (nras.org.uk), and regional fibromyalgia support groups across the UK (affiliates of Fibromyalgia Action UK). The survey link was shared by the researcher and supervisor on Twitter and Facebook, tagging the fibromyalgia organisations *(Appendix 5),* An invitation letter *(Appendix 6)* and a study package consisting of the participant's information sheet, consent form, and contact details to the research student for further information was shared with members and social media platforms. For some charities, NRAS UK, a fee was made as a donation to share the study link on Twitter handle and website with their members diagnosed with fibromyalgia. Participants that agreed to take part in the study were required to complete an online consent form after reading the online participant information sheet *(Appendix 7)* to show that they agreed to take part in the study.

Participants were also provided with the researcher's contact details to call or email if they needed further information or any questions before deciding to complete the survey or if they wished to complete the questionnaire over the phone. This was attached via the Jisc online survey link, formerly the Bristol Online Survey, licenced by the University of Salford. After completing the consent form, the survey tool was designed to progress to the demographic information and outcome measures section. Participants were automatically assigned a unique study ID to log onto the online system and complete the survey to not be identifiable from the data collected. The survey included socio-demographic information such as work and living status (living alone or with a partner) and patient-reported outcome measures to measure health and physical activity outcomes.

5.4.2 The rationale for online recruitment

An online survey was used to recruit participants from social media groups and patients' organisations after considering its advantages over traditional pen and paper surveys (Spijkerman, Knibbe, Knoops, Van De Mheen, & Van Den Eijnden, 2009; Van Selm & Jankowski, 2006). The use of social media as a tool for research has gained popularity over recent years, evident from billions of subscribers on Facebook and Twitter, including special interest groups such as patients' organisations (backlinko.com/fakebook-users).

Patients' organisations on social media provide access to thousands of patients and participants from a wide geographical area who are potentially registered in various NHS and GP surgeries across the UK. Considering the prevalence of fibromyalgia, affecting 1 in 20 people (Fayaz et al., 2016), more participation was anticipated through social media groups and charities in the UK. For example, one of the social media platforms contacted for recruitment, Fibromyalgia Research UK, has over thirteen thousand members on the Facebook group. This consist of people diagnosed with fibromyalgia interested in taking part in fibromyalgia research. Before joining these social media groups, part of the membership vetting procedure requires potential members to fill a form that confirms fibromyalgia diagnosis from a GP or specialist or be a researcher who wants to share a study with the members.

Patient organisations are becoming more critical in research by providing access to participants (Boulanger, Keohane, & Yeats, 2019; Opava & Carlsson, 2012). Advancements in modern technologies such as accessibility to the internet and social media platforms have aided in connecting people with interest (Kimiafar, Sarbaz, & Sheikhtaheri, 2016). This advancement galvanised patients with rare diseases and potentially controversial conditions like fibromyalgia to share experience and support one another by sharing motivational information, coping strategies, and adopting helpful behaviour to manage pain, feedback on treatment, discussing the side effects of medications and recommending treatment preference to practitioners (S. Gur & Ablin, 2019). These organisations also advocate for rights of recognition and policy implementation to better their living standards (Opava & Carlsson, 2012; Thakar & Cundiff, 2020).

Digital platforms provide an alternative to reaching out to participants (Wallin et al., 2016). A recent survey of over 1000 GPs conducted in the UK indicated that over 72% of the GPs use digital platforms to provide mental health interventions (Breedvelt et al., 2019). Digital surveys are easier to administer than printing and distributing paper copies to participants (Spijkerman, Knibbe, Knoops, Van De Mheen, & Van Den Eijnden, 2009; Van Selm & Jankowski, 2006). A link is generated, which is shared with potential participants for research or treatment: this enables reaching participants within a short timeframe, and one person can also share or forward with other potential participants, thereby creating a snowballing effect against the paper survey where only the target participant can be reached (Heiervang & Goodman, 2011; Kimiafar et al., 2016). With developing technological advances in health services, it is becoming easier to connect and perform even more complex tasks with internet services available on various devices such as mobile phones, tablets, and laptops (Srivastava, Pant, Abraham, & Agrawal, 2015).

5.4.3 Challenges with online survey

Despite the logistic advantages of digital online surveys over traditional paper surveys, there are still challenges with online surveys to consider (Lefever, Dal, & Matthíasdóttir, 2007). Participants recruited through social media and digital platforms may not represent the population; hence bias may exist (Ruths & Jurgen, 2014). Several factors need to be considered to minimise bias in the digital survey. Selection bias is introduced when participants in the study are not representative of the selected population (Sedgwick, 2014). This bias is associated with recruitment, mainly social media and digital platforms, where some participants are not expected to be on the platform. As such, the generalisation of findings will be limited to the participants on the platforms. There are potentially cohorts of people with fibromyalgia not on social media platforms, and this survey did not recruit from NHS and GP surgeries; thus, a convenience sampling strategy was adopted (Sedgwick, 2013).

This study mitigated the potential of selection bias by reaching out to fibromyalgia local organisations and support groups, who may not necessarily be active online (Lie et al., 2019). Fibromyalgia local organisations were identified through the national fibromyalgia organisation, Fibromyalgia Action UK and were contacted through email invitation to participate in the study. Some local organisations (Salford and Eccles Fibromyalgia Support Groups) invited the researcher for discussion in one of their monthly meetings, which resulted in the participation of the survey and part of the members were recruited for the qualitative interview.

5.4.3.1 Internet access

Inadequate coverage poses a threat to representation that impacts external validity (Monti et al., 2020). Participants are often omitted due to the failure of surveys to capture a group of people in the population (Eckman & Kreuter, 2013). Lack of internet coverage is expected in low-income rural dwellers or developing countries where access to the internet is low, increased age, decreased education and ethnicity- non- Hispanic white respondents (Hsia, Zhao, & Town, 2020; Shebl et al., 2009). Although, in developed countries such as the UK, this is not a challenge as access to the internet and digital utilisation is relatively high, as shown by the office of national statistics 2017, where approximately 90% of adults were shown to be using the internet (Blank, Graham, & Calvino, 2017). Interestingly, even among the elderly population (65 years and above), a sharp increase in internet use was recorded between 2011 (52%) to 2017 (75%) (Blank et al., 2017).

5.4.3.2 Non-response bias

Non-response is a methodological problem that can hamper the generalisability of findings as individuals who do not participate in the study might have different characteristics from the participants that completed the study (Gray, 2016). Methods proposed to determine nonresponse bias include estimating non-response bias by comparing early and late respondents (Studer et al., 2013). Since this survey is administered online, it will not be easy to draw some assumptions regarding non-response since respondents would access the survey at various times. To assess uniformity, sociodemographic characteristics and symptoms scores were compared with previous studies investigating physical activity in fibromyalgia.

5.4.3.3 Information accuracy

Digital online surveys are more prone to information inaccuracy compared with physical information where the researcher has access to the participants and controls the measurement (Mondal & Mondal, 2018). Information accuracy may be due to social desirability bias. Participants are unwilling to disclose accurate information, with studies reporting women to more likely to misreport their BMI, primarily via an online survey (Burke & Carman, 2017). Similarly, information inaccuracy may be due to recall bias, where participants cannot recall actual information and thus provide inaccurate information.

5.4.3.4 Confounding factors

Confounding is a common bias associated with observational studies resulting from an association between observed and exposure variables (Brookhart, Sturmer, Glynn, Rassen, & Schneeweiss, 2010). Although several ways of handling confounding variables in observational studies, such as matching, adjustments and stratification, it is still challenging to control all the confounding variables (Bernardino et al., 2020). Previous studies that investigated physical activity and pain in people with fibromyalgia, statistically adjusted for age and BMI as confounding factors (Fontaine et al., 2011; Kaleth et al., 2013; Kaleth et al., 2014; Merriwether et al., 2018; Segura-Jimenez, Castro-Pinero, et al., 2016; Segura-Jiménez et al., 2017; Soriano-Maldonado et al., 2016). This is given the relationship between age and lower physical activity and the impact of obesity on physical activity. In addition to controlling for age and BMI, this study aims to control the impact of bio-physiological factors (age, gender, BMI, medications, health conditions), psychosocial factors and symptoms domain (depression, anxiety, fatigue, sleep, and employment status) in line with the biopsychosocial framework to identify the impact of these factors on the association between physical activity and pain. Conceptually, all variables are treated as potential confounders to investigate their impact on the relationship between physical activity, physical function, and pain interference.

5.4.4 Sample size

Two basic principles inform sample size determination: power and representation (Shieh, 2017, 2020). The sample size required is proposed to be determined by the data type and distribution (Gogtay, 2010). A simulation study to predict sample size for linear regression and model validation suggests 173 participants for the power of 0.80, the traditional power, or 227 for the power of 0.90 for model validation (Jan & Shieh, 2019). Similar guidelines for correlation coefficient for a two-tailed test with specified power of .80 and alpha of .05 shows that 84 participants are required (Algina & Olejnik, 2003).

Cross-sectional surveys are generally conducted to observe natural phenomena. Previous surveys investigating physical activity in fibromyalgia (Segura-Jiménez et al., 2019; Segura-Jimenez, Soriano-Maldonado, et al., 2017) have used representation formula calculated based on:

p= expected prevalence or based on previous research precision (prevalence of fibromyalgia in the UK reported at 5%)(Fayaz et al., 2016).

$Z1-\alpha/2$ = Critical value and an expected value for the corresponding confidence level (At 95% CI or 5% level of significance (type-I error).

Based on this formula, sample 384 was targeted for representation in the fibromyalgia UK population. (Liu, Shen, Ning, & Qin, 2017).

5.4.5 Inclusion criteria

- Participants were required to confirm if they had a diagnosis of fibromyalgia by their general practitioner or specialist (rheumatologist) to be involved in this study. This is an online survey, as there is no access to patient records to confirm the diagnosis and a source of information inaccuracy.

- Adult - 18 and older

5.4.6 Exclusion criteria

- Participants under the age of 18 were excluded from the study
- Participants with self-reported severe neurological conditions impact physical activity

5.5 Socio-demographic variables and measurement

Participants who agreed to participate in the study filled an online consent form and demographic information, i.e., age, gender, self-reported health conditions, living status, current employment status, medications, weight and height, medications used for symptom reliefs.

5.5.1.1 Work status

Employment plays a critical role in pain appraisal and physical activity participation (Janevic et al., 2017; Rios & Zautra, 2011). Studies have shown that employment status plays a huge role in accumulating physical activity and pain appraisal (Grønning, Rødevand, & Steinsbekk, 2010; Popham & Mitchell, 2007). A higher socioeconomic burden is reported in people with fibromyalgia relating to more hours of sickness absence than other chronic pain cohorts such as RA (Lachaine, Beauchemin, & Landry, 2010; Markkula et al., 2011; Silverman et al., 2009). Although studies have demonstrated lower physical activity and higher mental and social burden in people with fibromyalgia (Palstam, Bjersing, & Mannerkorpi, 2012), there is less insight into work status on physical activity and pain intensity in people with fibromyalgia. This survey included one item question on whether participants are employed (Yes or No) (Segura-Jimenez, 2016) and the type of work (full time, part-time, unemployed).

5.5.1.2 Living status

The role of family support on physical activity behaviour and pain perception has been reported (Briones-Vozmediano, Vives-Cases, & Goicolea, 2016; Jamison & Virts, 1990; Reisine et al., 2003). Qualitative studies have explored living with fibromyalgia and the negative experience of caring responsibilities (Briones-Vozmediano et al., 2016; Cooper & Gilbert, 2017). Despite the potential impact of family support on pain and physical activity participation, studies looking at pain and physical activity behaviour have not explored the impact of living status on pain and physical activity. Living status was assessed using a single item choice question in the socio-demographic section. Previous studies investigating the health-related quality of life in fibromyalgia have used marriage status for socio-demographic characteristics (Segura-Jimenez, Estevez-Lopez, et al., 2016). Although marriage status is commonly used in the social context of health outcomes (Lillard & Panis, 1996; Robards, Evandrou, Falkingham, & Vlachantoni, 2012), living status is thought to be more relevant and was used to capture participants that are married or have partners or significant other. A question was asked, “what is your living status with an option (living alone, living with family or with dependents). This question was piloted among the single item’s sociodemographic questions, and participants found the question relevant.

5.5.1.3 Self-reported health conditions

Fibromyalgia is associated with chronic pain conditions such as RA, OA, inflammatory bowel syndrome, and ankylosing spondylitis (Fitzcharles et al., 2018; Yunus, 2012). Systematic reviews have also shown a high prevalence of mental health conditions in people with fibromyalgia (Alciati et al., 2020; Kleykamp et al., 2020; Kudlow et al., 2015; Low & Schweinhardt, 2012). This study records other health condition(s) apart from fibromyalgia based on common comorbidities (Fitzcharles et al., 2018; Kleykamp et al., 2020). Participants were asked if they had any other condition(s) apart from fibromyalgia (Yes and No). A free line text box was provided to enable the participant to write if they have other health condition(s) that was not listed, and this was categorised into three primary common commodities associated with fibromyalgia such as mental health conditions, musculoskeletal disorder, multiple conditions, i.e., a combination of mental health conditions, musculoskeletal disorders and other conditions (Bou Khalil et al., 2018; Hoskin et al., 2018; Kleykamp et al., 2020; Lichtenstein et al., 2018; Vincent et al., 2014).

5.5.1.4 Self-reported Body Mass Index

The prevalence of obesity in people with fibromyalgia is high and linked with a higher disease burden, lower physical activity participation, higher pain intensity, and higher psychological symptoms (Gota, Kaouk, & Wilke, 2015). Studies investigating physical activity in fibromyalgia control the impact of BMI on physical activity (Mannerkorpi et al., 2010; Merriwether et al., 2015; Soriano-Maldonado et al., 2016). In this survey, participants were asked to provide information about their weight (kg or stone and pounds) and height (cm). The numbers provided on height and weight were used to calculate the BMI (Misra & Dhurandhar, 2019). The BMI calculation is widely accepted as the metric for measuring overweight, dividing the weight by height (Nuttall, 2015).

5.5.1.5 Medications

Given the severity of symptoms and prevalence of comorbidities, most people with fibromyalgia are on various medications to help with pain symptoms, sleep, and other symptoms (Mease, Dundon, & Sarzi-Puttini, 2011; Skaer, 2014). The evidence-based guideline, EULAR 2018, recommends - Amitriptyline, Duloxetine, Tramadol and Pregabalin, as the first-line medications for pain depending on severity (Macfarlane et al., 2017). Participants were asked whether they take pain medications or other types of medication for their fibromyalgia symptoms, i.e., pain, sleep, depression, and anxiety. Considering the wide range of medications used to manage fibromyalgia and prevalence of comorbidities, other comorbidities' associated with fibromyalgia (Arnold, 2008; Calandre & Rico-Villademoros, 2012; CS, 2005; Lichtenstein et al., 2018; Mease, 2017; Thieme et al., 2004), medications were treated as a binary variable obtained in studies in people with fibromyalgia (Fontaine & Haaz, 2010; Segura-Jimenez et al., 2019).

5.6 Variables and Measurements

This study was guided by the OMERACT guidelines for measuring symptoms recommended for fibromyalgia studies and the biopsychosocial framework. The minimum set of outcome measures recommended by the OMERACT consensus includes psychological factors such as mood, depression and anxiety, pain, physical function, sleep, fatigue (Borrell-Carrio et al., 2004). The FIQR was explicitly designed to capture these symptoms and the most commonly used outcome measure in fibromyalgia *(Appendix 8)* (Bennett et al., 2009).

In addition to the symptoms domain defined by the OMEARCT, this study investigates the impact of social factors such as employment and living status, bio-physiological and interpersonal factors such as age, gender, BMI, medications and other conditions as recommended by the biopsychosocial framework (Tan et al., 2004; Williams & Arnold, 2011). The study used these symptoms as independent and controlling variables to predict physical activity, physical function, and pain interference (dependent variables). The rationale for each of these variables is explained in the subsequent sections, and summary of variables see *(Appendix 9)*

5.6.1 Patients Reported Outcome Measures in Fibromyalgia

The absence of biomarkers to diagnose fibromyalgia means healthcare practitioners rely on patient-reported outcome measures to diagnose fibromyalgia and measure the efficacy of interventions (Bellato et al., 2012; Choy et al., 2010). However, given the volume of outcome measures, a group of clinicians and researchers under OMERACT identified the need to narrow down and improve outcome measures in fibromyalgia through a data-driven consensus (Mease et al., 2009). Following series of Delphi studies with clinicians and patients to establish unanimity on the relevant domain for fibromyalgia in clinical trials, the OMERACT recommends sets of outcome measures for inclusion in all fibromyalgia studies, which includes pain, fatigue, sleep, cognition, multidimensional function, and tenderness (Mease et al., 2009).

Similarly, the Initiative on Methods, Measurement and Pain Assessment in Clinical Trials (IMMPACT) has identified areas of interest for any clinical pain study. IMMPACT proposes to examine four main areas: (1) severity of suffering, (2) physical functioning, (3) mental functioning, and (4) general improvement/well-being. Despite being two separate entities, OMERACT and IMMPACT, there was a significant consensus between the organisations regarding what domains to include in clinical trials for fibromyalgia. It should be remembered that whilst each organisation has defined the related domains, no organisation has dictated the essential tools to be used in the examination of each domain (Williams & Kratz, 2016).

5.6.2 Physical Activity Level: International Physical Activity Questionnaire

The International Physical Activity Questionnaire Short Form (IPAQ-SF) *(Appendix 10)* was used to measure perceived physical activity levels over the previous week (Hagstromer, Oja, & Sjostrom, 2006). The IPAQ-SF measures time spent in low, moderate, and vigorous physical activity and is shown to have excellent properties, with 0.8 compared to long-form IPAQ, in studies conducted in 12 countries (Craig et al., 2003). The data was processed using the standardised recommendations, including error checking, data cleaning and truncation (Hagstromer, Oja, & Sjostrom, 2006).

Data on physical activity was summarised in two categories: total activity and IPAQ defined activity (low, moderate, high). The total activity is calculated by a reported continuous variable as Metabolic Equivalents (METS) multiplied by the minutes spent on physical activity throughout the week. METS are validated parameters thresholds used to quantify the intensity of physical activity (Mendes et al., 2018). The MET represents the energy expenditure of physical activity determined by dividing the energy cost of an activity (ml O2/kg/min) x by 3.5 (Jetté, Sidney, & Blümchen, 1990). The IPAQ define levels of physical activity based on the total score of reported physical activity in a week and categorise them as below (Hagstromer et al., 2006).

- Higher physical activity is defined as achieving three or more days of vigorous physical activity of at least 1500 METs per week for seven days or moderate activity totalling 3000 METS min/week.
- Moderate physical activity is defined as 30 or more minutes of moderate-intensity physical activity per day for five days or at least 600 METs/minute a week.

- Low activity or sedentary behaviour is defined as not meeting moderate or higher activity categories (Guidelines for processing and scoring IPAQ, 2005).

Among different questionnaires used for quantifying physical activity, the IPAQ- SF is a widely used outcome measure for classifying physical activity levels in fibromyalgia (Góes et al., 2012; Merriwether et al., 2018; Segura-Jimenez, Soriano-Maldonado, et al., 2017). The questionnaire has an acceptable construct validity and test-retest reliability for measuring physical activity levels and patterns in healthy adult populations compared with accelerometer-based measurement (Hagstromer et al., 2006; Silsbury, Goldsmith, & Rushton, 2015). Though the validity and reliability of the IPAQ-SF in the fibromyalgia population are scarce, the questionnaire has been used to classify physical activity levels in various populations studies, including people with fibromyalgia (Lee et al., 2011; Merriwether et al., 2018).

In the study conducted by Merriweather et al. (2018) to investigate the correlations of lifestyle physical activity with fibromyalgia symptoms, they found that both measurements of physical activity using (ACTi Graph accelerometer and IPAQ) were consistent in estimating physical activity categories, and similar pain and psychological domains. The comparatively low burden of the IPAQ short form over accelerometer makes it more convenient for online data collection (Sylvia, Bernstein, Hubbard, Keating, & Anderson, 2014).

The systematic review (Section 3.5.4) found variability in physical activity measurements among studies. Both objective and subjective were used to measure physical activity categories. The ACTi graph accelerometer-based device mainly was used as the objective method to measure physical activity categories, with five studies using this method. Five other studies used various patient-reported outcome measures such as the IPAQ-SF, CHAMPS, 6 minutes' walk test, AMPS, SF-36 physical function subscale to quantify physical activity.

The subjective measurement of physical activity in studies included in the systematic review (Chapter three) was a limitation as physical activity and physical functioning was used interchangeably across studies even though the concepts of physical activity and physical functioning are entirely different (Ryan, Murphy, Boland, Galvin, & Smith, 2018). While physical activity measures the frequency and intensity of physical activities such as walking, stair climbing, physical function relates to the performance in doing these tasks, i.e., muscle performance, strength, and endurance (Góes et al., 2012; Rubin et al., 2019; Torma, Houck, Wagnild, Messecar, & Jones, 2013). Although there were variations in classification and measurement between the objective and subjective methods, this variation did not significantly impact the outcome of the studies in the systematic review.

5.6.3 Brief Pain Inventory- Pain Interference

Pain is the primary symptom of fibromyalgia and is central to other fibromyalgia symptoms (Ablin, 2017; lvin et al., 2016; Wolfe et al., 2016). Intensity and interference are two common measures of pain in fibromyalgia (Bigatti & Cronan, 2002). While pain intensity scales are commonly used and validated outcome measures to assess the severity of pain using a single item numerical scale, pain interference measures multiple aspects of pain interference, such as mood, walking, working, sleep, and relationships (Williams & Arnold, 2011). Pain interference was measured using the Brief Pain Inventory (BPI). This questionnaire measures pain intensity and functional interference with pain with a recall period of 24 hours or one week (Williams & Arnold, 2011) *(Appendix 11)*

5.6.4 The Fibromyalgia Impact Questionnaire-Revised (FIQR)

The FIQR was used in this study to measures single items severity scales for depression, anxiety, sleep, fatigue, pain intensity and disease severity (Bennett et al., 2009). The fibromyalgia Impact Questionnaire-Revised (FIQR) was designed to capture core symptoms of fibromyalgia. FIQR is the most used research instrument for evaluating fibromyalgia outcome indicators in clinical trials (Williams & Arnold, 2011). The FIQR assesses pain intensity, disease severity, and physical function in people with fibromyalgia. The FIQR has 21 items divided into the physical function domain, the overall impact, and the symptoms domain. Each item is rated on a scale of 0 (no problem) to 10 (worst). The total score of the FIQR is the sum of the weighted domain scores. Higher scores indicate greater disease severity and impaired physical function (Bennett et al., 2009). Reliability and convergent validity of the FIQR individual items have been well established in fibromyalgia. Internal consistency is of FIQR items measured using Cronbach alpha was 0.95, with individual item correlations ranging from 0.56 to 0.93 (Merriwether et al., 2017). The FIQR was used in this study to assess core symptoms such as pain intensity, physical function, depression, anxiety, fatigue, and disease impact to ease the time burden of completing long outcome measures.

5.6.4.1 Physical Function (FIQR scale)

Physical function is one of the core outcomes recommended by the OMERACT and IMMPACT consensus as part of the minimum outcomes in fibromyalgia studies (Dworkin et al., 2008; Mease et al., 2009). While this thesis investigates physical activity behaviour, the systematic review (chapter 2) highlights studies using physical activity and physical function interchangeably)3.6.2). Physical function was used as one of the dependent/outcome variables and physical activity to observe patterns of links between pain with physical activity and physical function.

The FIQR was used to measure physical function. The physical function domain contains nine questions that measure the ability to do daily functions such as shopping, washing, preparing meals, vacuum-cleaning (Bennett et al., 2009). The score of each question ranges from 0 (no difficulty) to 10 (very difficult). All scores are divided by three to obtain a final score for the physical ability domain. The Physical function FIQR scale has demonstrated an excellent psychometric property with convergent validity of r=-0.073 and high internal consistency (Cronbach a=0.87) (Meriwether et al., 2017) compared with Patient-Reported Outcome Measures Information System (PROMIS), a bank system developed by the National Institute of Health to standardise measurements and outcome measures in health (Merriwether et al., 2017).

5.6.4.2 Single Item FIQR scale- Fatigue

Fatigue is among the critical symptoms of fibromyalgia recommended by OMERACT as a core outcome in fibromyalgia studies (Lukkahatai et al., 2016). Fatigue is expressed as a lack of energy and included in the FIQR as a single item intensity scale (Lukkahatai et al., 2016). The single item scale is commonly used to measure fatigue or multidimensional fatigue inventory to measure other fatigue components, especially if fatigue is one of the primary outcomes of interest. The fatigue intensity shows a good construct validity and internal consistency with the multidimensional fatigue inventory (Başoğlu, Öncü, Kuran, & Alptekin, 2020; Ericsson & Mannerkorpi, 2007). This study measured Fatigue using a single item energy scale in FIQR, which measures energy intensity over a week. This scale has shown a high internal consistency (Cronbach alpha 0.58 to 0.94, P<0.05) PROMIS (Merriwether et al., 2017).

5.6.4.3 Single item FIQR scale- Sleep

Sleep problems are prevalent among people with fibromyalgia and are recommended as part of the core symptoms of fibromyalgia reported by more than 80% of people included in clinical trials and diagnosis (Wu et al., 2017). The link between sleep disturbances and core symptoms of fibromyalgia such as pain intensity (Bigatti, Hernandez, Cronan, & Rand, 2008; Bloom et al., 2018; Keskindag & Karaaziz, 2017) physical activity (Dolezal et al., 2017; Wunsch, Kasten, & Fuchs, 2017), psychological symptoms (Consoli et al., 2012) and a significant mediator between the relationship between pain and psychological symptoms such as depression and anxiety is well established (Diaz-Piedra et al., 2014; Lillis et al., 2018).

Studies investigating sleep problems in fibromyalgia tend to use different outcome measures to investigate various dimensions of sleep problems: a recent systematic review identified five main outcome measures used to assess sleep problems which include Pittsburgh Sleep Quality Index, Jenkins Sleep Scale, Sleep Quality Numeric Rating Scale, Medical Outcomes Study-Sleep Scale, and Fibromyalgia Sleep Diary (Climent-Sanz et al., 2020). They concluded that both five of these outcome measures have psychometric properties that are valid and reliable in assessing sleep problems in people with fibromyalgia (Climent-Sanz et al., 2020). The FIQR single item scale shows good content validity and reliability in measuring sleep quality (Cappelleri et al., 2009). The numeric scale rate sleep quality 0-10, with 0 indicating waking up well-rested and 10 indicating waking up tired: higher scores indicate poor sleep quality, and lower scores indicate a better sleep quality (Bennett et al., 2009).

5.6.5 Psychological Domains

5.6.5.1 Single Item FIQR scale- Depression

Depression is a core symptom of fibromyalgia and one of the outcome symptoms recommended by patients and clinicians in the OMERACT consensus (Mease et al., 2009). The lifetime prevalence of depressive disorders among people with fibromyalgia is reported between 60% (Løge-Hagen et al., 2019). Longitudinal studies show a strong reciprocal relationship between pain intensity and depression (Kroenke et al., 2011; Steiner et al., 2015). Similarly, depression has been shown to mediate the relationship between pain and physical activity in people with fibromyalgia (Steiner et al., 2015). Despite the potential mediating impact of depression, given the relationship between depression with pain and physical activity, studies have not explored the impact of depression on pain and physical activity.

Several questionnaires have been used in the literature to measure various aspects of depression in people with fibromyalgia (Gracely et al., 2012; Nam, Tin, Bain, Thorne, & Ginsburg, 2014; Williams & Kratz, 2016). The single item FIQR depression scale reported high internal consistency on PROMIS (Cronbach = 0.94) (Meriwether et al., 2017). Several outcomes have been used across clinical trials in fibromyalgia to measure different constructs of depression, depending on the study's aim (Bennett et al., 2009; Carville & Choy, 2008; Choy & Mease, 2009). Studies that aim to explore depressive symptoms tend to use more detailed outcome measures to capture multidimensional depression (Nam, Tin, Bain, Thorne, & Ginsburg, 2014): the subscale measures depression on a scale of 0-10; the higher scores indicate more depression over the past seven days (Bennett et al., 2009).

5.6.5.2 Single item FIQR- Anxiety

Anxiety is among the core symptoms of fibromyalgia recommended by the OMERACT consensus. Anxiety is independently associated with a sedentary lifestyle and is a known mediator between pain and depression (Diaz-Piedra et al., 2014). Genetic studies have linked familial aggregation with anxiety- suggesting family involvement in the anxiety (Fernández-de-Las-Peñas et al., 2012). Although anxiety is linked with pain and physical activity, which makes it a potential mediator of the relationship between pain and physical activity, the systematic review's findings did not explore the impact of anxiety as a mediator.

The single item FIQR anxiety scale is a valid and reliable scale to measure the severity of anxiety in people with fibromyalgia (Mease et al., 2009). The FIQR single item anxiety scale has a higher internal consistency of Cronbach alpha 0.93 and validity of 0.63 compared with the PROMIS scale. Several outcomes across fibromyalgia clinical trials are used to measure different anxiety constructs, such as the Beck Depression Inventory (BDI) and Beck Anxiety Inventory, depending on the study aim (Steiner et al., 2016). Studies that aim to explore multidimensional anxiety symptoms tend to use more detailed outcome measures such as the Generalised Anxiety Questionnaire (GAD) to capture multidimensional depression (Nam et al., 2014). The single item subscale in FIQR measures anxiety on a scale of 0-10; the higher scores indicate severe anxiety over the past seven days (Bennett et al., 2009).

5.6.5.3 Pain Intensity

The FIQR pain scale was used to measure the severity of pain. The pain subscale has a minimum score of 0 and a maximum of 10, with lower scores indicating lower pain and a higher score indicating severe pain (Bennett et al., 2009).

5.7 Piloting of the questionnaire

The survey was piloted with 11 participants diagnosed with fibromyalgia before launching the survey *(Appendix 12)*. The piloting aimed to identify potential challenges with constructs of the single item socio-demographic questions and the burden of completing patient-reported outcome measures used in the study. Participants were asked to comment on any single item questions, section, or outcome measures they thought need clarification. Furthermore, participants were asked to comment on the time burden of completing the survey and make any suggestions. The pilot survey was done through the Jisc online survey licensed by the University of Salford. The participant's information sheet, containing the details about the study, the researcher's contact details, and the supervisor for further comments and clarifications, was attached to the online survey link.

The participants agreed that the single-item socio-demographic and health characteristic questions were easy to understand without rephrasing or rewording. These single item socio-demographic questions are not captured in any of the patient-reported outcome measures. The participants reported that the timing of completing. As a recap, the systematic review (chapter 3) highlights various outcome measures used in fibromyalgia studies to measure pain, physical activity, and other symptoms domain in fibromyalgia. The aims of the studies usually inform the choice of outcome measures. While comprehensive outcome measures assess multidimensional constructs of symptoms domain and provide a holistic perspective, single-item severity scales also provide an option for measuring the exact domains and shown to have excellent construct validity and reliability compared to the comprehensive outcome measure used for measuring multidimensional symptom domains (Mease et al., 2009). Considering the time burden of completing the outcome measures and the potential burden of completing long outcome measures, single item severity scales were used for the independent variables and multidimensional questionnaires for the dependent variables. Table 5-1 is the summary of variables, description, and type. Further descriptions of psychometric properties of the outcome measures consisting of the validity and reliability are presented in the sections underneath.

Table 5-1: Variables and description

Variable	Description	Item	Type of variable
Age	How old are you	1	Continuous Independent
Work status	A single item question on whether participants are employed (Yes or No) and the type of work (full time, part-time, unemployed).	2	Categorical Independent
Living status	A question was asked, "what is your living status with an option (living alone, living with family or with dependents	1	Binary Independent
BMI	Participants were asked to provide information about their weight (kg or stone and pounds) and height (cm). The numbers provided on height and weight were used to calculate the BMI, dividing the weight by height	2	Continuous Independent
Comorbidities	Participants were asked if they had any other condition(s) apart from fibromyalgia (Yes or No). A free line text box was provided to enable the participant to write if they have other health condition(s) that was not listed, and this was categorised into three primary common commodities associated with fibromyalgia such as Mental Health Conditions (MHC), Musculoskeletal Disorder (MSD), Multiple Conditions, i.e., a combination of MH, MSD, and other conditions	2	Binary Independent
Pain Interference	Pain interference was measured using the Brief Pain Inventory (BPI). The questionnaire measures pain intensity and pain interference scale. The pain interference scale has seven items- general activity, mood, walking ability, regular work, relation with other people, sleep, and enjoyment of life. Each item has a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 70 indicating the maximum interference		Continuous **Dependent**
Pain Intensity	The FIQR pain scale was used to measure the severity of pain. The pain subscale has a minimum score of 0 and a maximum of 10, with lower scores indicating lower pain and a higher score indicating severe pain.	1	Continuous Independent

Physical activity	IPAQ-SF was used to measure perceived physical activity levels over the past week. The IPAQ-SF measures time spent on low, moderate, and vigorous physical activity. Data on physical activity was summarised in two categories: total activity and IPAQ-SF defined activity (low, moderate, high). The total activity is calculated by a reported continuous variable as Metabolic Equivalents (METS) multiplied by the minutes spent on physical activity throughout the week. The IPAQ defined activity category levels of physical activity based on the total score of reported physical activity in a week. • Higher physical activity is defined as achieving three or more days of vigorous physical activity of at least 1500 METs per week for seven days or moderate activity totalling 3000 METS min/week. • Moderate physical activity is defined as 30 or more minutes of moderate-intensity physical activity per day for five days or at least 600 MET/minute a week. • Low activity or sedentary behaviour is defined as not meeting moderate or higher activity categories (Guidelines for processing and scoring IPAQ, 2005).	12	Continuous and categorical **Dependent**
Physical function	Physical function was measured using the FIQR function domain. The Function domain has a total of 9 questions assessing the difficulty of doing essential physical function like brushing the hair, preparing a meal, vacuum, groceries, stair climbing, changing bedsheets, and sitting in a chair were scored 0-10. 0 indicates no difficulty, and 10 indicating very difficult. A higher score indicates a worse function	9	Continuous **Dependent**
Mood	Mood was measured using the Brief Pain Inventory scale. The scale measures the intensity of anxiety on a 0-10. With 0 indicates no mood disturbance and 10 indicates severe mood disturbance	1	Continuous variable Independent
Anxiety	Anxiety was measured using the FIQR anxiety scale. The domain measures the intensity of anxiety on a 0-10 scale of 0, indicating not anxious and 10, indicating extremely anxious.	1	Continuous variable Independent

Depression	Depression was measured using the FIQR depression subscale. The subscale measures depression on a scale of 0-10; the higher scores indicate more depression over the past seven days	1	Continuous variable Independent
Fatigue	Fatigue intensity was measured using a single item of the FIQR that measures energy. The scale has a 0-10 range that measures energy, with 0 indicating lots of energy and 10 indicating No energy.	1	Continuous variable Independent
Sleep	The FIQR was used to measure sleep quality. The sleep quality scale has a 0-10, with 0 indicating waking up well-rested and ten indicating waking up tired—higher scores indicating poor sleep quality and lower scores indicating a better sleep quality	1	Continuous variable Independent
Disease impact	The fibromyalgia impact will be measured using the FIQR, which comprises 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and a higher score, indicating a more significant effect on the individual's life.	21	Continuous variable Independent

5.8 Data Management

- The survey responses were exported from the online platform, Jisc online survey, provided and licensed by the University of Salford into an Excel file for data cleaning and management.
- Values for weight entered in stones and pounds were converted to kilogram (kg), and values for height entered in feet and inches were converted to centimetres.
- BMI was calculated as weight/height^2 (kg/m^2)
- The time spent in physical activity, vigorous-moderate-light, was calculated for each subject and entered in a new column to indicate the total time of physical activity within the week as per IPAQ guidelines. No more than three hours of

physical activity in any category was recorded, as recommended by the IPAQ guidelines (Hagstromer et al., 2006)

5.9 Statistical Analysis

5.9.1.1 Descriptive statistics

Descriptive statistics of mean and standard deviation for the normally distributed variables and median for the skewed variables were conducted to describe the continuous variables such as age, weight, BMI, physical activity level, fatigue, disease severity, anxiety, depression, and pain intensity. The categorical variables such as living status, employment, medications, and other conditions were presented as frequency and percentage.

5.9.1.2 Normality Assumptions

Normality assumptions of all the continuous variables were checked using the Kolmogorov-Smirnov see Table 5-2. The Shapiro-Wilk tests and histogram observation before conducting the inferential statistics see table 5.2 for normality assumption continuous variables (Curran-Everett, 2017). Kolmogorov Smirnov and Shapiro Wilk tests are the most standard normality tests that measure distribution function (Rosenthal, 1968). A normality test is a vital step in deciding whether parametric or non-parametric statistics are appropriate (Mishra et al., 2019). Methods of assessing normality include numerical test statistics and visual methods through histogram observations (Lee, 2020). The numerical method has an objective advantage over the visual method; however, Kolmogorov Smirnov tends to be over-sensitive to extreme values, especially in a large sample size (Mishra et al., 2019). A histogram observation is strongly recommended to ascertain the distribution pattern of the data. This is in line with the suggestion of Pallant et al. (2007), who argues that in a large sample size of more than 30 participants, assumptions of normality are not necessary. This is also in agreement with the central limit theorem, which suggests that a sample size of more than 30 participants tends to be expected even if Shapiro-Wilk is significant (Curran-Everett, 2017). Before conducting inferential statistics, Kolmogorov Smirnov's Shapiro Wilk test (Table 5-2) showing that all variables are not normally distributed. However, considering that participants are more than 30, a histogram inspection was conducted using each variable to inform whether a parametric or non-parametric test is appropriate (Ghasemi & Zahediasl, 2012).

Table 5-2: Normality assumptions of continuous variables

	Kolmogorov-Smirnov		
Variables	Statistic	df	Sig
Pain intensity	.188	240	.000
Fatigue	.213	240	.000
Sleep	.205	240	.000
Pain interference	.078	240	.001
Depression	.115	240	.000
Anxiety	.137	240	.000
Total FIQR	.068	240	.009
Physical Activity	.219	240	.000
Body Mass Index	.182	240	.000

5.9.1.3 Correlation

The correlation coefficient test was used to assess the association between dependent and independent variables (Bland & Altman 1995). The two most typical types of correlations are the Spearman’s and Pearson’s moment correlation, which have some assumptions of suitability for distribution of data but are shown to be fundamentally similar in assessing the linearity between dependent and independent variables (Pripp, 2018; de Winter et al., 2016).

Spearman's correlation coefficient was conducted to assess the linear association between physical activity, physical function with psychosocial domains such as fatigue, sleep disturbances, depression, anxiety, and pain. The correlation coefficient estimates the linear association between two variables (dependent and independent variables)(Prion & Haerling, 2014). The correlation coefficient ranges from -1(negative correlation) to 1 (positive correlation) and 0, meaning no correlation (de Winter, Gosling, & Potter, 2016). Spearman's correlation is robust against non-normally distributed variables as it uses the rank of observations instead of actual values as obtained for Pearson's correlation (Pripp, 2018; de Winter et al., 2016).

Although Pearson's correlation assesses the relationship between two continuous linear variables assuming that the dependent variables are normally distributed, Spearman's assess the relationship between two non-normally distributed variables (Pripp, 2018). The rationale for choosing Spearman's correlation over Pearson's was the violation of normality assumptions for the dependent variables (physical activity, physical function, and pain interference). Although simulation studies have shown that Pearson's correlation is robust against normality assumptions provided the sample size is more than 30 per group (de Winter et al., 2016), Spearman's correlation provides more precision for non-normally distributed variables and is robust against outliers (Humphreys, Puth, Neuhäuser, & Ruxton, 2019). A partial correlation was conducted to adjust for age and BMI, given the relationship between advanced age and higher BMI with lower physical activity (AHA Guidelines, 2003). Partial correlation measures the strength of two continuous variables while controlling the impact of the third variable (Li, Liu, & Lou, 2017).

5.9.1.4 Linear regression

A simple linear regression was conducted to predict the univariate association between the dependent (pain interference, physical activity, and physical function) and independent variables. While correlation coefficient measures the strength of association between two variables, regression analysis quantifies the association using an equation where the coefficients a and b intercept (Bewick, Cheek, & Ball, 2003; de Winter et al., 2016). The relationship between two linear variables, for a sample size n, is described mathematically as: $yi = \beta 0 + \beta 1xi + \varepsilon i$ (Casson & Farmer, 2014). The equation line is obtained using least squares by drawing a point that gives a predicted or best-fitted value in the data (Bewick et al., 2003).

Physical activity, measured using the IPAQ and physical function, measured using the FIQR physical function scale, and pain interference measured using the BPI was used as the dependent variable in this study Table 5-1. A preliminary assumption testing was done to ensure that linear regression is appropriate as violations of the critical assumptions will provide wrong estimates see *(Appendix 13)*(Casson & Farmer, 2014; Schmidt & Finan, 2018). The first critical assumption is that both variables (dependent and independent) have a linear association. This was checked using the correlation coefficient and scatter plot examination in SPSS (Curran-Everett, 2017). The second assumption is that the dependent variable should be continuous (Casson & Farmer, 2014). This assumption is met as both physical activities measured using the IPAQ, and physical function scores, measured using the physical function domain of FIQR, are continuous.

The third assumption of linear regression is the assessment of random errors. This assumption is checked by examining the Probability Plot (PP) or Quantile- Quantile (Q-Q) plot of residuals against expected values to determine the goodness of fit. The assumption of continuous variance is violated if the distribution shows a pattern on the Q-Q plot (Casson & Farmer, 2014; Marill, 2004). Both assumptions were met for the dependent variables (physical activity, physical function, and pain interference) and independent variables (pain intensity, depression, anxiety, sleep, fatigue, and disease burden). The linear regression findings were presented in standardised coefficient, and confidence interval was interpreted in the text. The rationale for interpreting the standardised beta is the variability of measurement scales such as intensity scales ranging from 0-10 and pain interference scales ranging from 0-80. This will help provide context using the standardised coefficient (Kwan & Chan, 2011; Rochon, Gondan, & Kieser, 2012).

5.9.1.5 Multiple regression

A multiple regression analysis tests how much variance in a dependent variable is explained by numerous predictor variables (Kim, 2019). In hierarchical multiple regression analysis, independent variables are inputted in blocks to provide variance for each model and compare the R^2 and F-statistic changes between the blocks (Ross & Willson, 2017). Hierarchical models deal with multiple variables to account for the impact of confounding variables (Jeong & Jung, 2016; Richardson, Hamra, MacLehose, Cole, & Chu, 2015). Before conducting multiple linear regression, a simple linear regression was conducted to assess the strength of the relationship between psychological symptoms, physical activity, and pain (Schmidt & Finan, 2018). The assumption of linearity between independent variables and the dependent variable was checked using the SPSS (Bewick et al., 2003; Marill, 2004; Schmidt & Finan, 2018). Linearity assumption was checked between the dependent and independent variables using the P-P plot to evaluate the random residuals' distribution against the dependent variable (Casson & Farmer, 2014). Collinearity statistics and residuals were checked using the IBM SPSS (licensed by the University of Salford). (Yang, Tu, & Chen, 2019; Yin, Lieng, & Cheong, 2006). Collinearity is the strong relationship between two independent variables and multicollinearity between more than two independent variables (Kim, 2019). Multicollinearity exists when the Variance Inflation Factor and tolerance are more than 5 to 10 (Kim, 2019; Markovitz, 2005; Schroeder, 1990).

Hierarchical multiple regression was conducted in line with the biopsychosocial model to predict the impact of the biopsychosocial factors on the relationship between pain interference and physical activity. Four models were constructed, and at each stage of the regression, variables were introduced to investigate the change following the introduction of new variables. The first model was a simple relationship between dependent variables (physical activity, physical function, and pain interference) and independent variables. In the second model, age, gender, and BMI were introduced. In the third model, biological and social factors such as other conditions, medications, social factors such as living and employment status were introduced. In the fourth model, psychological symptoms were introduced. Two tables were presented: the model summary and the individual contribution of each variable in the model.

5.9.1.6 Analysis of variance

A one-way analysis of variance (ANOVA) was conducted to compare the differences between physical activity categories (low, moderate, high) and pain intensity, pain interference. The rationale for using ANOVA is to compare categories of physical activity cut points described the IPAQ as (low, moderate, and high) to determine if there is a significant difference between categories of physical activity with pain. ANOVA is a parametric test that measures the differences in group means and assumes normality and robust against normal distribution (Troncoso Skidmore & Thompson, 2013). A Tukey-post-hoc analysis was conducted to investigate the between-group difference in means given the unequal participants in physical activity categories (McHugh, 2011). Other assumptions for ANOVA are the homogeneity of variance, which were checked using Levene's test in the SPSS. A positive Lavene's test: $p<0.05$, indicates the data has violated homogeneity of variance across the groups (Kucuk, Eyuboglu, Kucuk, & Degirmencioglu, 2016).

5.10 Result

5.10.1.1 Socio-demographic characteristics

Socio-demographic characteristics of the participants are presented using frequency and percentages (Table 5-3). The survey was carried out between November 2019 to July 2020, where 245 participants responded to the survey from multiple sources described in the participants and setting (section 5.4.1). Most of the participants were female (87%) and white British (90%). About 40% of the participants stated that they were currently unemployed, while 31 % were employed full time. Most of the participants (80%) were diagnosed with other conditions apart from fibromyalgia, categorised into three. This is consistent with the high prevalence of comorbidities associated with fibromyalgia described in 2.5.10. Most participants (35%) have a combination of musculoskeletal, mental health and other systemic conditions, followed by MSD only (30%) and Mental Health only (17).

Table 5-3: Sociodemographic and health characteristics

Variables	**Number (percentage)**
Gender	**N (%)**
Male	20 (8.2)
Female	222(90.6)
Other	3 (1.2)
Ethnicity	
White/White British	222 (90.8)
Asian/British	7(3)
Mixed	6 (2.5)
Employment status	
Full time	86 (31)
Part-time	60 (24)
Unemployed	99 (40)
Other Health Conditions	
No	42 (17)
Yes	203 (83)
Mental health conditions	*41 (17)*
Musculoskeletal conditions	*75(30)*
Multiple conditions	*87(35)*
Family history of fibromyalgia	
Yes	39 (16)
No	206 (84)
Taking medications for fibromyalgia	
Yes	200 (82)
No	45(8)
Living status	
Married	120 (49)
Single	54 (44)
Living with significant other	46 (37)

MHC- Mental Health Conditions- Generalised Anxiety Disorder, Depression, Bipolar, PTSD, Obsessive Compulsive Disorder, Attention Deficit Hyperactive Disorders (ADHD, Musculoskeletal conditions included RA, OA, spondylarthritis, SLE, among others, Multiple conditions: Inflammatory Bowel Syndrome IBS, Diabetes, Hypertension, and Cancer, a combination of MHC and MSD.

5.10.1.2 Descriptive statistics

Descriptive statistics of health characteristics are presented in the mean (standard deviation). The descriptive statistics Table 5-4 show the participants' mean age was 43.6 (12). Among fibromyalgia symptoms, sleep disturbance 8/10, pain 7/10, and energy were the most severe symptoms.

Table 5-4: Descriptive statistics of continuous variables

Variables	N	Mean (SD)
Age	245	43.6 (12)
BMI	240	30.9 (12.9)
FIQR		
Disease burden (0-100)	245	64 (15.3)
Physical Function (0-80)	245	50 (15.8)
Pain (0-10)	245	7.2 (1.6)
Depression	245	5.7 (2.8)
Sleep	245	8.1 (1.9)
Energy	245	7.4 (2.0)
Anxiety	245	6.0 (2.7)
Physical activity (total)	245	513.7 (1981)
High	42	4534
Moderate	88	1943
Low	115	146
BPI Pain interference	245	49.3 (13.8)

Abbreviations: BMI- Body Mass Index, FIQR- Fibromyalgia Impact Questionnaire-Revised, IPAQ- International Physical Activity Questionnaire, MET- Metabolic Equivalent, Mn- Minutes, wks.- Weeks

5.11 Objective 1- to determine the association between physical activity, physical function with pain and psychological and clinical symptoms

Spearman’s correlation was conducted to investigate the association between physical activity with pain (intensity and interference), psychological domains (mood, depression, anxiety), and disease impact (FIQR total) (Table 5-5). There was a significant correlation between physical activity (total) measured with IPAQ and pain intensity (rs =-0.331 p <0.05) and pain interference (rs =-0.371 p <0.05). Similarly, there was a significant association between physical activity and psychological symptoms (anxiety rs=-.13, depression -.16, energy -.33, all p <0.05). However, after adjusting for age and BMI, anxiety and depression were not statistically significant (anxiety rs =- 0.37 p = 0.03, depression rs =0.16 p = 0.06, energy rs -0.33 p = 0.01). This implies that higher physical activity is associated with lower pain intensity, pain interference, anxiety, and depression.

Table 5-5: Correlation between physical activity total (IPAQ) and pain, psychological scales, and disease impact

Outcome Domain	Outcome Variable	N	Unadjusted *rs*	Adjusted *rs* (Age & BMI)	*p*-value	
					Unadjusted	Adjusted
Pain (FIQ-R)	Pain Intensity	245	-0.331	-0.246	**<0.001**	**<0.001**
BPI	Pain Interference	245	-0.371	-0.244	**<0.001**	**<0.001**
Psychological and symptoms (FIQR, scales)	Anxiety	245	-0.139	-0.058	**0.030**	0.376
	Depression	245	-0.161	-0.095	**0.011**	0.142
	Energy	245	-0.334	-0.173	**0.006**	**0.007**
	Sleep	254	-0.055	-0.009	0.395	0.885
Disease Impact (FIQR total)	Disease impact	245	-0.267	-0.368	**0.001**	**0.013**

Significant difference (p<.005) is shown in **bold**. Abbreviations: N sample size, *rs* Spearman's correlation, BPI Brief Pain Inventory, FIQR Fibromyalgia Impact Questionnaire-Revised, IPAQ- International Physical Activity Questionnaire, MET- Metabolic Equivalent, Mn- Minutes, wks.- Weeks, BPI- Brief pain inventory pain interference scale has eight items with a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 80 indicating the maximum interference. Pain intensity- 0 to 10 with lower scores indicating lower pain and a higher score indicating severe pain; Pain interference- The; Depression, anxiety, energy, sleep- The subscales measures severity of symptom on a scale of 0-10; the higher scores indicate higher symptom severity; Disease impact- was measured using the FIQR, which comprises of 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and a higher score, indicating a more significant effect on the individual's life.

5.11.1.1 Association between physical function with, pain, psychological domain, and disease impact

Spearman's correlation was conducted to investigate the association between physical function with pain, psychological domains, and disease impact, as the physical function score was not normally distributed. The result indicates a significant positive association between physical function with pain intensity (see table 5-6) (rs =.52 *p* <0.01), and pain interference (rs = 0.58 p <0.01). Similarly, there was a significant positive association between physical function and psychological symptoms (mood rs =.37, anxiety rs =.30, depression r =.30, energy rs =.45, sleep rs=.38 all p =<0.01). The strongest correlation was between physical function and disease impact (rs=.808 p <.001). This suggests that as the burden of physical function increases, pain and psychological symptoms increases. Similarly, as physical function difficulty increases, disease impact increases.

Table 5-6: Correlation between physical function (FIQR) domain, pain intensity, interference, psychological domains, and disease impact

Outcome Domain	**Outcome Variable**	**N**	**Unadjusted *rs***	**Adjusted (Age & BMI)**	***p*-value**	
					Unadjusted	**Adjusted**
Pain intensity (FIQ-R)	Pain Intensity	245	0.528	0.563	**<0.001**	**<0.001**
BPI	Pain Interference	245	0.578	0.641	**<0.001**	**<0.001**
Psychological and symptoms (FIQR scales)	Anxiety	245	0.308	0.340	**<0.001**	**<0.001**
	Depression	245	0.301	0.319	**<0.001**	**<0.001**
	Energy	245	0.450	0.419	**<0.001**	**<0.001**
	Sleep	245	0.389	0.379	**<0.001**	**<0.001**
Disease Impact (FIQR total)	Disease impact	245	0.808	0.641	**<0.001**	**<0.001**

Significant difference (p<.005) is shown in **bold**. Abbreviations: N sample size, rs Spearman's correlation, BPI Brief Pain Inventory, FIQR Fibromyalgia Impact Questionnaire-Revised, IPAQ- International Physical Activity Questionnaire, MET- Metabolic Equivalent, Mn- Minutes, wks.- Weeks, BPI- Brief pain inventory. Pain intensity- 0 to 10 with lower scores indicating lower pain and a higher score indicating severe pain; Pain interference- The pain interference scale has seven items- general activity, mood, walking ability, normal work, relation with other people, sleep, and enjoyment of life. Each item has a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 80 indicating the maximum interference; Depression, anxiety, energy, sleep-The subscales measures severity of symptom on a scale of 0-10; the higher scores indicate higher symptom severity; Disease impact- was measured using the FIQR, which comprises of 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and a higher score, indicating a more significant effect on the individual's life.

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5.11.1.2 Association between pain interference and pain, physical activity, psychological scales, and disease impact

Spearman's correlation was conducted to investigate the association between pain interference, physical activity, physical function, psychological domains, and disease impact. The result indicates a significant positive association between pain interference with physical function see Table 5-6 (rs =.57 p<0.01) and physical activity (rs = -0.38 p<0.01). Similarly, there was a significant positive association between pain interference and psychological symptoms (anxiety rs =.45, depression rs =.52, energy rs =.42, sleep r =.47 all p<0.01). The strongest correlation was between pain interference and disease impact (rs=.78 p <.001). This suggests that as pain interference increases, psychological symptoms increase. Similarly, as physical function difficulty increases, disease impact increases. Also, as pain interference increases, physical activity decreases.

Table 5-7: Correlation between pain interference, physical activity, psychological scales, and disease impact

Outcome Domain	Outcome Variable	N	Unadjusted *rs*	Adjusted (Age & BMI) *rs*	*p*-value	
					Unadjusted	Adjusted
Physical activity *IPAQ Total*	Physical Activity	245	-0.371	-0.244	**<0.001**	**<0.001**
PF (FIQR)	Physical Function	245	0.578	-0.641	**<0.001**	**<0.001**
Psychological and clinical FIQR scales	Anxiety	245	0.458	0.493	**<0.001**	**<0.001**
	Depression	245	0.521	0.569	**<0.001**	**<0.001**
	Energy	245	0.429	0.376	**<0.001**	**<0.001**
	Sleep	254	0.473	0.463	**<0.001**	**<0.001**
Disease Impact (FIQR total)	Disease impact	245	0.740	0.782	**<0.001**	**<0.001**

Significant difference (p<.005) is shown in **bold**. Abbreviations: N sample size, rs Spearman's correlation, BPI Brief Pain Inventory, FIQR Fibromyalgia Impact Questionnaire-Revised, IPAQ- International Physical Activity Questionnaire, MET- Metabolic Equivalent, Mn- Minutes, wks.- Weeks, BPI- Brief pain inventory pain interference scale has eight items with a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 80 indicating the maximum interference. Pain intensity- 0 to 10 with lower scores indicating lower pain and a higher score indicating severe pain; Pain interference- The; Depression, anxiety, energy, sleep- The subscales measures severity of symptom on a scale of 0-10; the higher scores indicate higher symptom severity; Disease impact- was measured using the FIQR, which comprises of 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and a higher score, indicating a more significant effect on the individual's life.

5.11.1.3 Relationship between pain interference, physical activity, physical function, psychological symptoms, and impact of fibromyalgia

A simple linear regression was conducted to predict the independent association between pain interference, physical activity, physical function, psychological domain (Table 5-8). Preliminary analysis was conducted to ensure no violation of assumptions. The result of the regression indicates a positive relationship between pain interference, physical activity (β=-225 *p* =<0.01) and physical function (β=-.343 *p* = <0.01), depression (β=.556 *p* = <0.01), anxiety (β=.472 *p* = <0.01). This suggests that as pain interference increases, physical activity decreases by 22%; similarly, as pain interference increases, depression, anxiety, energy, and sleep problems increase.

Table 5-8: Association between pain interference, physical activity, physical function clinical symptoms and psychological symptoms

Outcome Domain	Outcome Variable	95% CI	β	*p*-value
IPAQ	Physical activity	-.002 --.001	-.225	**<0.001**
FIQR PF scale	Physical function	.483-.460	.650	**<0.001**
Psychological and clinical symptoms (FIQR)	Depression	2.17- 3.18	.556	**<0.001**
	Anxiety	1.83- 2.96	.472	**<0.001**
	Energy	1.72- 3.28	.377	**<0.005**
	Sleep	2.60- 4.19	.476	**<0.001**
FIQR	Disease impact	0.63- 0.77	.786	**<0.001**

Dependent variable pain interference
Significant difference (p<.005) is shown in bold.

Significant difference (p<.005) is shown in **bold**. Abbreviations: N sample size, rs Spearman's correlation, BPI Brief Pain Inventory, FIQR Fibromyalgia Impact Questionnaire-Revised, IPAQ- International Physical Activity Questionnaire, MET- Metabolic Equivalent, Mn- Minutes, wks.- Weeks, BPI- Brief pain inventory measures pain interference and has eight items with a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 80 indicating the maximum interference. Pain intensity- 0 to 10 with lower scores indicating lower pain and a higher score indicating severe pain; depression, anxiety, energy, sleep subscales measures severity of symptom on 0-10 with the higher scores indicate higher symptom severity; Disease impact- was measured using the FIQR, which comprises of 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and a higher score, indicating a more significant effect on the individual's life.

A simple linear regression was conducted to predict the independent association between physical function, pain intensity, pain interference, psychological and clinical domain Table 5-9. Preliminary analysis was conducted to ensure no violation of assumptions. The result of the regression indicates a positive relationship between physical function and pain interference (β=.481 *p* =<0.01) and physical pain intensity (β=.242 *p* = <0.01). Depression (β=-164 P=<0.01) and energy (β=.156 *p* =<0.01) were also associated with physical function. However, sleep and anxiety were not associated with a higher burden of physical function.

Table 5-9: Linear regression between physical function, pain intensity and interference and psychological variables

Outcome Domain	Outcome Variable	95% CI	β	*p*-value
Pain (FIQR) BPI	Pain interference Pain intensity	.402–5.339	.481	**<0.001**
		1.23– 3.39	.242	**<0.001**
Psychological and clinical symptoms (FIQR)	Depression	-1.68--.12	-.164	**0.023**
	Anxiety	-.176-1.36	.472	0.129
	Energy	1.72-3.28	.156	**0.003**
	Sleep	-.606-1.12	.032	0.553

Dependent variable: Physical function

Significant difference (*p* <.005) is shown in **bold**. Abbreviations: N sample size, rs Spearman's correlation, BPI Brief Pain Inventory, Abbreviation: FIQR Fibromyalgia Impact Questionnaire-Revised, IPAQ- International Physical Activity Questionnaire, MET- Metabolic Equivalent, Mn- Minutes, wks.- Weeks, BPI- Brief pain inventory measures pain interference and has eight items with a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 80 indicating the maximum interference. Pain intensity- 0 to 10 with lower scores indicating lower pain and a higher score indicating severe pain; depression, anxiety, energy, sleep subscales measures severity of symptom on 0-10 with the higher scores indicate higher symptom severity; Disease impact- was measured using the FIQR, which comprises of 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and a higher score, indicating a more significant effect on the individual's life.

5.12 Objective 2- Determine the impact of biophysiological factors (age, BMI, underlying conditions, and medications), psychosocial factors (depression, anxiety, employment and living status) on the association between pain and physical activity

5.12.1.1 Hierarchical regression to control for biopsychosocial variables on the association between pain interference and physical activity

The association between pain interference and physical activity was assessed, controlling for the impact of BMI, gender, age in model two; medications and other conditions in model three; social factors, employment, depression, and anxiety in model four. The models aligned with the study's conceptual framework, the biopsychosocial model (Jeong & Jung, 2016; Richardson et al., 2015) and described in 5.9.1.5. Table 5-10 present the model summary indicating R^2 value and change in each model. Table 5-11 presents the contribution of each variable in the model.

Model one shows an R^2 value of .065, indicating that physical activity explains 6% of pain interference *p* =<.001. When age, gender and BMI were added in model two, the value of R^2 increased to 8% variance in pain interference, which accounted for a 1.6% increase and not statistically significant *p*=0.25. When other bio-physiological factors (conditions and medications) and social factors (employment status) were added in model three, the R2 increased to 10%, increasing by 2% and not statistically significant *p*= 0.191. When psychological symptoms (anxiety and depression, and fatigue) were added in model 4, the R^2 value increased to 43%. This indicates that depression, anxiety, and energy contribute 33% of additional variance in pain interference and is statistically significant (*p* = <0.001).

Table 5-10: Hierarchical regression between pain interference and physical activity controlling for biopsychosocial symptoms

Model	Rs	SE	Rs change	F Change	Sig. F Change
1	.065	13.411	.065	16.451	**.000**
2	.081	13.381	.016	1.360	.256
3	.099	13.330	.019	1.597	.191
4	.434	10.634	.338	62.711	**.000**

Dependent variable: Pain interference
Significant difference (*p* <.005) is shown in **bold**.
Model 1- Physical activity, Model 2- Physical activity BMI, gender, age, Model 3- Physical activity, gender, BMI, Age, employment status, medications, conditions. Model 4- Physical activity, gender, BMI, Age, employment status, medications, conditions, anxiety, depression, energy.

Table 5-11: Hierarchical regression between pain interference and physical activity (model description)

Models		SE	β	Sig	CI p-value	
1	(Constant)	1.096		.000	49.720	54.037
	Physical activity	.000	-.254	**.000**	-.003	-.001
2	(Constant)	4.886		.000	32.762	52.015
	Physical activity	.000	-.242	**.000**	-.003	-.001
	BMI	.067	.061	.328	-.066	.197
	Gender	2.480	.060	.342	-2.525	7.247
	Age	.072	.094	.134	-.034	.250
3	(Constant)	7.748		.000	19.766	50.299
	Physical activity	.000	-.242	**.000**	-.003	-.001
	BMI	.068	.080	.206	-.048	.219
	Gender	2.507	.050	.433	-2.971	6.907
	Age	.074	.102	.112	-.028	.263

	Employment status	1.014	.070	.272	-.882	3.113
	Medications	2.218	.108	.090	-.596	8.145
	Other conditions	2.280	-.039	.547	-5.868	3.118
4	(Constant)	6.692		.025	1.881	28.250
	Physical activity	.000	-.166	**.002**	-.002	.000
	Body Mass Index	.055	-.008	.884	-.117	.101
	Gender	2.063	.071	.177	-1.273	6.858
	Age	.060	.161	**.002**	.066	.302
	Employment status	.819	.061	.236	-.642	2.587
	Medications	1.833	.030	.569	-2.567	4.657
	Other conditions	1.843	-.035	.498	-4.881	2.380
	Energy	.371	.202	**.000**	.615	2.078
	Depression	.260	.488	**.000**	1.834	2.858
	Anxiety	.388	.200	**.009**	.256	1.785

(p <.005) **bold**; VIF- Variance Inflation Factor (5-10 indicates collinearity); Abbreviations: BPI brief pain inventory, FIQR Fibromyalgia Impact Questionnaire-Revised, N sample size, BPI Brief Pain Inventory. B unstandardised beta, CI Confidence Interval, β standardised beta.

5.12.1.2 Hierarchical regression controlling for biopsychosocial variables on association between physical function and pain intensity

The relationship between physical function and pain intensity was assessed, controlling for the impact of BMI, gender, age in model two; medications and other conditions in model three; social factors, employment, depression, and anxiety in model four. The models align with the study's conceptual framework, the biopsychosocial model (Jeong & Jung, 2016; Richardson et al., 2015). Table 5-12 presents the model summary, and Table 5-13 presents the contribution of each variable.

Model one shows an R2 value of .334, indicating that pain intensity explains 33% of physical function *p*=<.001. When age, gender and BMI were added in model two, the value of R2 increased to 36% variance in physical function, which accounted for a 2.6% increase and statistically significant *p*=0.02. When other bio-physiological factors (conditions and medications) and social factors (employment status) were added in model three, the R2 increased to 40%, increasing 4% and statistically significant *p* = 0.01. When psychological symptoms (anxiety and depression, and fatigue) were added in model 4, the R-square value increased to 45%. This indicates that depression, anxiety, and energy contribute 5% of additional variance in physical function are statistically significant (*p* = <0.01).

Table 5-12: Hierarchical regression controlling for biopsychosocial variables on *physical* function and pain interference

Model	Rs	SE	R^2 Change	F Change	Sig. F Change
Model 1	.331	4.334	.334	119.452	**<0.001**
Model 2	.360	4.277	.026	3.138	**0.026**
Model 3	.406	4.146	.046	6.023	**0.001**
Model 4	.458	3.986	.052	7.333	**<0.001**

Dependent variable: Physical function
Significant difference (p<.005) is shown in **bold**.
Model 1- Pain intensity, Model 2- Pain intensity, BMI, gender, age, Model 3- Pain intensity, gender, BMI, Age, employment status, medications, conditions. Model 4- Pain intensity, gender, BMI, Age, employment status, medications, conditions, anxiety, depression, energy

Table 5-13: Objective 3- Hierarchical regression controlling for biopsychosocial variables on physical function and pain interference (model description)

Models		SE	β	Sig	CI p-value	
1	(Constant)	2.891		.000	8.527	19.919
	Pain Interference	.057	.648	**.000**	.632	.856
2	(Constant)	4.749		.137	-2.273	16.441
	Total interference	.056	.630	**.000**	.612	.834
	BMI	.059	.112	**.022**	.020	.254
	Gender	2.210	-.047	.337	-6.478	2.229
	Age	.064	.110	**.026**	.017	.271
3	(Constant)	6.715		.038	-27.249	-.790
	Pain Interference	.055	.605	**.000**	.586	.802
	BMI	.058	.151	**.002**	.069	.299
	Gender	2.164	-.056	.244	-6.788	1.738
	Age	.064	.091	**.063**	-.006	.245
	Employment status	.873	.041	.392	-.971	2.467
	Medications	1.921	.189	**.000**	3.815	11.384
	Other conditions	1.959	.095	**.049**	.014	7.732
4	(Constant)	6.807		.002	-34.927	-8.102
	Pain Interference	.068	.572	**.000**	.523	.790
	BMI	.057	.157	**.001**	.079	.305
	Gender	2.158	-.012	.807	-4.779	3.724
	Age	.064	.098	**.044**	.003	.254
	Employment status	.847	.040	.393	-.944	2.393
	Medications	1.902	.166	**.001**	2.943	10.438
	Other conditions	1.918	.078	.100	-.615	6.945
	Fatigue	.395	.185	**.000**	.635	2.191
	Depression	.412	-.195	**.010**	-1.889	-.264
	Anxiety	.412	.148	**.036**	.056	1.681

(p<.005) are shown in **bold**; VIF- Variance Inflation Factor (5-10 indicates collinearity); Abbreviations: BPI brief pain inventory, FIQR Fibromyalgia Impact Questionnaire-Revised, N sample size, BPI Brief Pain Inventory. B unstandardised beta, CI Confidence Interval, β standardised beta.

5.13 Objective 3 - Comparison between physical activity categories (high, moderate, and low) and pain

A one-way ANOVA was conducted to compare pain interference between categories of physical activity (high, moderate, and low). The ANOVA result showed a significant difference in pain interference between physical activity categories (F (2,244) = 14.46, *p* =0.01) Table 5-14. A Tukey post hoc analysis 5-15 shows that the mean score of high physical activity was statistically significant compared to low physical activity. This indicates that higher physical activity was associated with lower pain interference than low physical activity *p*= <.001. Similarly, moderate physical activity was statistically significant compared to low physical activity *p* = <.001. However, higher physical activity was not significant when compared to moderate physical activity *p* = .115.

Table 5-14: ANOVA table- pain interference and physical activity categories

Source	***df***	***SS***	***MS***	***F***	***P***
Between groups	2	4964.9	2482	14.4	<0.01
Within groups	242	41520.6	171		
Total	244	46485.5			

Homogeneity of variance .112, SS Sum Square, MS Mean Square, P Significance

Table 5-15: ANOVA (multiple comparisons) physical activity categories and pain interference

PA Categories	PA Categories	MD	SE	Sig
Low	Moderate	-6.791	1.855	<.001
	High	11.696	2.362	<.001
Moderate	Low	-6.791	1.855	<.001
	High	4.905	2.457	0.115
High	Low	11.696	2.362	<.001
	Moderate	-4.905	2.457	0.115

Abbreviation: PA Physical Activity Mean Difference, SE Standard Error, Sig Significance, Low-not meeting moderate or higher activity categories, Moderate- Moderate physical activity is defined as 30 or more minutes of moderate-intensity physical activity per day for five days or at least 600 MET/minute a week, High- Higher physical activity is defined as either achieving three or more days of vigorous physical activity of at least 1500 METs per week for seven days or moderate activity totalling 3000 METS

Figure 5-1 compares the categories of physical activity (low, medium, and high) on pain interference. Lower physical activity shows a higher burden of pain interference compared with moderate physical activity. Higher physical activity mean scores show lower pain interference.

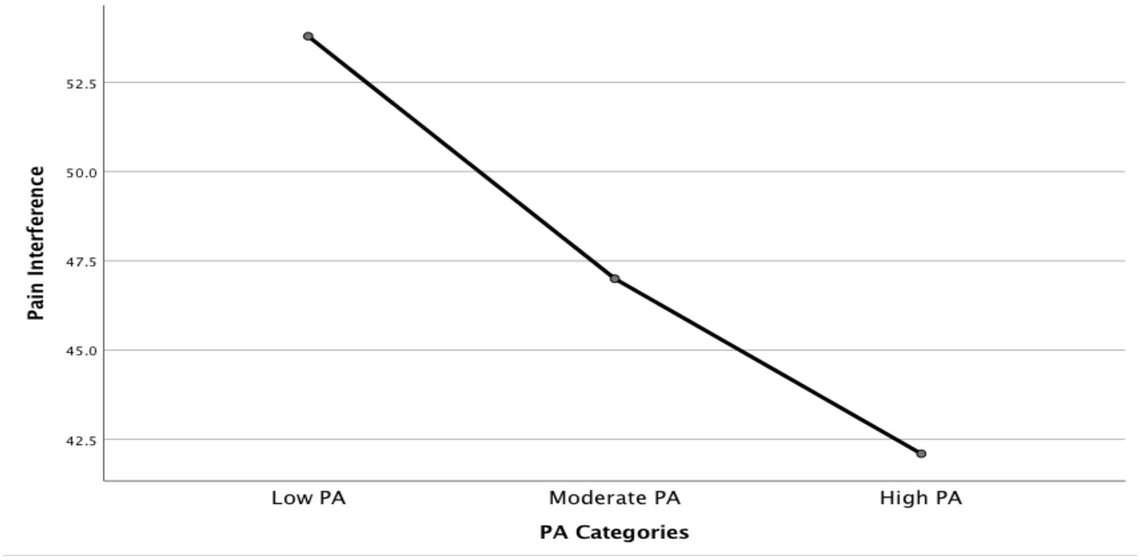


Figure 5-1- Pain interference between physical activity categories

5.13.1.1 Comparison between physical activity categories (high, moderate, and low) and pain intensity

A one-way ANOVA was conducted to compare pain intensity between physical activity categories (low, moderate, and high). There was a significant difference in pain intensity between categories of physical activity *p* =<0.001 (F (2,244) = 14.801, *p* =<0.01). A Turkey post hoc test shows a statistically significant difference between physical activity categories and pain intensity Table 5-16. This indicates that participants who scored higher physical activity had lower pain intensity compared to those who scored low physical activity *p* < 001. Similarly, those who scored moderate physical activity had more significantly lower pain than those who scored low physical activity *p*<0.001. There was no statistically significant difference between those who scored high and moderate physical activity on pain intensity p= 0.86

Table 5-16: ANOVA table- comparing pain intensity between physical activity categories

Source	df	SS	MS	F	P
Between groups	2	73.21	36.6	14.80	<0.001
Within groups	242	598.54	2.4		
Total	244	671.1			

Homogeneity of variance .203 (<.05 suggest a violation of homogeneity), SS Sum Square, MS Mean Square

Table 5-17: ANOVA (multiple comparisons) between physical activity categories and pain intensity

PA Categories	PA Categories	MD	SE	Sig.
Low PA	Moderate PA	1.037	.219	**<0.001**
	High PA	1.201	.304	**<0.005**
Moderate PA	Low PA	-1.037	.219	**<0.001**
	High PA	.164	.318	0.864
High PA	Low PA	-1.201	.304	**<0.005**
	Moderate PA	-.164	.318	0.864

Abbreviation: PA Physical Activity Mean Difference, SE Standard Error, Sig Significance, Low-not meeting moderate or higher activity categories, Moderate- Moderate physical activity is defined as 30 or more minutes of moderate-intensity physical activity per day for five days or at least 600 MET/minute a week, High- Higher physical activity is defined as either achieving three or more days of vigorous physical activity of at least 1500 METs per week for seven days or moderate activity totalling 3000 METS min/week.

Figure 5-2 shows the average mean of pain intensity scores between the physical activity categories. High physical activity averaged 6.5 on a scale of 10, and low physical activity showed an average of 7.5 on 10.

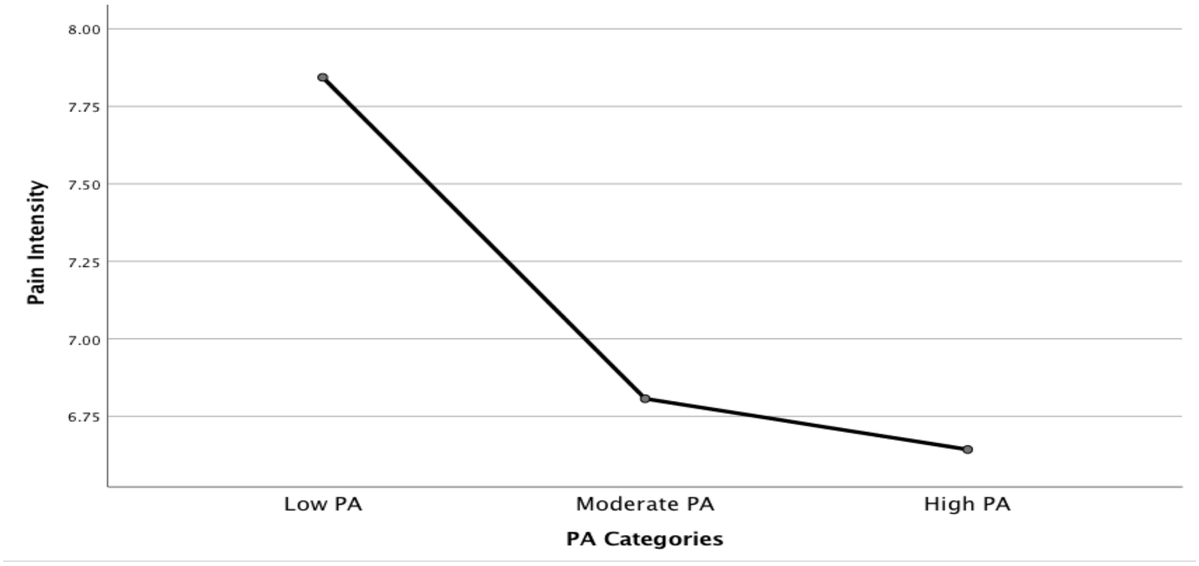


Figure 5-2- Pain intensity average between physical activity categories

5.14Results summary and interpretation of findings

- This study shows that lower physical activity was associated with higher pain intensity and interference or vice versa. Similarly, lower physical activity levels were associated the higher depression, anxiety, and lower energy. This implies that people with fibromyalgia having lower physical activity participation are likely to report higher pain intensity, pain interference, high depression, and anxiety. However, they were not statistically significant after controlling for Age and BMI, anxiety, sleep, and depression (see 5.10.1.3.)
- When physical function was introduced as a dependent variable, pain intensity and interference were strongly associated. This implies that people with fibromyalgia who reported a higher burden of physical function are likely to report higher pain intensity and interference. Similarly, a higher physical function burden was associated with

higher depression, anxiety, sleep, and lower energy. After controlling for age and BMI, physical function with pain, depression, anxiety, sleep, and energy was still significant.

- When pain interference was introduced as a dependent variable, physical activity and function were associated with pain interference and intensity. A stronger association was observed with pain interference with physical activity and physical function. This implies that people with higher pain interference are likely to report lower physical activity and more difficulty with physical function. Similarly, people with less physical activity are more likely to be more likely to report higher depression, anxiety, have more sleep problems, and lower energy.
- A simple linear regression was conducted to predict pain with physical activity, physical function, and psychological domains- depression, anxiety, and energy. The regression analysis indicated that physical activity was a significant predictor of pain interference. However, Disease impact, physical function, depression, and anxiety were the most significant predictor of pain interference
- Hierarchical multiple regression was conducted to predict the impact of the biopsychosocial factors on the association between pain interference and physical activity. Four models were constructed, and at each stage of the regression, variables were introduced to investigate the change following the introduction of new variables. The first model was a simple association between physical activity and pain interference, which was significant. In the second model, age, gender, and BMI were introduced. There was no increase to suggest that age, gender, and BMI impact the association between pain interference and physical activity. The second, third and fourth models introduced the biological factors such as other conditions, medications, and social factors such as living and employment status, which was also not significant.

However, after adding the psychological symptom- depression and anxiety- the model showed a significant change, indicating that depression and anxiety significantly impact the relationship between pain interference and physical activity. A similar pattern of association was observed when physical function and pain interference were introduced as dependent variables.

- Using a one-way ANOVA to examine pain intensity and interference between physical activity categories (low, moderate, and high), the result suggests a significant difference in pain intensity and interference between categories of physical activity. This indicates that people with fibromyalgia who do high and moderate physical activity in a week have lower pain intensity and interference than those with low physical activity.

5.15 Discussion

The aim of this study was to investigate the association between physical activity and pain and the impact of psychosocial symptoms on the association between pain and physical activity. This study shows that lower physical activity was associated with higher pain intensity or vice versa. Likewise, lower physical activity was associated with higher depression, anxiety, sleep disturbances, and lower energy. This survey also found a significant relationship between psychological symptoms such as depression and anxiety with pain and physical activity.

The baseline characteristics indicate that half of the participants in this study did not meet the physical activity recommendation based on adults' UK physical activity guidelines. Physical activity guidelines unanimously recommend 75−150 minutes of vigorous-intensity physical activity or 150−300 minutes of moderate-intensity physical activity in a week (Ding et al., 2020). The UK physical activity guidelines show that over 65% of men and 61% of females meet physical activity guidelines (UK chief medical officer report 2019). Likewise, a population survey on physical activity patterns in the US shows that 52% of adults meet the physical activity recommendation (CDC 2018). Looking at the physical activity patterns in the UK and the US, it is reasonable to suggest that people with fibromyalgia live less physically active and potentially having more sedentary behaviour than the healthy population.

Although there is a dearth of data to compare physical activity patterns between people with fibromyalgia and their cohorts, few studies have shown that people with fibromyalgia are less physically active compared to their cohorts (Ellingson et al., 2012; Segura-Jimenez et al., 2015). The baseline characteristics of previous studies investigating physical activity categories with fibromyalgia symptoms indicate that most participants recruited scored lower physical activity, then moderate, and only a few were categorised as vigorously active.

The relationship between pain intensity and Interference was consistent with previous studies. Increased physical activity was associated with decreased pain intensity and interference. Similarly, moderate to vigorous physical activity was associated with lower pain intensity than low physical activity. Neurobiological studies have shown an increase in endogenous substances and conditioned pain modulation following exercise (Eller-Smith et al., 2018). These hypotheses are supported by a variety of physical activity interventions such as resistance training (Gómez-Hernández et al., 2020), aerobic exercises (Bidonde et al., 2017), stretching (Gómez-Hernández et al., 2020), and unstructured physical activities such as walking (Mannerkorpi et al., 2010; Pastor-Mira et al., 2020) and leisure physical activity such as Zumba dancing (Assunção Júnior et al., 2018). These findings are consistent among observational studies, demonstrating a strong relationship between sedentary behaviour or lower physical (Ketels et al., 2020) activity category and higher pain intensity in people with fibromyalgia.

Similar findings were corroborated in experimental studies exploring various physical activity forms, showing that a higher level of physical activity was associated with lower pain. This is Irrespective of the type of study design and various outcome measures used to quantify physical activity. Therefore, the key challenge is identifying predictors of physical activity in people with fibromyalgia to improve targets for physical activity interventions.

Employment status was not a mediator between physical activity and pain. However, previous studies have shown a higher disease burden in people with fibromyalgia than other chronic pain conditions such as OA and R.A (Kleinman et al., 2009), leading to increased sick leave and early retirement (Kivimaki et al., 2007). Although types of jobs were not explored in this study to ascertain the nature of physical demands of the jobs, multidimensional symptoms and severity of other symptoms associated with fibromyalgia were also shown to impact jobs. Given the interrelation between symptoms, i.e., waking up unrefreshed affecting energy levels and lack of energy affecting mood, these symptoms can affect job performance.

Higher severity of psychological symptoms (depression and anxiety) was associated with physical activity and pain. These findings are consistent with previous studies indicating a higher prevalence of mental health conditions (Fitzcharles et al., 2018; Løge-Hagen et al., 2019). Neurobiological studies have established an overlap between psychological symptoms and pain through sharing common neurotransmitters such as serotonin (Goesling, Clauw, & Hassett, 2013; Gupta & Silman, 2004; Kleykamp et al., 2020). This explains why anti-depressant is used as first-line pain medications in fibromyalgia (Mease, 2005; Uçeyler, Häuser, & Sommer, 2008) and the rationale for cognitive behavioural therapy (Larkin et al., 2015).

Targeting depression as a mediator for physical activity and increased pain intensity in people with fibromyalgia. This study indicates that depression is associated with lower physical activity. Given the high prevalence of depression evident from population studies, for example, a survey from a subsample of people with fibromyalgia indicating that people with fibromyalgia have a three times higher odd ratio of depression than people without fibromyalgia (Fuller-Thomson et al., 2012). Studies have concluded that depression is strongly linked with low physical activity in people with fibromyalgia (Andrade, Steffens, Vilarino, Sieczkowska, & Coimbra, 2017). Evidence supports that physical activity interventions for improving depression symptoms have shown to be effective in people with fibromyalgia.

Anxiety was a significant mediator of pain and physical activity. This study shows that anxiety is associated with low physical activity and higher pain intensity and interference. This is consistent with studies indicating the impact of anxiety on physical activity participation. A meta-analysis comparing exercise and non-exercise control groups indicates the long-term effect of exercise on improving anxiety symptoms (McDowell et al., 2017b). However, improvement was only noted after 26 weeks of exercise, which indicates a long-term effect. Motivating people with anxiety to complete 26 weeks of exercise interventions would seem a huge challenge considering the burden of adhering to exercise and physical activity (Ang et al., 2011; Dalle Grave, Calugi, Centis, El Ghoch, & Marchesini, 2011).

5.16Limitations and strength

There is a dearth of data investigating physical activity and exploring the impact of biopsychosocial factors in the relationship between pain and physical activity and function in the fibromyalgia population. Most studies investigating non-structured physical activity behaviour in people with fibromyalgia were conducted in the US and Spain, as shown in the extraction table of the systematic review (section 3.5.2.)

Given the nature of the multiple symptoms involved in fibromyalgia and the interrelationship between the symptoms, for example, systematic reviews have shown that sleep problems are associated with psychological symptoms (Littlewood, Kyle, Pratt, Peters, & Gooding, 2017), psychological symptoms associated with pain (Martinez et al., 2015), pain related to low physical activity (Víctor Segura-Jiménez et al., 2019) cannot be ascertained. However, a recent longitudinal study followed up people with fibromyalgia for two years and established a cluster based on symptoms severity but did not find a significant variation in the trajectory of symptoms from the baseline across the clusters (Hoskin et al., 2018). This indicates adequate symptom stability and validation of association in the cross-sectional study.

The second limitation of this study is the use of subjective outcome measures to quantify physical activity. Measuring physical activity is challenging irrespective of the methods used with systematic reviews showing varied convergent validity with between commonly used objective devices between hand and hip wearables (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014; Degroote, De Bourdeaudhuij, Verloigne, Poppe, & Crombez, 2018). While objective measures are more shown to have superior validity and reliability (An, Jones, Kang, Welk, & Lee, 2017), they are practically more difficult to administer, especially in large samples. In contrast, subjective measures are easy to administer, especially in large population studies but are less reliable than objective measures (Kaleth, Ang, Chakr, & Tong, 2010). Although both methods intend to quantity the same physical activity construct, i.e., time spent on physical activity and intensity, the difference between the accelerometer-based and self-reported assessments is not well established in people with fibromyalgia. Merriweather (2018) quantifies physical activity using both accelerometer and IPAQ-SF and found a moderate correlation on physical activity classification between the two measures (Merriwether et al., 2018).

6 Chapter 6- Physical activity behaviour and impact of biopsychosocial and contextual factors- qualitative interviews

6.1 Introduction

This chapter presents the qualitative component of the mixed methods approach. The chapter describes the background of the study, methods, thematic analysis of semi-structured interviews, discussion, and summary of findings. The findings were structured under themes and subthemes from the qualitative interviews conducted with the participant, with verbatim quotations from participants' responses presented in *italics*. As a recap, the objective of the qualitative interviews was to explore the perception of physical activity behaviour and pain perception and the impact of psychosocial, contextual, and environmental factors on physical activity behaviour and pain perception.

6.2 Background

There has been considerable interest in investigating the effectiveness of exercise and physical activity interventions for pain management in people with fibromyalgia (Busch et al., 2007a; Busch et al., 2013). This has resulted in various guidelines recommending exercise as the first line of management for people with fibromyalgia (Fitzcharles, 2013a, 2013b; Macfarlane et al., 2017). Notwithstanding the efficacy of exercise and physical activity on pain and other fibromyalgia symptoms, adhering to exercise and physical activity intervention remains a considerable challenge for people with fibromyalgia (Andrade, de Azevedo Klumb Steffens, Sieczkowska, Peyré Tartaruga, & Torres Vilarino, 2018). Studies have reported a high attrition rate in exercise (Bardal, Roeleveld, & Mork, 2015; Bidonde et al., 2017; Sanz-Bañosa et al., 2018). The reason for high attrition in exercise groups are unclear. However, there has been a suggestion on difficulty coping with the intensity of exercises evident from studies reporting increased pain perception following exercise, thus explaining the reason for people with fibromyalgia to abstain from exercise (Andrade et al., 2020; da Cunha Ribeiro et al., 2018; Newcomb, Koltyn, Morgan, & Cook, 2011; Ribeiro et al., 2018).

Several studies have also examined other forms of unstructured physical activity, such as walking in people with fibromyalgia (Álvarez-Gallardo et al., 2019; Ekici et al., 2010; Ellingson et al., 2012; Fontaine et al., 2010; Fontaine et al., 2011; Gavilán-Carrera et al., 2019; Kaleth et al., 2013; Ribeiro et al., 2018). However, most of the studies adopted a positivist paradigm. Thus, the impact of biopsychosocial factors such as beliefs, perceptions, experience, coping strategy and interpersonal factors were not explored in depth. The dearth of data on personal experiences and perspectives on physical activity behaviour and pain has rendered physical activity interventions hard to implement in practice. Given that pain and physical activity are associated with multidimensional factors such as emotion (Lumley et al., 2011), perception (Habiger, Flo, Achterberg, & Husebo, 2016), an individual difference (Fillingim, 2017), and biopsychosocial factors (Lourenço et al., 2015), makes it very complex. Therefore, a qualitative approach to complement the quantitative study to obtain rich data to ascertain factors impacting the relationship between pain and physical activity behaviour in this population.

6.3 Method

6.3.1 Design

A qualitative design was necessary because people's experiences provide the most meaningful data to understand personal experiences, contextual and biopsychosocial factors and their impact on physical activity behaviour and pain in people with fibromyalgia (Hammarberg, Kirkman, & de Lacey, 2016). This study adopts a critical realist ontology and epistemology in the analysis and interpretation of findings to explore causal mechanisms that would help identify the contributions of multidimensional factors to enhance understanding of pain perception and physical activity behaviour in people with fibromyalgia (Fletcher, 2016; Nairn, 2012; Shipway, 2015). The critical realist approach encourages going beyond describing patterns within the data to identify causal mechanisms that explain social events (Fletcher, 2016). However, the critical realist has no robust methodological set of criteria for research. Many philosophies such as grounded theory (Bunt, 2016; Kempster & Parry, 2011) and case studies have adopted the critical realist approach in interpreting findings (Easton, 2010). According to Bunt (2016), this allows the researcher to decide the scope of application.

6.3.2 Sampling

In this study, purposive sampling was used to identify participants' experiences about the phenomenon of interest (Palinkas et al., 2015). In qualitative research, purposeful sampling is frequently employed to find specific phenomena or areas of interest. (Creswell, Klassen, Plano Clark, 2011). Different types of purposive sampling strategies were described by Palinkas (2015), depending on the study's objectives. Purposive sampling in this study aims to target variation, which involves recruiting people with fibromyalgia from various ages, gender, and socioeconomic backgrounds to ensure a more comprehensive representation from these backgrounds in the sample. Other purposive sampling techniques include targeting homogeneity groups- a subgroup of people with specific characteristics and mainly used in focused group interviews or snowballing purposive sampling that identifies people of similar characteristics (Green et al., 2015; Palinkas et al., 2015).

6.3.3 Saturation point

The principle of sample size in qualitative studies is not contingent on obtaining many participants; instead, the aim is to obtain enough data to address the research question (Palinkas et al., 2015). Saturation is defined as a limit to where data collection or analysis terminates, with a strong origin in grounded theory, and failure to reach saturation has been proposed to impact the research validity significantly (Morse, 2015). Several philosophies have different views on saturation, i.e., while the grounded theorist view saturation as the point where there is no new development of categories in the data, in thematic analysis, saturation is viewed as a point where no new codes and themes emerge from the data (Lorelli S. Nowell, 2017).

In this study, an estimated sample of 10- 15 individuals with fibromyalgia was targeted from various backgrounds, given the lack of consensus on a specific number to attain saturation in the qualitative study (Palinkas et al., 2015). There was an intention to recruit more participants if new themes kept emerging, and data collection would be terminated if data saturation was reached before the proposed sample size. The decision of saturation was reached by both the researcher and supervisor following redundancy of information after the 10th interview. The NVIVO codes that emerged from the interview transcripts were shared with the supervisor to ensure that no new themes emerged in the subsequently 11th and 12th interviews.

6.3.4 Participants

Participants were recruited from UK fibromyalgia patient organisations through social media platforms and local fibromyalgia organisations see Figure 6-1. The recruitment was done parallel with the quantitative survey (chapter 5) to ensure that participants from the interview were representative of the participants recruited in the survey. This is discussed in detail in the participation section of the survey. As a recap (section 5.4.1), only participants based in the UK were contacted and included in the study. The rationale to recruit from the patient's organisation was to have access to a large group of diverse participants all over the UK. An invitation letter (*see Appendix 14)* and study package consisting of the participant information sheet (see *Appendix 15),* consent form, interview schedule, and contact details to the research student were sent to the organisations to share with their members. Those who agreed to participate in the study were required to complete the consent form and socio-demographic information to ensure they were eligible to participate and were allowed to ask questions via telephone before agreeing to consent to ensure informed consent. Participants must meet the eligibility criteria, i.e., diagnosed with fibromyalgia and aged 18 years and older and willing to participate in the study before they were contacted to arrange the telephone interview. The recruitment flow chart is displayed in Figure 6-1.

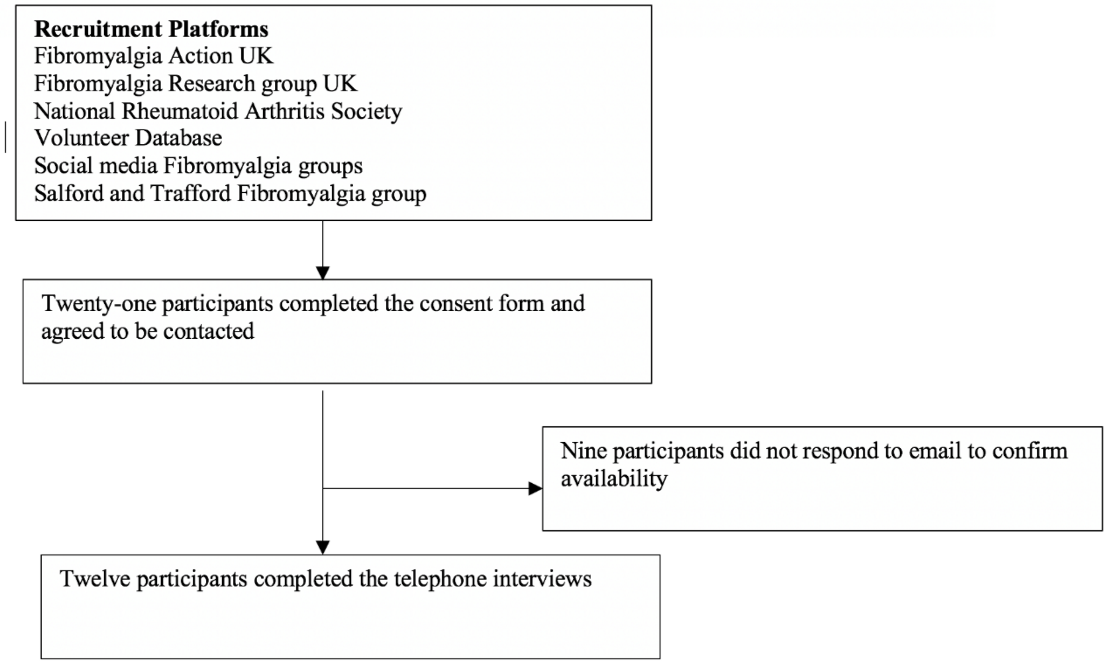


Figure 6-1- Recruitment flow chart

Table 6.1 presents the sociodemographic characteristics of the participants that completed the interviews. The age range of the participants was between 20-70; the oldest participant was between 65-70 years, two participants aged between 60-65 years, three participants aged between 50-60, three aged between 40-50, and the remaining two were aged between 20-35. This represents a spread of age and the age range in representation from these groups. Gender representation was adequate, considering the prevalence of fibromyalgia is over 70 % in women. Among the 12 participants that completed the interviews, only two participants were male.

Table 6-1: Sociodemographic characteristics (qualitative interviews)

Participant No/ Pseudonyms	Age range	Ethnicity	Gender	Employment status	Living status	Family History	Medications
P1- Sheba	50-55	Mixed	Female	Full Time Office work	Lives alone	No	Opioids, Antidepressant
P2- Smith	30-35	British	Male	Part-Time Shop assistant	Lives with father	Father	Antidepressant, Anti-acids
P3- Clara	40-45	British	Female	Part-Time Office work	Lives with partner	No	No
P4- Sara	65-70	British	Female	Full Time Church	Lives with husband	No	Not mentioned
P5- Adam	30-35	British	Male	Retired Volunteer	Lives with Partner	No	Anti-convulsant
P6- Jannie	60-65	British	Female	Retired	Lives with husband	No	No
P7- Eve	60-65	British	Female	Full Time office work	Partner	No	No
P8- Maggie	20-25	British	Female	Student Full time	Living with Family	Mum and Grand mum	Anti-Psychotic
P9- Liz	50-55	British	Female	Unemployed	Partner	No	Opioid
P10- Monica	55-60	British	Female	Unemployed	Alone	No	Opioid Anti-convulsant Antidepressant
P11- Ann	40-45	British	Female	Unemployed	Lives with husband	No	No medications
P12- Suzy	45-50	British	Female	Sick leave	Single	Mum	Opioid Anti-convulsant Antidepressant

6.3.5 Telephone Interviews

Telephone interviews were adopted as the appropriate model for this study based on the need to reach participants from more expansive geographical areas across the UK during the Covid-19 pandemic when face-to-face interviews would not be feasible. Other advantages, such as the participants' feasibility to reschedule, the perceived anonymity of the interviewee, and the likelihood of participants accepting telephone interviews over face-to-face interviews, were considered during the planning stage of this study. Telephone interviews in qualitative research have gained more popularity over the years despite the sceptics of this medium to collect data in qualitative research (Sturges & Hanrahan, 2004). Researchers believe that it is easier to gather contextual factors, which is essential in the context of this research, in telephone interviews than a face-to-face interview (Novick, 2008; Smith, 2005; Ward, Gott, & Hoare, 2015). Studies have also attributed the participants' openness to disclosing embarrassing, distressing or deviant behaviours in telephone interviews than face-to-face interviews (Ward et al., 2015).

6.3.6 Scheduling

Participants were asked to choose a time and date of their convenience and be aware of the flexibility to reschedule. This is aimed to ensure ease and flexibility for participants that is more achievable through telephone interviews (Sturges & Hanrahan, 2004). This was in anticipation that some participants would be employed and would have a limited time within the regular working hours or working days while some may be involved in caring and other personal responsibilities. Therefore, participants were offered a flexible schedule to conduct telephone interviews in the evenings and weekends, depending on their preference, to reduce participant burden (see Appendix 16).

6.3.7 Recording

Participants were reminded that the interview would be audio recorded to aid the transcription verbatim before the interview. This is to serve as a gentle reminder and reiterate the process. This has been mentioned in the Participant Information Sheet and consent forms, signed by the participants. Considering the ethical implications, data protection, a digital recording system was used for the recording. A Skype call recorder was used as a backup to record the telephone interview. Before commencing the interviews, both recording systems were checked for audio quality and functioning.

6.3.8 Duration of interview

At the recruitment stage, participants were informed that the interview would be participant-led and could last to a maximum of an hour or shorter depending on the participant's responses. Most of the interviews lasted more than 30 minutes as participants were happy to provide an in-depth explanation of how fibromyalgia affected them.

6.3.9 Establishing trust

Establishing trust and rapport is essential to obtaining quality responses and respecting the participant's integrity and feeling. Dejokheere et al. (2017) suggests that the interviewer needs to be authentic, use a normal tone, and avoid slang and jargon even when participants use such tones to reflect their status and avoid a judgmental stance. The researcher contacted the participants who consented to participate in the study through email to thank them and explain the format and time it would take to complete the telephone interview as stated in the participant information sheet. On the day of the interview, participants were sent another email as a kind reminder to make last-minute changes to the schedule for personal reasons. Therefore, participants were either contacted at the time of their choice or given the option to reschedule the interview if they wished to do so. After ringing the participant, the researcher conducted a brief introduction to ensure that participants were at ease before recording commences. After that, participants were advised that the interview would be recorded, and their names would not be mentioned to protect their anonymity. The interview started with general questions to allow the participant to settle in and feel more comfortable. Most of the participants answered the phone and engaged with the researcher very well. They provided a detailed account of how fibromyalgia affects their health, well-being, and physical activity behaviour with little to no need for prompts.

6.3.10 Interview structure

A semi-structured interview schedule was used to explore participants' in-depth experience, perception, and context on their perceived chronic pain and physical activity behaviour. Semi-structured interviews are the most common form of qualitative interview methods used in health research. Unlike the structured questions that allow for single responses, a semi-structured interview guide was developed with a schematic presentation of core open-ended questions with potential prompts to elicit more in-depth information.

6.3.11 Reviewing notes and Reflection

During the interview, reflective notes were taken to analyse the verbatim transcripts further. The concept of notetaking during interviews is recommended as ideas and thoughts during the conversation will guide subsequent steps in the analysis (Montgomery & Bailey, 2007; Slotte V & Lonka, 1999). It is argued that the utilisation of memoing (i.e., recording reflective notes about what the researcher is learning from the data) and field notes taken either during an interview or immediately after the interview be far better than using just the verbatim. As interviews were conducted on the telephone, note-taking was not seen as intrusive to the interview.

6.3.12 Transcription

Transcription is a process of reproducing the audio recorded interview into words that could include unspoken words like body language and emotions. At the same time, verbatim is described as a word-by-word replication of audio recording (Wellard & McKenna, 2001). Audio recordings from the interview were transcribed verbatim, read and re-read for accuracy by the researcher. The interview transcript was shared with selected participants in conformity with ethical standards and ensured validity and trustworthiness (Polit & Beck, 2007). This provides an opportunity for the interviewee to reflect on his responses.

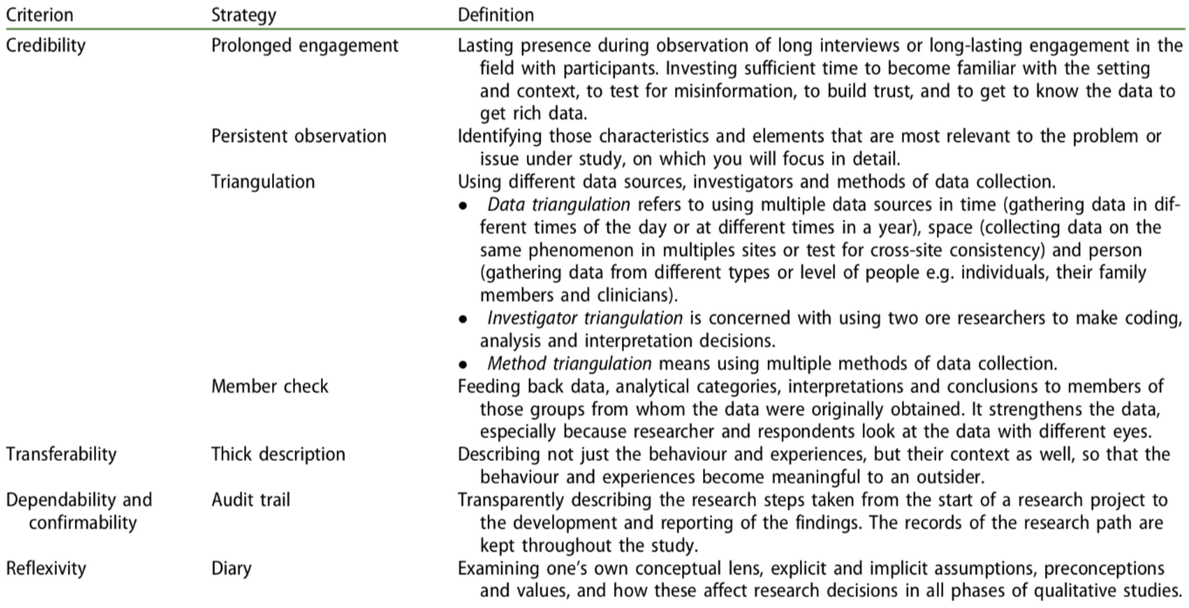
6.4 Thematic analysis process

Data analysis was conducted using thematic analysis and a critical realist framework to discuss the qualitative interview findings. Thematic analysis is a flexible data analysis as it is not tied to any methodology, epistemology, or theoretical framework (Braun & Clarke 2006; Clarke & Braun, 2013). The flexibility of thematic analysis has drawn criticism for lack of consistency and coherence (Holloway & Todress, 2013); however, to address the principle of trustworthiness and consistency, Braun and Clarke (2006) suggest guidelines for conducting a thematic analysis. Depending on the aim of the study, theoretical thematic analysis or an inductive thematic analysis can be deployed as several approaches to thematic analysis were described by Alhojailan (2012) and Javadi & Zarea (2016). This study adopted the thematic analysis steps proposed by Braun and Clarke (2006) (Table 6-2).

Table 6-2: Thematic analysis steps- adopted from Braun and Clarke (2006)

Step 1: Become familiar with the data	Step 4: Review themes,
Step 2: Generate initial codes	Step 5: Define themes,
Step 3: Search for themes,	Step 6: Write-up

This study was guided by the principles of confirmability and trustworthiness in qualitative research as described by (Korstjens & Moser, 2018). After reading and re-reading to be familiarised with the data, coding was done using the NVIVO software to identify and record patterns. This process enables the formation of themes and sub-themes within the codes. A selection of transcriptions and coding, themes, and sub-themes was carefully reviewed by the lead supervisor, an experienced researcher in qualitative methodology, to present the final themes accurately.



Criterion	Strategy	Definition
Credibility	Prolonged engagement	Lasting presence during observation of long interviews or long-lasting engagement in the field with participants. Investing sufficient time to become familiar with the setting and context, to test for misinformation, to build trust, and to get to know the data to get rich data.
	Persistent observation	Identifying those characteristics and elements that are most relevant to the problem or issue under study, on which you will focus in detail.
	Triangulation	Using different data sources, investigators and methods of data collection. ● *Data triangulation* refers to using multiple data sources in time (gathering data in different times of the day or at different times in a year), space (collecting data on the same phenomenon in multiples sites or test for cross-site consistency) and person (gathering data from different types or level of people e.g. individuals, their family members and clinicians). ● *Investigator triangulation* is concerned with using two ore researchers to make coding, analysis and interpretation decisions. ● *Method triangulation* means using multiple methods of data collection.
	Member check	Feeding back data, analytical categories, interpretations and conclusions to members of those groups from whom the data were originally obtained. It strengthens the data, especially because researcher and respondents look at the data with different eyes.
Transferability	Thick description	Describing not just the behaviour and experiences, but their context as well, so that the behaviour and experiences become meaningful to an outsider.
Dependability and confirmability	Audit trail	Transparently describing the research steps taken from the start of a research project to the development and reporting of the findings. The records of the research path are kept throughout the study.
Reflexivity	Diary	Examining one's own conceptual lens, explicit and implicit assumptions, preconceptions and values, and how these affect research decisions in all phases of qualitative studies.

Figure 6-2- Principles of Confirmability and Trustworthiness adopted from Korstjens & Moser (2018)

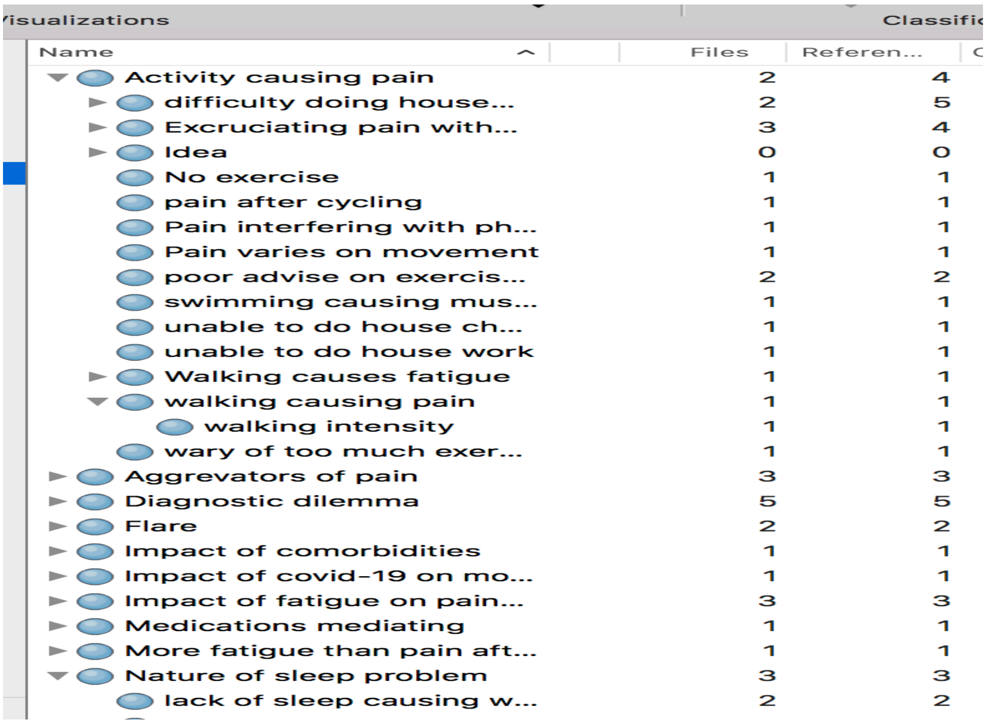
6.4.1 Step 1: Becoming familiar with the data.

According to Braun and Clark (2006), the first step of thematic analysis is becoming familiar with the data. During the interview, notes were taken to reflect on essential points in the conversation, which, simultaneously with the recordings, enables data coding and generating themes in the subsequent stages. The audio-recorded telephone interviews were transported from the recording device to the computer in a Path-FM1 qualitative data analysis file folder. Each recording was labelled with anonymous names and ID numbers of the participants. An excel sheet was created containing all participants anonymised demographic information. All recordings from conversations were uploaded into the NVIVO software, provided, and licensed by the University of Salford. Before commencing on transcription, the researcher listened to each interview's audio to ensure the recording's quality, which is needed for easy transcription. All transcription was done using the NVIVO software, enabling the researcher to hear the conversation while reading the transcript and editing the transcript and truncating verifiable information such as names and locations. Each transcript was revised to ensure the accuracy of the content. The transcript and audio files were shared with the supervisor to ensure the transcript reflected the interview. Each interview took approximately five hours to transcribe. All anonymised transcripts were saved in the university's secure server (F drive) and shared with the lead supervisor through the University Microsoft One-Drive shared folder to enable access.

6.4.2 Step 2: Generating initial codes

Codes were generated in line with critical realist ontology and epistemology of exploring social mechanisms. A deductive approach was used to generate codes to answer the research question. Inductive coding by grounded theorists with critical realism philosophy has drawn criticism because critical realists engage with existing literature and theory to form reality, contrary to the grounded theory, which distances itself from the existing literature (Fletcher, 2016).

In this study, coding was approached by continually revisiting the data in a reflective and interacting manner to formulate ideas and concepts with the background literature in mind (Hammarberg et al., 2016). Many provisional codes were drawn from the interviews using the NVIVO software, which sort and systematically organise codes and themes identified by the researcher (Figure 6-3). In that sense, the NVIVO is an organisation software for the qualitative researcher, rather than an analysis tool, e.g., SPSS, as the demand depends on the researcher as the analytical tool. All codes were treated as essential, while the dominant codes were used to identify themes (Nowell, 2017). After an exhaustive coding process, all codes were reviewed to ensure no repetitions and similar codes were merged. A codebook was generated to describe how coding was done to ensure the credibility and trustworthiness of the process. The codebook was shared with the lead supervisor in conformity with the process validity and reliability for agreement on the main themes (Braun & Clarke, 2006; Creswell, 2014).



Name	Files	Referen...
▼ Activity causing pain	2	4
► difficulty doing house...	2	5
► Excruciating pain with...	3	4
► Idea	0	0
No exercise	1	1
pain after cycling	1	1
Pain interfering with ph...	1	1
Pain varies on movement	1	1
poor advise on exercis...	2	2
swimming causing mus...	1	1
unable to do house ch...	1	1
unable to do house work	1	1
► Walking causes fatigue	1	1
▼ walking causing pain	1	1
walking intensity	1	1
wary of too much exer...	1	1
► Aggrevators of pain	3	3
► Diagnostic dilemma	5	5
► Flare	2	2
► Impact of comorbidities	1	1
► Impact of covid-19 on mo...	1	1
► Impact of fatigue on pain...	3	3
► Medications mediating	1	1
► More fatigue than pain aft...	1	1
▼ Nature of sleep problem	3	3
lack of sleep causing w...	2	2

Figure 6-3- Code’s map in NVIVO

6.4.3 Step 3: Searching for themes

The search for themes continued from the second process, generating initial codes to identify themes that emerged from the coding process. Themes collect ideas and experiences generated within the data set through multiple codes (Sundler, Lindberg, Nilsson, & Palmér, 2019). This process was done independently by the researcher and the lead supervisor to ensure credibility and trustworthiness in data analysis. Mind maps were used to ensure consistency in both the second and third stages. In line with the recommendation of King (2004), the search for themes began by harmonised codes generated at stage two to help guide in generating sub-themes and themes. Similar codes were grouped under categories generated using the NVIVO software *see Appendix 17*

6.4.4 Step 4: Reviewing of themes

Braun and Clarke (2006) proposed that the themes generated in stage three be assessed and refined. Each theme was assessed for validity at this stage to determine whether there is enough evidence within the data to explain the theme. Redundant themes were collapsed with other themes, and dominant themes were broken. More than ten proposed themes were generated at stage three based on the categorisation of codes. This process also involved an independent review by the lead supervisor, and a joint meeting was arranged to agree on the final themes and subthemes.

6.4.5 Step 5: Defining and naming themes

The themes identified were named to capture the concept of interest so that each name was given a sense of a story underneath the theme (Braun and Clarke 2006). Where themes need modification, the themes were reanalysed. King (2004) recommends an iterative process of reflection as themes name can always change and recommended a peer debriefing with an experienced qualitative researcher. In compliance with this suggestion of ensuring credibility and transparency, the supervisor assessed the codes and themes for a possible name change of themes. The final themes are subthemes presented in Table 6-3.

Table 6-3- Final theme and subthemes

Main Themes	Subthemes
Lack of guidance of adapting suitable physical activity	1. Positive perception and negative experience of physical activity 2. Fear of increased pain after physical activity 3. Impact of physical activity intensity on pain 4. Impact of weather conditions on physical activity 5. Insufficient understanding of physical activity
Impact of fatigue	1. Impact of physical fatigue and pacing 2. Impact of mental fatigue on physical activity
Impact of treatment on physical activity and pain	1. Impact of psychological interventions on acceptance and coping mechanisms 2. Medication impacting negatively
Social impact	1. Impact of physical burden on work participation 2. Impact of employer support on physical and mental wellbeing 3. Perceived work discrimination 4. Impact of family support on well being 5. Physical burden of care: duties and responsibilities

6.4.6 The researcher’s orientation

The researcher’s background is in Musculoskeletal physiotherapy with interest in pain management. As a physiotherapist trained in India and practised in Nigeria, training and clinical practice were centred on the physiological model. This emphasises functional restrictions, biomechanical principles, and physiological mechanisms. There was little emphasis on adopting a holistic psychosocial approach to managing pain and restrictions commonly treated by physiotherapists. Although the researcher has recognised the impact of biopsychosocial factors in chronic conditions in hindsight, the application in practice was limited due to the medical model approach. This might have been due to the physiotherapists’ key priority: to manage the physical function without much regard for the impact of psychosocial factors such as coping strategy, illness perception, psychological symptoms, and social factors in Nigeria. This has contributed to the potential bias towards objectivity and quantification rather than subjectivity and depth at the beginning of the PhD journey.

However, during the PhD, the researcher embraced a comprehensive, biopsychosocial approach, guided by the supervisory team to explore the psychological, social, environmental, and contextual factors on physical activity behaviour and pain in people with fibromyalgia. This paradigm shift was shaped by a rigorous literature review and a systematic review conducted during the PhD. Additional training was received through lectures and external seminars and support and feedback from the lead supervisor on frequent meetings to shape the qualitative component of this study. This led to the recognition of the need for the qualitative inquiry to broaden this study's perspective by identifying the impact of personal views, attitudes, and challenging behaviours that will serve as a basis for delivering more targeted treatment to people with fibromyalgia. To strengthen these skills, the researcher has undertaken several training courses on the foundation of qualitative research, interviewing techniques, data collection methods, analyses, and interpretation of qualitative data. Before conducting interviews with participants, the researcher also had the opportunity to do qualitative practice interviews with the academic supervisor and fellow PhD candidates to build skills and confidence.

6.5 Theme 1- Lack of guidance in adapting suitable physical activity

The first broad theme was concerned with participants’ behaviour and views on physical activity levels. Participants were asked to describe their daily activities and how their physical activity behaviour affected fibromyalgia symptoms. This included any form of physical activity the participants engage, such as structured exercises, e.g., either done at home and the gym, attendance to Zumba or yoga classes supervised by a professional, and other forms of leisure activities, e.g., walking, swimming, cycling, and doing house chores. This aimed to explore participants behaviour towards physical activity and identify the barriers and challenges of physical activity participation. From the participants' responses to the range of physical activities involved in their day-to-day life, there were diverse ranges in the choice of physical activities and the intensity at which these are performed.

In contrast, most participants find leisure and non-structured physical activity such as walking and low-intensity physical activity such as stretching and yoga to be more beneficial for pain than intense physical activity. There seems to be a common perception among participants that staying active through various physical activities is essential for maintaining good health. However, despite the positive perception of physical activity on health, the experience of increased pain perception following various forms of physical activity was consistent and even more severe following intense exercise. Participants reported experiencing increased pain after physical activity, which played an essential role in preventing frequent engagements in these activities and may explain more time spent on sedentary behaviours to recuperate from pain due to physical activity exertions. The exciting highlight of this theme was the perceived lack of guidance received on physical activity frequency, physical activity choice, and intensity attenuation. Five subthemes are discussed under this theme. Figure 6.4 is a concept map of theme one and subthemes.

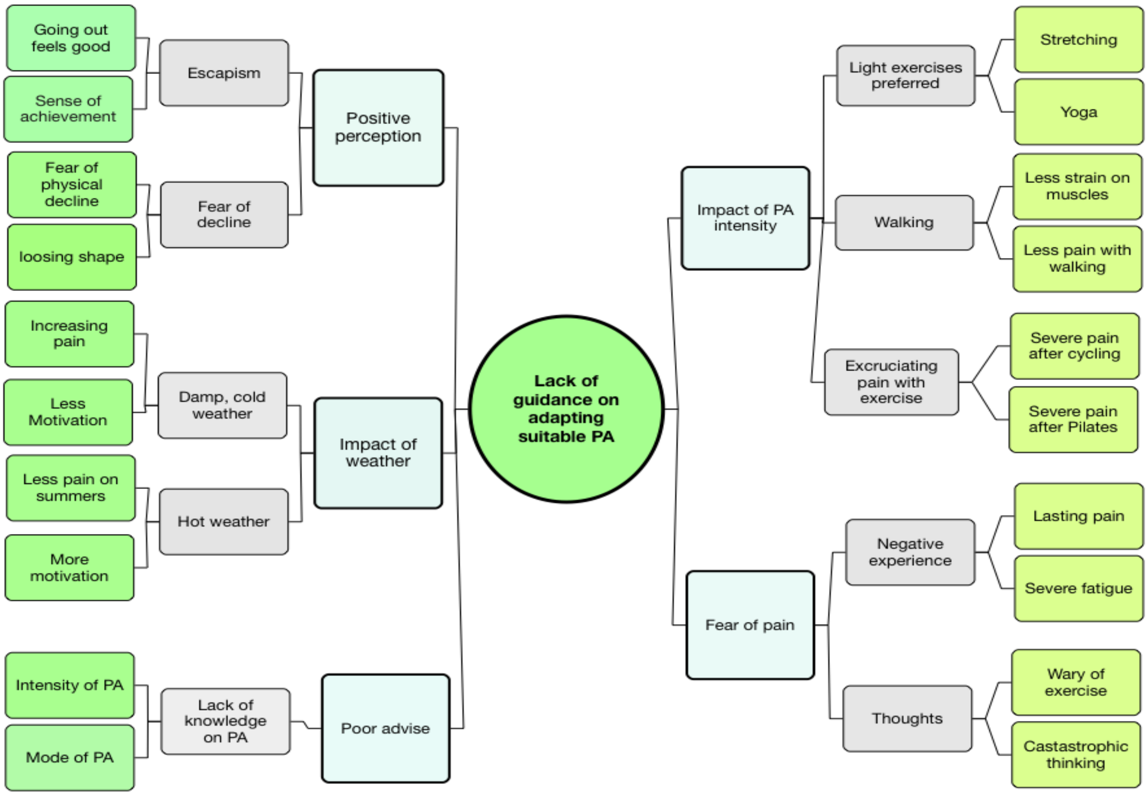


Figure 6-4- Concept diagram of theme one: lack of guidance on adapting suitable physical activity

6.5.1 Subtheme one: Positive perception of physical activity

Participants have expressed a positive perception of physical activity. There is a general view among participants that any form of physical activity is beneficial for health. There was an expression of physical, emotional, and mental health benefits after physical activity. Fear of potential physical deterioration resulting from sedentary behaviour and inactivity was expressed as a concern and a motivating factor to be active despite the potential for increased pain intensity following physical activity. A sense of achievement, mental health improvement, distraction, and escapism were essential benefits of physical activity. These facilitators have potentially made most participants maintain a level of physical activity despite the repercussion of pain.

This participant illustrates how fibromyalgia symptoms have contributed to his physical decline compared to before the condition. Nevertheless, despite knowing he would experience more pain after physical activity, he still believed inactivity would make him deteriorate further over time, potentially making him ultimately housebound.

> *"I mean things have declined over the years. But I don't want it to decline where I'm sort of completely housebound. So, it's you know a bit of a fight really"- Adam.*

These participants expressed a similar positive perception of physical activity (exercise and walking) improving physical and mental health. Engaging in physical activity was reported to improve mood, and through physical activity, participants reported a distraction effect. In addition to mood, satisfaction and accomplishment were also expressed, despite the prospect of aggravating pain and severe fatigue.

“I guess I totally agree, but I do believe any form of exercise is good with a mental health condition”- Clara.

“The feeling of going somewhere, leaving the house to walk or do leisure physical activity has been expressed to have a distraction effect. There is expression of feeling good following leisure physical activity” -Sheba.

" I think just being able to go somewhere and empty your head for an hour is a good thing"- Smith.

"Um, immediately after, pretty positive 'cause you get the sort of like endorphin but- also really tired"- Maggie.

"I know that If I don't do something physical to boost my cardiac. Amm I'm just gonna I'm just going to die very early"- Adam.

6.5.2 Subtheme two: fear of excruciating pain after physical activity

Despite positive perceptions and benefits derived from physical and mental health, they reported increased pain intensity after physical activity. Participants expressed increasing pain following various forms of physical activities such as swimming, cycling and Yoga. Interestingly, the choice of physical activity had no apparent bearing on age. While participants Smith and Adam, are younger- between 30 and 35, Suzy and Clara were between 40 and 50. Both participants expressed fear of pain linked to physical exertion required to do the activities mentioned (i.e., swimming and yoga). This has caused participants to refrain from doing structured physical activities they enjoyed.

I tried doing yoga a few months back. I did it for a day and then I couldn't kneel for about a week, I was in so much pain- Suzy *sometimes I say it takes a sometimes the pain is that bad. Just trying to put any kind of movement or weight. That is just been impossible. -Smith*

I did some swimming one time, and I pulled a muscle from my back, which gave me a trap, none of which made me have spasms all over my body that I actually dreaded going into pool again- Clara.

And sort of you know, like swimming, I mean, you know, I go into swimming, and I feel really rough for it, but I believe, you know, in my head, I think that while I'm trying to do good to myself by maintaining my sort of I know a lot of people can sort of with fibromyalgia, can end up sort of bedridden and amm whats the word- Adam

6.5.3 Subtheme three: Impact of physical activity intensity on pain

Most of the participants in this study appear to live between sedentary and mild and moderate physical activity categories from the participants' day-to-day activities. Vigorous physical activities such as swimming, cycling and strength training were not commonly reported, as only Sheba, Jannie, and Adam have reported engaging in vigorous physical activities. Although experiencing increased pain after other forms of mild to moderate physical activities such as Yoga and stretching were reported, participants who engaged in vigorous physical activities reported more excruciating pain than those who did a mild physical activity walking.

This participant expresses fear of doing too much exercise despite deriving pleasure from these. She describes needing to do less vigorous, which helps better with the pain experience than high-intensity exercise. However, even after setting the intensity of exercise, she feels the ache.

"I think you've had to set up yourself gently. And to be honest, I said on Wednesday that class was such a very gentle class group.

> *And when I got tired, I did actually stop"- amm I usually feel very achy and. I will generally have a shower and get into my gym jams and just sit and take my painkillers- Sheba.*

This participant expresses severe pain that often requires taking pain medications to ease the pain after doing exercise.

> *"In all honesty wrecked!! everything hurts. I just ache. So, I come home and have a hot shower, get rest, take my painkillers. And quite often just go to bed" - Jannie*

This participant also expresses extreme pain after exercising and is potentially bed-bound for days after doing too much exercise.

> *"Um, gets aggravated, it's-it's the extreme. So, if I don't do any exercise or any-any movement, it -um, I get very stiff and achy. But if I do too much exercise. I can leave myself bed-bound for days"- Adam*

Mild physical activity such as walking is preferred and linked with less pain than vigorous physical activities such as swimming and cycling. Although this participant did not think walking would be beneficial for pain, the participant acknowledged the importance of walking in improving stamina.

> *"I did find it walking beneficial, not hugely, but yes, beneficial. I don't think it's improved the pain it improved my stamina"- Sara.*

6.5.4 Subtheme four: Impact of weather conditions on physical activity

Participants were asked questions to explore other factors that influence their physical activity participation. Weather conditions were one of the dominant influences that emerged as barriers to physical activity and increasing pain. Participants attributed climate conditions as a critical barrier that deters physical activity participation due to increasing pain intensity. This participant expresses how ‘*extreme weather*’ conditions reduce her mood of going out for a walk and experience increased pain severity with extreme winters.

> *“..Um, it gets a lot of worst in* ***extreme temperatures****. So-over the winter, there's been times when I've been in education where I haven't turned up, attended once a week or not even-- not at all for several weeks because I can't, um. I can get out of bed -or like walk about the house. But, uh, going out in the cold and walking to the bus stop--just leaves me in agony" - Maggie*

This participant also has a similar experience of increased pain during cold, wet weather. She expressed having more flare-ups due to harsh weather conditions she describes as impacting her pain and potentially going out.

> *"Oh, yeah. oh, yea well,* ***damp weather****, damp wet weather when it's cold, bitterly cold. I tend to wear a scarf around my neck “. – Clara.*

Jannie strongly believes weather conditions have a strong influence on pain and physical activity participation.

> *"And I think it's the weather as well. I know some stupid weather, but I. Yes, I really think it's the weather"- Jannie*

Adam also describes the nature of widespread pain perception experienced, emphasising weather contributing to pain.

> *"It feels like my body's is bruised, badly bruised, that's probably hard to describe it. And, you know, I think my other half quite often, sometimes morning I feel like I've been hit by a bus and that's how I feel. I mean, I mark my pain a lot and sort of I mean, around sort of my shoulders and back, but hands and feet really, particularly when you know the worst areas. They're just feel like say obviously, the* ***weather*** *has made matters even worse"- Adam.*

6.5.5 Subtheme five: Insufficient understanding of physical activity

Participants who engage in structured physical activity such as aerobic and strengthening exercise express poor understanding of their conditions by the people responsible for guiding them on the appropriate exercise given their conditions. Suzy expresses a negative experience following what she describes as a flawed exercise protocol.

> *"When I went to like, pain therapy and stuff like that it just all involved a lot of stretching and stuff like that. And then I've been recovering for three or four days when I was in so much pain, but no one would listen. They just keep saying do the exercises over and over and no matter how much I did them it was just hurting more and more" Suzy.*

Maggie also expresses similar experience with exercise classes believing that most exercise instructors have insufficient knowledge of exercise prescription for people with fibromyalgia. Instead of moderating the exercise intensity, they recommend that she do more, causing more pain and potentially needing more time to recover from the previous intense exercise session.

> *"Exercise classes are really odd because they don't tend to specifically ca-- Like, a lot of the instructors ar-aren't necessarily knowledgeable about--health conditions and they might, yeah. And they don't-- I've had like gym, um, routines where you get set by one of the trainers -and there was one they gave me, and they wanted me to do 50 squats every time -I went to the gym. And my knees are my worst joints. And so, I looked at the guy and was like, "I've-just explained to you I've got chronic pain." - Maggie*

6.6 Theme 2 - Impact of fatigue on physical activity and pain

Participants expressed overwhelming fatigue as a barrier to physical activity. This has been even more detrimental to physical activity than the fear of increasing pain reported in theme one. The lack of pacing physical activity was evident in theme one. Some participants tended to do more physical activity at a time rather than splitting or adapting less strenuous physical activities like walking, which was also reported to be painful, not as severe. This was the case in this theme as those participants whom do vigorous physical activity suffer from physical fatigue after exercise. However, other participants who do not engage in vigorous physical activity also expressed feeling tired, doing mild physical activity such as cleaning the room or even without engaging in any physical activity. Two subthemes emerged under this theme: physical fatigue and pacing and the impact of mental fatigue on physical activity.

6.6.1 Subtheme one- Impact of physical fatigue and pacing

Physical fatigue relates to the feeling of exhaustion following physical activity. This type of fatigue persisted for a day after moderate to vigorous physical activity such as Salsa dance, swimming, and cycling. This potentially means more days of adopting a sedentary behaviour to recover from a day of vigorous physical activity in addition to a sedentary workstation. Most participants who reported physical fatigue appears to be those that engage in moderate to vigorous. Participant 01 expresses feeling fatigued the next day following a salsa dance class.

> *"I went to a salsa class on Wednesday umm, and I made through most of the class, I was a bit stumbling in places. But the next day I was extremely tired. And then I sort of crushed up the rest of the afternoon, but I still suffer for the next day"- Sheba*

Adam also expresses lingering fatigue, which tends to last the next day and improves as the week progresses following swimming. This is in addition to the intense pain experience following cycling. This results in adopting sedentary behaviour in six days to recover from a daily exertion.

> *"The next day is generally a bit achy and especially on the knees, but it tends to improve over the week and then it gets back to the following week again. It's just that it's just a cycle. over the next six nights and then it's time to cycle again" – Adam.*

Sheba also reports a similar experience of severe fatigue following moderate to severe physical exertion. Like Adam, Sheba stressed the need to adopt a milder physical exertion and not go beyond her threshold to cause severe fatigue and potential flare-up.

> *"Last time I was cycling. I knew I was tired, and I knew if I kept on, I put myself into Probably a flare-up if I wasn't Careful- And if I've done slightly too much or I'm not feeling well, then the weekend is basically umm housebound. I basically just rest"- Sheba*

Maggie also expressed massive fatigue following mild physical activity such as cleaning the room that should not demand much energy. Still, she states needing to rest for an hour after the physical activity.

> *"It's not necessarily pain. Um, I get like really bad fatigue with, umm. So, if I do too much, uh, too many chores-- As I was cleaning my room ready for university the other day -and I did about an hour and a half of like solid tidying and hoovering, and then I had to take a nap for four hours" - Maggie.*

6.6.2 Subtheme two: Impact of mental fatigue on physical activity

Apart from physical fatigue resulting from engaging in moderate to vigorous physical activity participation, some participants, primarily those who do not engage in moderate to vigorous physical activities, also expressed feeling tired and lacking the energy to do even a mild physical activity house chore. This has been related to mental exhaustion.

Smith expresses having low energy even without doing anything, which affects doing some house chores. This can happen randomly in the middle of the day, according to Smith.

> *"Usually like you sometimes feel like just very fatigued. It's like just I don't know don't have the energy to pretty much get up some time even if I'm being idle, I'll just midway through the day just become very fatigued. I was to go into town, do some chores, but you know, I just haven't had the energy to do that." Smith*

Sara describes how fatigue impacts her job, making it challenging to concentrate despite working in a sitting workstation.

> *"I think the fatigue effect you know, the capacity really that daytime capacity to do the amount of stuff I normally would do and*

concentration. It's difficult at times. But fatigue certainly makes that difficult"- Sara.

Adam finds it difficult with fatigue, affecting the concentration level and decreased capacity to do normal daytime activities.

" I think the fatigue effect you know, the capacity really that daytime capacity to do the amount of stuff I normally would do would and concentration"- Adam.

The impact of mental fatigue on mood was also expressed by this participant, who describes getting depressed due to having no energy to do anything. This type of fatigue is not physical due to engaging in any physical activity but often affects the mood to do any physical activity, making the participant even more sedentary.

"..my whole body is so tired--that I'm just exhausted all the time,. I get depressed because I get so low because I feel like, “What sort of life is it?” Suzy

Other than the commonly reported fatigue after physical activity, there seems to be another form of fatigue mediated by poor sleep. This participant expressed low sleep quality, which was commonly reported among the participants in waking up unrefreshed. This is expressed to affect energy levels which potentially affects physical activity participation.

"There are times where I'm so exhausted in the morning. And if I go back to sleep, it's difficult when to wake up. So, but I don't I don't sleep deeply either when I'm asleep "- Eve.

Fatigue, as expressed by the participants, seems to be a significant barrier to physical activity. The fear of fatigue was expressed as the reason for doing physical activity less frequently. Fatigue was expressed as physical- having to do with exhaustion after activity for a duration of time as described by some participants or mental - which has to do with psychological and possibly the side effects of the medications taken for pain participants.

6.7 Theme 3- Impact of treatment

The impact of treatment on pain and physical activity was one of the themes that emerged from the interviews. Most participants in this study are on various medications to help with pain and other fibromyalgia symptoms such as sleep disturbances. Some participants are not on medications because they find medications not helpful for pain and other fibromyalgia symptoms such as sleep, mood, and fatigue. Under this theme, two subthemes emerged: The impact of psychological intervention on acceptance and coping strategy and medications negatively impacting physical activity.

6.7.1 Subtheme one: Impact of psychological intervention on acceptance and coping strategy

Few participants in this study had previously undergone psychological inputs and education for fibromyalgia, and they highlight the positive impact of the psychological intervention on general health. This involves helpful coping strategies and positive illness perception.

Sheba expressed the impact of CBT and how her perspective of fibromyalgia changed. She attributes having a breakthrough for managing her condition better in terms of prioritising and acceptance following CBT. She states the following:

> *"There is CBT, and you know, given knowledge of what fibro is and things like that. That was really helpful. And that was probably my turning point, to be honest. it's more acceptance of, you know, I can't do the things that I used to do like going out every weekend dancing. Getting going. Yeah. going to weekends as they dance all*

> *day and dance all night. umm going out for a long bike ride. It's known that I can't do those things now, but you know, trying to do what I can." Sheba*

A similar experience was narrated by Maggie, who also had sessions of CBT. She describes having a better understanding of her condition and how self-recognition. Through better understanding and self-recognition, she has learned to cope better with potential negative thoughts. This has improved her mental health and has developed the mental ability to cope with pain.

> *"I think mainly because it focused on, uh, the sort of, um, like mental health, psychological si de of things. That's lessened- -the amount of stress that I feel because I'm able to get -myself out of recognise, uh, negative thinking patterns and get myself-out of the sort of holes that I used to fall into. Because with, um, fibromyalgia, obviously, being in pain all the time can make you really, really depressed and -so-. I was in pain, so I didn't do anything. Uh- -because I wasn't doing anything-I was in pain. It just sort of perpetuates that cycle, and I just already used to this. Whereas now, I have a lot of, uh -do-- you-you have this thing called a-a cap map, where you essentially map out every single behavioural pattern and sort of those thoughts focus you get into and then you can visually point out exits. So, I have that stuck on my wall, and it helps me get out of, um, that". - Maggie*

Adam reported a similar positive experience with mindfulness. He expressed the benefits of psychological interventions on his mental health and understanding the impact of self-management strategies following CBT and mindfulness.

> *"It definitely helped because it gave you know, it's so easy to get bogged down in the relentlessness of the cycle of you know pain, work, sleep, no sleep, sleep, pain, work. You know, a few days on. A few days off. And so, you have to have some sort of coping*

> *strategy. I Listen to mindfulness. I listen to sort of sleep hypnosis, you know, sometimes you can leave it on all night if necessary. Just try and keep the headphone in just up or distract my mind, my brain. Sometimes it works. Sometimes it doesn't work… You know, it's mindless. There's no clock. You haven't got a, you know, remember anything. And you just dose to sleep, it's a bonus" - Adam.*

Ann also finds mindfulness and breathing techniques essential for coping with anxiety.

> *"I've had CBT, yes. Uh, it's helped to a point…I did do mindfulness, I did a bit of breathing techniques, um, which helped to a point. It certainly helped with the anxiety." Ann*

6.7.2 Subtheme two: Medication impacting negatively

Participants were asked if they take medications for pain management and relieve their pain and other fibromyalgia symptoms. This is to explore the impact of pain medications for alleviating pain and physical activity participation. Given that most participants have other underlying conditions apart from fibromyalgia and take other medications, medication questions were restricted to pain medications. Most participants have expressed opposing views on taking pain medication and mostly did not find the medications useful for pain relief.

Clara narrates the severe side effects she experiences from taking pain medications. She expressed feeling slow and slurred after taking pain medications. Furthermore, after weighing the benefits and the side effects she experienced from the medications, she decided to stop taking the medications. This experience could have a significant impact on physical activity participation.

> *"No, no medications anymore. I came off the medications. As soon as I went on them, really because I found that it was really*

> *affecting everything. Like I was slower, I was slurred. They just felt like they were doing more damage than good. And in fact, they felt like they were wearing off. - Clara*

However, Smith felt that medications only help a little depending on the level of pain he is experiencing and potentially does not help all the time. Considering the side effect experienced after taking medications, it is possible to get temporary relief from pain and the potential side effects experienced, such as weakness and fatigue, which potentially affect physical activity participation.

> *"Sometimes it does, sometimes it doesn't depend on the level of pain."- Smith.*

Dizziness and fatigue are some of the symptoms of pain medications reported, negatively impacting physical activity behaviour. This would also potentially have an impact on the ability to work. Sheba describes the challenges of medications side effect below:

> *"I take amitriptyline and I generally have to go and lie down in the dark and have to sleep for it to pass. If I trying to work really it generally just lingers around" - Sheba*

Similar to the experience of side effects of medications shared by participants, Adam also avoids taking pain medications because of the side effects he describes as '*foggy'* and will not take pain medication in the daytime because of the side effects.

> *"I can't take it during the day though. I can only take it at night. Yeah. Because it just tends to make me a little bit foggy"- Adam.*

Adam also expresses having to limit the medications she takes and learn to deal with her symptoms differently rather than have blind faith in doctors who advise on constant pain management medications.

> *"But I don't want to increase the levels because I spent so many years now taking such high doses of tablets because. I. I had blind faith in doctors and GPs. Just take this. This will help keep taking, keep taking it up the dose and if not, it's not a good way to live"- Adam.*

6.8 Theme 4- Social impact

In the quest to explore physical activity behaviour, including pattern and intensity of physical activity, participants were asked to describe their day-to-day activities, including occupation and nature of the job, living status, and caring responsibilities. This is to explore the physical demand involves in jobs and caring responsibilities. The participants' characteristic tables 5.2 indicates that only three are full-time employment among 12 participants involved in the study. Two of the participants are working part-time, and interestingly, most of the participants, six, are either unemployed or on an extended sick leave. Further questions were asked to explore the factors affecting participants' ability to work and problems encountered for those employed. This is to establish the impact of work on physical activity and pain. Under this theme are five subthemes discussed: the impact of physical burden on work, employer support, work discrimination, family support and the physical burden of care.

6.8.1 Subtheme one: The impact of physical burden on work

Employment is an essential social factor with an impact on physical, mental, and psychological abilities. Being employed requires a substantial amount of physical activity ranging from commuting to work to physical tasks involved. Some jobs are more physically demanding, requiring prolonged standing, and moving. In contrast, some jobs are less physically demanding with more time spent sitting, such as office-based work, potentially more mentally demanding. Most of the participants in this study have expressed work-related problems linked with fibromyalgia symptoms. The impact of pain and fatigue on coping with work stress was a huge problem most participants experienced. Participants in employment narrated needing workplace adjustment or support from their employers to cope with work's physical demand. In some circumstances, participants could not stay in jobs due to the physical demand required to fulfil the roles.

Most participants who are not employed expressed challenges with jobs due to fibromyalgia symptoms and have been unable to work entirely due to the physical and mental demands of the jobs. Simultaneously, some require a significant adjustment, such as fewer working hours or the need to take extra breaks to cope with pain and fatigue symptoms. This has a considerable impact on economic status and potentially on psychosocial wellbeing.

Clara expresses the challenges she experienced when she was employed and eventually had to give up a career due to her inability to cope with the job demands because of symptoms and probably had to give up probably because there is no adjustment to the job.

> *" So, the plan was to become a detective. I had a private detective. I had done all the course and everything. However, I could not go forward with that because driving was terrible. I was very dizzy, I felt very nauseous. I felt terrible even for driving like a small distance so I could not fulfil that role"- Clara.*

Similar experience to Clara, Adam was already on the job, and despite having all the available support that he needed, he could not cope with the job demands and had to leave the job.

> *"But obviously, in respect to work and things, I had to kind of give up in that respect because it just wasn't going to happen, really" - Adam.*

Even jobs requiring less physical exertion can cause pain and thus need support, and understanding the employers' condition is crucial. This participant describes difficulty coping with jobs that are not as physically demanding.

> *" I could use a user seat when needed. So, it wasn't -actually that physically demanding, um, in comparison to other jobs. But for me, with um, fibromyalgia, it felt very demanding"- Maggie.*

Unemployment means less income and the likelihood of additional financial burden, which can have a psychological impact and even affect physical activity participation, as described by Maggie. She describes the inability to exercise due to the financial implications of subscribing to a gym membership. This is due to the ongoing challenges with her employers.

> *"But because I no longer have a job, I can no longer afford to do that. So, it's been a bit hit and miss the last and then of course we have the lockdown, didn't we? So- Um, obviously if I do get reinstated and-and get some money coming in then I will- I will recommence the classes"- Maggie.*

6.8.2 Subtheme two: Impact of employer support

Employer understanding of fibromyalgia and workplace adjustments has been recognised by most participants that were employed. Participants described employer support as having adjustments in taking extra breaks during shifts, working fewer hours, and flexibility with taking shifts when feeling unwell. Participants have described this as essential to staying in jobs.

Maintaining the physical demand due to symptoms is quite challenging, especially when having a bad day. This has an implication on working hours and potentially types of jobs to suit physical capacity. Smith describes needing more breaks during a shift to cope with work demands.

> *"Even though like we are only limited to like a 20-minute break every like within a seven-hour shift, I say I am allowed to if I am feeling bad to stop and just take a sit down. So, if a day is ever really bad, then there is someone willing to swap some stuff around to cover my shift"- Smith.*

Sheba feels very lucky to have extra support from employers to take an extra break when needed due to fatigue during work. This potentially goes a long way in helping the participant cope with the job's physical demands and staying at work. Support is needed for people with fibromyalgia to encourage physical activity participation.

> *"I know I'm very lucky. The people I work for, they are very accommodating. if I'm not feeling too good It's a case of stop working if I'm tired, it's gone and rest."- Sheba*

This participant expressed the lack of understanding of the ordinary condition but expressed the importance of co-worker's support and understanding, making some difference regarding work adaptation.

> *"I've got a good set of colleagues. They might not all understand it, but they are understanding of me. And I think they know me to be a hard-working person. So, they know I'm not just, you know, been or if you'd like"- Sara.*

6.8.3 Subtheme three: Perceived work discrimination

The previous subtheme highlights the importance of employer support participants employed to cope with work's physical demand. This has not been the case for some participants who described a lack of support from employers. As a result of the lack of workplace adjustments and understanding of their condition, some participants expressed difficulties with their physical demands. In some cases, declaring fibromyalgia affects the prospect of been employed.

Participants expressed poor knowledge of fibromyalgia among the general population as the significant problems and negative experiences commonly encountered by people with fibromyalgia in employment. Ann highlights the challenges of living with a disability like fibromyalgia and employers' negative experiences.

> *"Uh, at the moment I'm unemployed. Um, I was-- Well, I was-- They-they were trying to-- they were trying to medically retire me on the grounds of ill health but and-- they-they actually dismissed me before that process was complete. So, I'm still waiting to see if that will go through. So, at the moment, we're sort of challenging that on the grounds that, um, firstly because I've-I've got a disability and secondly because they just didn't follow the proper processes. But, you know, we just have to wait and see what happens there. So, I kind of seem a bit like stuck between a rock and a hard place, because I can't look for another job because if they reinstate me"- Ann.*

A similar perception of discrimination against people with fibromyalgia was expressed by Maggie, who also had a similar experience with previous employers after declaring fibromyalgia. Maggie is relatively younger and has gone through a series of what she described as a devastating experiences following rejections. Moreover, the reason for rejection was on chronic pain ground.

> *“Um, when it happened, it was the first-ever job I'd actually landed. I -got all the way through to the final process, and I had a start date, they were going to send me my uniform. And then I got a letter in the post after the health screening that basically said, um, "You're not, well because you have chronic pain, we-we're not gonna hire you. And I just-- Uh, I was, um, si-- No, I fibromyalgia-I was-- How old was I? About 17 and that devastated me. It made me feel- like I was-- I couldn't do anything. Um, it's because employers didn't take me on. I had to-- I have had to take legal action in the past because employers -would get to the health screening--and then I declare chronic pain, and they would, um, they wouldn't hire me.” - Maggie*

The negative experiences with employers of labour experienced by people with fibromyalgia and chronic pain condition described by Adam mean employment potential are wiry. More people with chronic pain conditions like fibromyalgia would have to give up on employment. This could have a massive impact on physical activity participation and potentially increased sedentary behaviour. Adam expressed giving up on the job due to the impact of the physical burden.

> *“...but obviously, in respect to work and things, I had to kind of give up in that respect because it just wasn't going to happen, really”- Adam.*

Liz expressed every challenge of people with an invisible condition like fibromyalgia. Fibromyalgia is not a condition with an objective diagnosis like a fracture. People who do not suffer the condition and are not experts fail to understand and make sense of the severity of pain expressed by people with fibromyalgia.

> *"If you've got a broken leg or a broken arm, that the plaster cast. And you can instantly say something is wrong. But because you're there standing in front of them or going to work or doing whatever you are doing, You're fine. You must be fine. you're standing there"- Liz.*

Besides the physical challenges of work, which has been expressed as a challenge for the employed participants, unemployment has a significant burden on mental health, leading to heightened anxiety and depression. Although being employed comes with a physical and emotional challenge, being out of a job could pose an even more psychological burden on physical activity. Adam expresses the psychological burden of losing a job.

> *"So, I mean, there have been times when I lost my jobon and going back about four years ago a business that I've worked for, they went broke, I lost my job and it really affected me psychologically. And I know what I believe. My belief is as long as I keep working doing something. I can cope"- Adam.*

6.8.4 Subtheme four: Impact of family support

The importance of job support was evident in the previous themes and subthemes. From the narratives and experiences gathered of participants on employment, support was essential for participants to cope with work demands. It is also plausible that employed participants would be more engaged in physical activity despite the pain and fatigue reported. Building upon the narratives of support, further exploration of social support from the larger society such as family and friends and their impact on physical activity, pain, and psychosocial wellbeing also highlight essential issues that could impact physical activity and pain in people fibromyalgia. Table one shows the participants' living status, with the majority of the participants living with a significant other such as partner, husband, and parents. This implies family responsibility for the participants, potentially exploring the physical and psychological translation of family. There was a common perception among participants of poor understanding of fibromyalgia from family and friends. The main symptoms involved in fibromyalgia- pain and fatigue- means that people with fibromyalgia would struggle to make the house chores on expected levels—difficulty doing these activities as shown in the previous theme due to pain and fatigue. Participants express been misunderstood and often perceived to be lazy and exaggerating their symptoms. Clara describes her family's perception of fibromyalgia.

> *"I think because it's such a complex and because I had finished work at the time. I think everyone think I was just being lazy or just being difficult. I think that's what they feel. But in the sense of them and in the sense of me, in all honesty, I think I was very paranoid and very insecure. So even if they gave me a normal look at the cutting, though, and I took it as they hated me, and I was very emotional"- Clara.*

Participant 01 expressed poor understanding from friends leading to distanced from her due to fear of the unknown, which she also attributed to the lack of understanding. This could be due to dealing with fibromyalgia symptoms such as mood, which can be seen as acting differently from friends.

> *"I mean, some people or some friends are basically taking a step away from you because they just did not understand it. And you know what? That's fair enough" Sheba.*

Clara describes a negative perception of fibromyalgia and feels misunderstood by close family.

This could have a negative impact on psychological wellbeing and physical activity.

> *"My in-laws even down my brothers, I think because it's such a complex and because I had finished work at the time. I think everyone thinks I was just being lazy or just being difficult. Really? I think that's what they feel" – Clara.*

Lack of understanding has been a predominant experience among participants. Maggie also thinks family members find it hard to comprehend the symptoms of fibromyalgia.

> *"And a lot of, um, people in my family that don't necessarily understand that can't-can't comprehend that I get so tired after doing so little"- Maggie.*

Suzy also highlights the difficulty encountered and feels people might understand the condition but find it hard to relate. Fibromyalgia is not a visible condition that people can see and understand easily. This feeling she described getting distressed with difficulty caring.

> *"Um, yeah, they try to be. But it's just hard for people to understand because they can't actually see what's wrong with me. They know that I'm in pain--but it's like- well, they can't see it so they can't relate to it.. And I- a lot of the time I- they- I get upset because I can't do stuff and I feel like it's putting stuff on the kids that they've got to do what I would normally"- Suzy.*

Few participants have expressed a contrary experience- having social support from family and friends, and the impact of positive experience regarding family support and understanding of their condition- which is vital psychologically and socially.

> *"But I'm very lucky that my family understanding am the son too I've got around me are extremely understanding with excellent and supportive"- Sheba.*

Having a family member or partner with chronic illness, the experience of support and understanding is quite different. Ann describes support from her friends and especially her daughter, who also has a chronic condition.

> *"Um, but I've got a group of very close friends who-who are very supportive. And my daughter is actually very supportive because she has clients that she has a long-term chronic condition as well"- Ann.*

Monica also expressed the positive impact of partner support and related understanding and sympathy because the partner also has a chronic condition and is better positioned to understand what it is like to live with fibromyalgia.

> *"Well, I think both that husband spent myself struggle with our own conditions at the moment, which we support each other. You know, we're sympathetic with each other and trying to support each other"- Monica.*

Jannie also describes the importance of having someone to offer support when needed and that it has been physically and psychologically helpful to have someone around.

> *"Well, I have seven children but like, they're all old now. The oldest is 32. Well, I've got three boys at home, but the girls are at my house every day. So, there's always somebody there to do something"- Jannie.*

6.8.5 Subtheme five: The physical burden of care

Keeping up with care responsibility is challenging due to fibromyalgia symptoms, especially pain, fatigue, and mood. Suzy, Liz, and Smith have varied care responsibilities expressed difficulty with care responsibilities, which means they often need assistance from the family members due to fibromyalgia symptoms. This has been frustrating for

Suzy expressed feeling guilty for not being able to care for her children as she should.

> *"And I just feel guilty all the time because they're my kids. I should be able to do stuff for them. But I'm just constantly-- All I wanna do is sleep. I try and do anything; I just feel like I'm falling asleep"- Suzy.*

> *"My husband tends to do most stuff because he gets sick of hearing me, like-puffing and puffing in pain and crying when I-- I try and do, like, just put in loads of washing machine -in the washing machine and stuff. But I get so, like, tired from just going up and down the stairs and then bending-over to get to the washing machine. It just hurts and then obviously with the jumping and stuff like that, I can't really be cooking and that"-Liz.*

An increased burden of family responsibilities has aggravated symptoms like pain, fatigue, and psychological wellbeing. This participant expressed an added burden of taking care of his dad, who also has fibromyalgia and dealing with work stress and fibromyalgia symptoms such as pain and fatigue.

> *"It's like he doesn't even assist like say like coming to do a little a bit of clean. You'll get up to just leave a complete mess that it's silly to have to do. It's just creating more housework than*

> *necessary. and You know, I've come I don't have to come back from work and do a massive load of cleaning" -Smith.*

6.9 Discussion

This study provides an in-depth perspective of physical activity behaviour in people with fibromyalgia and the impact of psychosocial, contextual, and environmental factors on physical activity and pain perception. The findings of this study identified five key themes: lack of guidance on tailoring physical activity interventions to suit individual needs for people with fibromyalgia to derive sustainable benefits, the impact of fatigue (physical and mental) on physical activity behaviour and pain perception, the influence of social structure - family, employers and society, on physical activity, psychological symptoms and pain and the impact of multicomponent treatment on coping strategy, acceptance and physical activity.

Evidence suggests the need to emphasise physical activity education and structured physical activity to suit individual needs. Preference for mild physical activity was expressed due to fear of increasing pain, consistent with the prevalence of fear of activity in people with fibromyalgia (Nijs et al., 2013; Turk, Robinson, & Burwinkle, 2004). Although overwhelming evidence suggests moderate to vigorous physical activity achieved through structured exercises or unstructured physical activity is associated with lower pain intensity in people with fibromyalgia (Bidonde, Busch, Bath, & Milosavljevic, 2014; Bidonde et al., 2017), the intensity of exercise has been a subject of debate. Whether moderate physical activity used in experimental studies is appropriate for people with fibromyalgia still needs to be clarified as what one person with fibromyalgia classes as a moderate physical activity may feel like a vigorous activity to another, has become clear from the interviews conducted in this study. A recent cross over study investigated whether the preferred mode and intensity of exercise was related to pain intensity. The study concludes preferred intensity over traditionally structured intensity for pain (da Cunha Ribeiro et al., 2018).

Emphasis should be given on frequency and mode of physical activity in people with fibromyalgia. Exercise and physical activity interventions have explored the effect of various forms of physical activity such as aerobic and strengthening exercise or non-structured physical activity such as walking (Busch et al., 2007; Busch et al., 2017). Contrary to experimental studies that specify the frequency of physical activity, there was an inconsistency of frequency and intensity among participants who engage in structured exercise as participants tend to do exercises once a week. Both exercise and physical activity have recommended frequency, i.e., 30 minutes/ three days of vigorous physical intensity or five days of moderate or combination of the two.

Despite the pain after physical activity, there was a positive perception of physical activity on general health. Previous qualitative studies have indicated high fear avoidance as a barrier to physical activity participation in people with fibromyalgia (Nijs et al., 2013; Turk et al., 2004) and expressed finding the word exercise "as scary (Russell et al., 2018). However, despite the repercussions of experiencing increasing pain after physical activity, participants believe that sedentary behaviour would long-term impact their physical health. Likewise, the pleasure derived from improved mood, escapism, and sense of achievement during physical activities were a vital facilitator of physical activity and a possible mediator of lower pain appraisal. This is consistent with studies showing the effect of exercise on mood (Gowans et al., 2001).

The immediate impact of physical activity was improving mood, not pain. Experimental studies have shown an immediate significant improvement in mood following exercise in fibromyalgia (Andrade et al., 2020; Gowans et al., 2001). This is consistent with the findings of this study, where participants reported feeling a sense of accomplishment, escapism, and distraction during physical activity despite the potential of increased pain experience after the exercise or mild physical activity. The appraisal of pain using the visual analogue scale or other numerical scales obtained in the quantitative research would differ from a subjective description of pain in qualitative studies (Trovato, Pace, Salerno, Trovato, & Catalano, 2010). This would imply that despite reporting increasing pain for participants who reported vigorous physical activity intensities such as cycling and swimming, pain intensity might be even less when measured on an intensity scale.

Finding a suitable physical activity intensity for people with fibromyalgia remains a challenge. Participants in this study have a varied choice of physical activity intensities. However, most of the participants are more comfortable with mild physical activities such as walking. Several studies, using different methodologies, have attempted to examine the appropriate intensity of physical activity for people with fibromyalgia (Atan & Karavelioğlu, 2020; Bobinski et al., 2015). While experimental studies typically adopt moderate-intensity exercises as a benchmark for physical activity recommendation for adults (Ding et al., 2020; Riebe et al., 2015), the argument against adopting moderate-intensity exercise was the fact that people with fibromyalgia have additional symptoms burden and are more likely to drop out from exercise due to increased pain and stress (Dobkin, Abrahamowicz, Fitzcharles, Dritsa, & da Costa, 2005; Zhang et al., 2018). This has prompted studies to examine mild and unstructured physical activity intensities, such as interventions targeting walking. Findings of a systematic review involving a thousand participants with fibromyalgia examined adherence to walking intervention and concluded a high attendance- 87% to walking interventions (Sanz-Banos et al., 2017).

Quantifying the intensity of physical activity subjectively can be unreliable, especially without a structured outcome measure. However, determining the frequency of physical activity is feasible through participants accounts of how often they engage in exercise or how many minutes of walking they achieve approximately in a certain period. In this study, the frequency of physical activity expressed by the participants was inconsistent and less than the recommended frequency - three times a week- to derive sustainable benefits, especially among participants who engage in various exercises. Several factors have been highlighted, including the intensity of physical activity and lack of splitting physical activity, which has caused severe fatigue.

In this study, physical activity intensity and frequency have caused more fatigue for participants who engage in moderate to vigorous physical activity forms. Fatigue is a core symptom of fibromyalgia and is often expressed by participants as more debilitating and a significant barrier to physical activity participation. Fatigue following physical activity is a normal physiological response; however, in people with fibromyalgia recovering from fatigue after physical activity tends to take longer than usual, which is associated with an enhanced rate of perceived exertion when compared with the average population (Bachasson et al., 2013; Srikuea et al., 2013). Participants in this study tend to get carried away by the momentary pleasure of physical activities such as swimming, cycling or Zumba classes. This has led to experiencing more fatigue and potentially spending more days recovering from the previous day's exertion. Besides physical fatigue due to moderate to vigorous exertions, fatigue was also reported following mild physical exertions such as doing house chores and walking or at random.

Mental fatigue was reported to be even more detrimental and impacting physical activity. In this study, participants express having less energy and thus disengage from physical activities due to lack of energy. This is a common experience in people with fibromyalgia and is often linked with sedentary behaviour, pain, and psychological symptoms (Dailey, Keffala, & Sluka, 2015). Studies have shown that mental fatigue is related to low physical activity- people who engage less in physical activity tend to report more fatigue than those who are active (Pulido-Martos et al., 2020). Similarly, studies have shown that people with fibromyalgia that reports more fatigue tends to have more mood disturbances, depression, and anxiety (Lukkahatai, Walitt, Espina, Gelio, & Saligan, 2016; Plazier, Ost, Stassijns, De Ridder, & Vanneste, 2015; Segura-Jiménez et al., 2017). Despite the considerable impact of fatigue on pain and physical activity behaviour, there is less attention on fatigue management like pain, considering how fatigue affects pain and physical activity behaviour, especially on grading activities to avoid overwhelming fatigue.

The side effect of medications was expressed as a potential barrier to physical activity. Participants expressed feeling 'dizzy' and 'foggy' after taking pain medications. Most people with fibromyalgia have other primary conditions and are on various medications (Kleykamp et al., 2020; Lichtenstein, Tiosano, & Amital, 2018; Yunus, 2012). The main symptom of fibromyalgia is chronic pain, and thus most people with fibromyalgia is placed on significant pain medications depending on the severity of pain and other associated conditions (Calandre & Rico-Villademoros, 2012; Chinn, Caldwell, & Gritsenko, 2016; Welsch, Üçeyler, Klose, Walitt, & Häuser, 2018). Participants expressed having only mild pain relief from medications aside from side effects associated with common medications used for managing pain (Bhusal, Diomampo, & Magrey, 2016). This has led some of the participants to altogether boycott medications. Given the adverse effects of prolonged use of medications, the guideline for fibromyalgia management recommends multicomponent therapy (MacFarlane et al., 2018).

Psychological treatment positively impacts pain and physical activity behaviour through positive illness perception and coping strategies. This is consistent with evidence indicating evidence of psychological clusters in people with fibromyalgia (Giesecke et al., 2003; Pulido-Martos et al., 2020; Sullivan, Smith, & Buchwald, 2002; Zhang et al., 2018). Psychological interventions such as CBT and mindfulness have shown promising results in fibromyalgia people (Bennett & Nelson, 2006; McCrae et al., 2020; Williams, 2003). Surprisingly, psychological interventions are not first-line treatment options despite the high prevalence of psychological symptoms such as anxiety, mood, and depression among fibromyalgia people (Ghiggia et al., 2017). In this study, participants who have undergone psychological treatment such as Cognitive Behavioural Therapy (CBT) and mindfulness appears to have positive illness perception, better coping strategy and higher physical activity behaviour.

The societal influence appears to have a significant impact on psychological wellbeing and physical activity behaviour. Several social challenges were expressed, such as lack of employment opportunity and support, family and caring responsibilities that could indirectly impact physical activity and pain. This is consistent with previous studies indicating higher work-related burden, early retirement among people with fibromyalgia compared with OA (Kleinman et al., 2009; Markkula et al., 2011; Robinson et al., 2012), and significant perceived work exertion compared to matched healthy group (Palstam et al., 2014). Considering fibromyalgia symptoms, it would be reasonable to expect a higher job burden and require additional support to cope with employment's physical and mental demands. A recent survey compared physical activity categories among women with productive-paid jobs and reproductive- caregiving and domestic role. The survey shows that paid working women with fibromyalgia had a more significant level of physical activity when compared to house working women (Girela-Rejón et al., 2020). Consequently, as expressed by the participants, lack of employment support will lead to socioeconomic challenges, lower physical activity, and potentially more pain and fatigue.

6.10 Conclusions

A multimodal approach, incorporating patient education with behavioural components, is essential to increase adherence to exercise and physical activity interventions to support self-management strategies in fibromyalgia. There is a need for a tailored physical activity recommendation for people with fibromyalgia for individualised needs, emphasising non-structured physical activity such as walking and accumulating short bouts of physical activity rather than traditional structured exercises. Physical activity intervention for fibromyalgia should incorporate multidimensional perspectives such as psychological interventions, personal and contextual factors such as living status, employment status, and social support need to consider potential. Fatigue management and attenuation of physical activity to avoid increased pain perception leading to increased sedentary behaviour should be incorporated in physical activity recommendations for people with fibromyalgia. There is a need for health care professionals to have targeted discussions with people with fibromyalgia on how to adopt an active lifestyle considering personal factors and the impact of medications on physical activity.

7 Combined Discussion and Conclusions

7.1 Introduction

This chapter will discuss the combined findings of the qualitative and quantitative studies, the limitations, novel contributions, and future research and conclusion implications. As a recap, this thesis aims to investigate the association between physical activity behaviour and pain in people with fibromyalgia. A convergent mixed-method approach was adopted to gain an in-depth understanding through combining distinct but complementary data (de Haan et al., 2021; Hadi & Closs, 2016) to enable understanding of the associations between physical activity, physical function and pain and the impact of biopsychosocial factors on these (through a quantitative paradigm) and to explore the perception of physical activity and the impact of psychosocial, contextual and environmental factors on physical activity and pain perception (through a qualitative paradigm).

The quantitative study identified physical activity patterns, the association between physical activity categories with pain and psychological symptoms, and the impact of biopsychosocial factors on the relationship between pain and physical activity. On the other hand, a qualitative enquiry was employed to enhance the understanding and experience of physical activity behaviour and pain, the impact of social, psychological, and environmental factors on pain and physical activity.

As presented in the methodology chapter (chapter 4), a convergent mixed-method approach was utilised by combining qualitative and quantitative studies for interpretation. In this section, key findings from both survey and interviews were combined to enable in-depth understanding.

7.2 Association between physical activity, physical function, and pain

The quantitative study findings indicate that lower physical activity and physical function were associated with increased pain intensity and interference. The survey findings are consistent with previous cross-sectional studies reporting a link between low physical activity and higher pain intensity (Kaleth, Slaven, & Ang, 2014; Segura-Jiménez et al., 2017). The mechanism of pain modulation following physical activity is established in neurobiological studies, demonstrating increased endogenous substances and conditioned pain modulation following exercise (Eller-Smith et al., 2018). Several physical activity interventions such as resistance training (Gómez-Hernández et al., 2020), aerobic exercises (Bidonde et al., 2017), stretching (Gómez-Hernández et al., 2020), and unstructured physical activities such as walking (Mannerkorpi et al., 2010; Pastor-Mira et al., 2020) and leisure physical activity (Assunção Júnior et al., 2018) have shown varied efficacy for pain intensity in people with fibromyalgia. Although exercise and physical activity interventions were more favourable than the control groups, the difference is below clinical relevance (Busch et al., 2007b; Busch et al., 2013). For example, a meta-analysis conducted by Bush et al. (2007) to evaluate the efficacy of strength training and aerobic exercises, including 34 studies, on fibromyalgia symptoms such as pain, physical function, tender points, and depression, found that pain reduction between exercise and control groups was only 13%. Similarly, another Cochrane systematic review involving 13 trials indicates that aerobic exercise only slightly decreased pain intensity with an estimated effect size of 11%. Interestingly, none of the systematic review trials reported improvement more significant than 30% to suggest clinical relevance (Bidonde et al., 2017). Despite the small sample size in most experimental trials, small effect size, and inconsistent reporting of exercise dose and withdrawals from exercise, guidelines still recommend exercises as the first line of management (Macfarlane et al., 2017).

Similar trends were observed in the observational studies, with most studies indicating a weak to moderate correlation between physical activity and pain intensity in people with fibromyalgia. The findings of the quantitative study showed a weak association between physical activity and pain intensity. These findings are consistent with several studies showing an inconsistent and weak relationship between pain and physical activity categories, i.e., low physical activity, moderate physical activity, and vigorous physical activity (Fontaine et al., 2010; Fontaine et al., 2011; Merriwether et al., 2018). This inconsistency of association between physical activity and pain intensity was observed in the systematic review to investigate non-structured physical activity and pain intensity.

7.3 The pattern of physical activity

Findings from both quantitative and qualitative studies indicate that people with fibromyalgia lead to more sedentary behaviour. The baseline characteristics indicate that almost half of the survey participants did not meet the physical activity recommendation based on the UK physical activity guidelines for adults. The physical activity guidelines unanimously recommend 75−150 minutes of vigorous-intensity physical activity or 150−300 minutes of moderate-intensity physical activity in a week (Ding et al., 2020). The UK physical activity guidelines indicate that over 65% of men and 61% of females met the physical activity recommendations (UK chief medical officer report 2019). Likewise, an in-depth description of day-to-day physical activity, explored in the interviews, indicates higher sedentary behaviour in most participants on most days. Looking at the physical activity data on the physical activity pattern in UK adults, it is reasonable to suggest that low physical activity potentially has more sedentary behaviour than the healthy population.

The qualitative study provides an in-depth description of physical activity behaviour, attitudes towards physical activity, and physical activity barriers. Although quantifying the intensity of physical activity subjectively can be unreliable, especially without a structured outcome measure, the frequency and preferred mode of physical activity were highlighted through participants account of day-to-day activities. The survey indicates lower physical activity patterns among the participants. The interviews also highlight a lower frequency of physical activity, less than the recommended frequency, three times a week, especially among participants who engage in structured exercises. Several factors have been emphasised, including the impact of physical activity intensity and lack of splitting physical activity, which has caused severe fatigue.

The qualitative study's findings further identified several factors that potentially lead to sedentary behaviour in people with fibromyalgia. Fear of increasing pain and fatigue was dominant, among other reasons highlighted for lower physical activity participation. The prevalence of pain in people with fibromyalgia is consistent with previous studies reporting fear of pain as a barrier to physical activity, leading people with fibromyalgia to refraining from exercises (de Gier et al., 2003; Larsson et al., 2017a; Nijs et al., 2013). Although there was a positive perception of physical activity on maintaining good physical function and general wellbeing, which has encouraged physical activity behaviour, the negative experience of pain and fear of physical activity causing more pain was a huge barrier to physical activity behaviour. These findings are consistent with a survey conducted to identify the perception of physical activity in fibromyalgia treatment where over 90% of the participants agree that exercises are only beneficial for general health and physical function, and only 13% agrees that exercise reduces pain intensity (McVeigh et al., 2003). These findings are corroborated by studies reporting increasing pain after exercise in people with fibromyalgia (Hoeger Bement et al., 2011), leading to a negative perception of exercise and physical activity (Russell et al., 2018).

The emphasis on long-term physical activity benefits should be prioritised and discussed, given the immediate experience of increasing pain. Although exercises and physical activity are recommended for pain, these benefits are not immediate, as shown in experimental studies (Bidonde, Busch, Bath, & Milosavljevic, 2014; Bidonde et al., 2017; Busch et al., 2013), and managing expectations would be essential for adherence. The mechanism of physical activity on pain perception is postulated by stimulating endogenous substances and descending pathways in the brain responsible for pain modulation (de la Coba et al., 2017; Eller-Smith et al., 2018; lvin et al., 2016). These mechanisms are shown to be achieved through four to 12 weeks of structured moderate intensity exercises or 15 weeks of Nordic walking (Geneen et al., 2017a; Giannotti et al., 2014; Salvat et al., 2017). The most significant improvement of exercise in fibromyalgia patients is recorded after 12 weeks of moderate-intensity exercises (Busch et al., 2013). Given the increased pain reported on commencing exercise, managing expectations and carefully considering habituation is essential for adherence and sustainable benefits. Although improvement in pain is not immediately following exercise or physical activity, the qualitative study indicates the immediate impact of physical activity and exercise on mood, which is consistent with studies indicating the impact of exercise and physical activity on mood (Andrade et al., 2020; Beltrán-Carrillo, Tortosa-Martínez, Jennings, & Sánchez, 2013; Gowans et al., 2001).

The choice of physical activity was a catalyst for achieving physical activity. The qualitative findings reveal that participants had a varied choice of physical activity. The unpopular preference was a structured physical activity such as strengthening exercises done in the gym or aerobic exercise such as swimming. Most participants prefer milder non-structured physical activities such as walking and gentle stretching. Physical activity could be due to personal preference and physical ability without reference to professional or healthcare practitioners' advice. Although physical activity preference is vital for sustainability and shown to encourage adherence to physical activity in people with fibromyalgia (da Cunha Ribeiro et al., 2018; Newcomb et al., 2011), the suitability might be problematic. This is because of the high prevalence of other conditions that would impact the physical function to accomplish certain types of exercise (Gota et al., 2015; Lichtenstein et al., 2018). Studies investigating adherence to physical activity and exercise suggest a high adherence rate in self-regulated, unstructured, mild physical activity such as walking, which has also shown comparable efficacy to other forms of exercises (da Cunha Ribeiro et al., 2018; Mannerkorpi et al., 2010; Sanz-Banos et al., 2017).

7.3.1 Physical activity education

Lack of guidance appears to be a significant barrier to physical activity participation. The qualitative study further explores physical activity behaviours and barriers that unravelled poor knowledge of administering physical activity. This was predominantly for participants who reported engaging in structured exercise. Lack of guidance has resulted in severe pain following physical activity, often leading to more days to recover from exercise exertion. The appropriate dose of exercise and physical activity is still a subject of debate given the variability of findings supporting vigorous, moderate, and light intensity exercise for pain (Mannerkorpi et al., 2010; Ribeiro et al., 2018). Given the heterogeneity of people with fibromyalgia (Fitzcharles et al., 2018; Hauser, Perrot, Clauw, & Fitzcharles, 2018), in terms of underlying conditions and physical function, exercise and physical are recommended to be patient-based with more emphasis on the gradual progression of exercise and physical activity (Fitzcharles, 2013b). Lack of pacing appears to be a barrier for exercise resulting from inadequate understanding of fibromyalgia by the instructors administering the exercises.

The impact of fatigue on pain and physical activity was corroborated in both quantitative and qualitative studies. The quantitative study shows that fatigue was a significant predictor of pain and physical activity. Similarly, the qualitative study indicates that fatigue was even more detrimental and impacting physical activity than pain. Fatigue is a common experience in fibromyalgia and is often linked with sedentary behaviour, pain, and psychological symptoms (Dailey et al., 2015; Perez de Heredia-Torres, Huertas-Hoyas, Maximo-Bocanegra, Palacios-Cena, & Fernandez-De-Las-Penas, 2016). Research has shown that fatigue is related to low physical activity and people with fibromyalgia who are less active tend to report more fatigue than those who are active (Pulido-Martos et al., 2020). Similarly, studies have shown that people with fibromyalgia who reports more fatigue have more mood disturbances, depression, and anxiety (Lukkahatai et al., 2016; Merriwether et al., 2018; Nijs et al., 2013; Segura-Jimenez, Borges-Cosic, et al., 2017; Segura-Jimenez, Castro-Pinero, et al., 2016; Segura-Jiménez et al., 2017). However, despite the considerable impact of fatigue on pain and physical activity behaviour, there is less attention on fatigue management like pain, considering how fatigue affects pain and physical activity behaviour.

7.3.2 Impact of unemployment on physical activity

The impact of employment on pain and physical activity was not established in this thesis. A similar finding was reported by Pérez-de-Heredia-Torres (2016), who found no difference in physical function between employed and unemployed people with fibromyalgia. Although there was a difference in outcome measures for assessing physical function as this survey used a FIQR physical function domain, Perez (2016) used a functional independent measure incorporating cognitive domain (Perez-de-Heredia-Torres et al., 2016). However, more studies have shown a higher disease burden in people with fibromyalgia than other chronic pain conditions such as OA and R.A (Kleinman et al., 2009), leading to increased sick leave and early retirement (Kivimaki et al., 2007). Although types of jobs were not explored in the quantitative survey to ascertain the nature of the physical demands of the jobs, the qualitative study highlights the difficulty with physically demanding jobs for participants employed. Given the interrelation between symptoms, i.e., waking up unrefreshed affecting energy levels and lack of energy affecting mood, these symptoms can affect job performance.

Physical function was a strong predictor of pain intensity. Physical function measures the ability to carry out essential daily functions such as cooking, groceries and hoovering and is recommended as a critical outcome in fibromyalgia studies. Consistent with previous studies indicating a higher burden of physical function in people with fibromyalgia (Santoro et al., 2014; Torma et al., 2013; VanRavenstein, 2014), the quantitative study shows a higher burden of physical function, which is associated with symptoms such as pain, fatigue, and psychological symptoms. A higher physical function burden was a stronger predictor of pain than physical activity, consistent with previous studies showing a stronger relationship between physical function and pain than physical activity. Although physical activity and physical function are related (Merriwether et al., 2018), there is a stark difference in the construct as physical function measures the severity of burden and physical activity measures the intensity and frequency of movement (Rubin et al., 2019; Sylvia et al., 2014). Previous studies show a similar pattern of relationships in physical function and physical activity with other fibromyalgia symptoms.

7.4 Perception of physical activity and the impact of psychosocial, contextual, and environmental factors on physical activity and pain perception.

Findings from quantitative and qualitative studies corroborate the influence of psychosocial factors on pain and physical activity behaviour. The quantitative study shows that depression and anxiety are linked with lower physical activity. Similarly, higher pain intensity and interference were also linked with higher depression and anxiety. These findings are consistent with previous studies showing a higher prevalence of mental health conditions among people with fibromyalgia resulting in depression and anxiety (Fitzcharles et al., 2018; Løge-Hagen et al., 2019). Neurobiological studies have established a connection between psychological symptoms and pain by sharing common neurotransmitters such as serotonin (Goesling et al., 2013; Gupta & Silman, 2004; Kleykamp et al., 2020). This explains why antidepressant is used as first-line pain medications in fibromyalgia (Mease, 2005; Uçeyler et al., 2008) and the rationale for cognitive behavioural therapy (Larkin et al., 2015).

7.5 Targeting depression and anxiety as a potential mediator for physical activity and increased pain intensity

The association between depression and anxiety with physical activity and pain intensity suggests that depression impacts the relationship between pain and physical activity (Peñacoba Puente et al., 2015). The quantitative study shows that depression and anxiety are significant predictors of pain and physical activity. This is in line with studies showing that depressed women with fibromyalgia are more likely to report higher symptoms and lower physical activity and physical fitness than non-depressed women with fibromyalgia (Del Pozo-Cruz et al., 2017). Aside from depression and anxiety directly linked with pain (Kroenke et al., 2011), a significant number of people with fibromyalgia in both quantitative and qualitative studies have underlying mental health conditions such as anxiety disorders and depression. The survey's baseline data shows that over 30% of participants indicate having a diagnosis of underlying mental health; most reported are depression and anxiety.

With studies reporting childhood adversities linked with the development of fibromyalgia (Alciati et al., 2020; Low & Schweinhardt, 2012; Varinen et al., 2017), there is a growing suggestion for tailored interventions targeting subgroups of people with fibromyalgia, especially with higher severity of depression and anxiety symptoms. Given the high prevalence of depression evident from population studies (Løge-Hagen et al., 2019), people with fibromyalgia have three times higher odd ratio of depression than people without fibromyalgia (Fuller-Thomson et al., 2012). Studies have established a strong link between depression and low physical activity in fibromyalgia (Andrade et al., 2017). However, managing depression and anxiety in people with fibromyalgia to improve physical activity is not adequately elucidated.

The need to unravel fibromyalgia symptoms for individualised treatment based on a subgroup is gaining momentum, and part of the proposed subgroups underlined are psychological clusters (Hauser et al., 2018; Vincent et al., 2014). The severity of psychological symptoms is proposed to be a prognostic criterion for interventions (Alberto Soriano-Maldonado et al., 2015). A meta-analysis comparing exercise and non-exercise control groups indicates the long-term effect of exercise on improving anxiety symptoms (McDowell et al., 2017b). However, improvement was only noted after 26 weeks of exercise, which indicates a long-term effect. Motivating people with anxiety to complete 26 weeks of exercise interventions would seem a huge challenge considering the burden of adhering to exercise and physical activity in fibromyalgia (Ang et al., 2011; Dalle Grave et al., 2011). This was corroborated in the qualitative study findings indicating the role of psychological intervention in adopting helpful coping strategies and phasing physical activity.

7.6 Social and environmental influence on psychological symptoms

The qualitative study identified several social factors that potentially trigger psychological symptoms, including family and living status, socioeconomic status, and interpersonal factors. Although the impact of living status and employment was not a significant predictor of the relationship between pain and physical activity in the quantitative study, the qualitative study revealed the challenges of living with fibromyalgia, especially with employers and family (Fuller-Thomson et al., 2012). Both studies indicate that a significant number of people with fibromyalgia are not employed. The percentage of unemployment is significantly high compared to the national average within the age category. Several reasons for not being employed include challenges with physical demands of work, lack of workplace adjustment, and stigma related to declaring fibromyalgia from the pre-employment checks. Consistent with previous phenomenological studies that explored the challenges of living with fibromyalgia, they identified common themes which involve lack of understanding from the society resulting in significant mental health deterioration (Juuso, Skär, Olsson, & Söderberg, 2011; Reich, Olmsted, & van Puymbroeck, 2006; Taylor et al., 2016).

Living status appears to have a positive and negative impact on mood and psychological wellbeing. Although the quantitative study did not find living status a significant predictor of pain and physical activity, the qualitative provided further context. The qualitative study indicates that living with a partner or having dependents has positively impacted physical and mental health. Participants who have supportive partners reported having less stress. However, other participants who expressed being misunderstood by their partners and close family tend to be more stressed and unhelpful coping behaviours. Lack of support is consistent with previous phenomenological studies in people with fibromyalgia, which identifies lack of support and invalidation, especially from partners who have a critical role in shaping illness perception and experience (Cooper & Gilbert, 2017; Huang et al., 2018; Reich et al., 2006; Taylor et al., 2016). The expression of colossal burden for those with caring responsibilities, especially if they must work part-time or full time, often results in stress due to the extra physical and mental demands of jobs and taking care of the family.

7.7 Impact of underlying health conditions on physical activity and pain intensity

Both quantitative and qualitative studies indicate that most participants, more than 80%, reported having other chronic conditions. The conditions were best categorised into three groups: musculoskeletal and pain, mental health, and other conditions. These categories are based on cluster analysis to categorise people with fibromyalgia based on comorbidities, symptom severity over a period to study the trajectory of symptoms (Fitzcharles et al., 2018; Grayston et al., 2019; Kleykamp et al., 2020; Løge-Hagen et al., 2019; Mease, 2017). Similarly, systematic reviews and population studies have shown a high prevalence of these conditions among people with fibromyalgia (Hoskin et al., 2018; Vincent et al., 2014; B. Walitt, Nahin, Katz, Bergman, & Wolfe, 2015; Yunus, 2012). Although these conditions are prevalent in people with fibromyalgia, there was no inference of the impact of pain and physical activity behaviour. Most physical activity research treats primary conditions or other health conditions as a binary variable without inference on the impact on physical activity or pain. While RCTs control the impact of comorbidities through randomisation, the observational studies do not provide much insight into the role of other conditions on pain and physical activity. Furthermore, there was no indication to suggest the impact of other conditions in the qualitative interviews on physical activity behaviour. However, treatment variation seemed to have much impact on illness perception and coping strategy.

7.8 Impact of psychological treatment

Psychological treatment positively impacts pain and physical activity behaviour through positive illness perception and adaptation of helpful coping strategies to manage pain and fatigue symptoms. Due to the variability of conditions associated with fibromyalgia and multiple medications, the quantitative study adjusted for the impact of medications; however, the qualitative study explored the impact of treatments on physical activity behaviour and pain. The participants who had CBT reported learning to split tasks to manage fibromyalgia symptoms, primarily pain and fatigue. Also, the participant who had CBT sessions reported learning to live with their condition and accepting their condition, which helps them manage their expectations, which have helped better illness perception and self-management. Studies are divided on the effect of CBT, with some studies indicating a lack of superiority for fibromyalgia symptoms such as sleep and pain (McCrae, Curtis, Miller, et al., 2020) and influence on exercise (Bennett & Nelson, 2006). Surprisingly, psychological interventions are not first-line treatment options despite the high prevalence of psychological symptoms such as anxiety, mood, and depression among fibromyalgia people (Ghiggia et al., 2017). In the qualitative study, participants with psychological treatment such as CBT appear to have positive illness perception, better coping strategy, and better attitude to physical activity behaviour.

Medications side effects appear to have an impact on physical activity behaviour. The impact of medications on pain and physical activity was not significant in the survey. However, the interviews highlight the side effect of medication causing fatigue and dizziness. Most participants with fibromyalgia have other primary conditions, as seen in qualitative and quantitative studies. Most participants are on various medications with side effects such as dizziness and fatigue (Kleykamp et al., 2020; Lichtenstein et al., 2018; Yunus, 2012). The main symptom of fibromyalgia is chronic pain, and thus most people with fibromyalgia are placed on pain medications depending on the severity of pain and other associated conditions (Calandre et al., 2015; Calandre & Rico-Villademoros, 2012; Chinn et al., 2016; Welsch et al., 2018). Participants expressed having only mild pain relief from medications aside from side effects associated with common medications used for managing pain (Bhusal, Diomampo, & Magrey, 2016). This has led some of the participants to boycott medications. Given the adverse effects of prolonged use of medications such as weight gain (Arnold et al., 2017), the guideline for managing fibromyalgia recommends multicomponent therapy (Ablin et al., 2013; Häuser et al., 2017).

7.9 Limitation and Strength

Strength

There is a dearth of data on a mixed-method approach investigating physical activity behaviour and exploring the impact of biopsychosocial factors associated with pain and physical activity in the fibromyalgia population. This mixed method approach has offered further insight into physical activity patterns measured using questionnaires and behaviour towards physical activity explored via participants' perspectives. Combining two studies (survey and interviews), this pragmatic approach has enabled the identification of social challenges encountered by people with fibromyalgia, contributing to psychological symptoms, higher pain perception, catastrophising, coping, and lower physical activity. Similarly, utilising a pragmatic approach has enabled the identification of potential factors leading to lower physical activity such as lack of guidance on adopting appropriate physical activity for people with fibromyalgia taking into cognisance physical function, lack of fatigue management and coping strategies as potential deterrence of physical activity.

Limitations

Although mixed method approach provides the opportunity of combining the findings of two methods with a different set of philosophical assumptions, there is scepticism of mixing varied sets of ontology and epistemology, and thus interpretation with caution is recommended (Castro, Kellison, Boyd, & Kopak, 2010; Creswell, Klassen, Plano Clark, & Smith, 2011). The impact of the multiple symptoms involved in fibromyalgia and the relationship between the symptoms, for example, systematic reviews showing that sleep problems are associated with psychological symptoms (Littlewood et al., 2017), psychological symptoms associated with pain (Martinez et al., 2015), pain related to low physical activity (Víctor Segura-Jiménez et al., 2019), cannot be ascertained in this thesis (Caruana et al., 2015; Kroenke et al., 2011). However, a recent longitudinal study followed up people with fibromyalgia for two years and established a cluster based on symptoms severity but did not find a significant variation in the trajectory of symptoms from the baseline across the clusters (Hoskin et al., 2018). This indicates adequate symptom stability and validation of association in survey studies.

The second limitation of this study is the accuracy of information. Self-reported information was obtained as the study was conducted online. For example, a self-reported diagnosis of fibromyalgia was required for participation. Since the researcher does not have access to the participants' medical records, it is impossible to determine their accuracy. The researcher has no control over the accuracy of participants' socio-demographic characteristics such as age and BMI.

7.10 Contribution

This thesis contributes to understanding physical activity patterns, behaviour, and barriers in people with fibromyalgia in the UK. The data on physical activity patterns among people with fibromyalgia in the UK is scarce, leading to a lack of context and insight into administering physical activity interventions in this population. Previous studies investigating physical activity in people with fibromyalgia suggest that people with fibromyalgia are less active than their cohorts. These studies were not conducted in the UK as most of the studies were conducted in the US and Spain different physical activity patterns to the UK population as shown in the systematic review (chapter 3). This thesis identifies the need for physical activity guidelines for people with fibromyalgia, given the impact of psychological symptoms such as depression, anxiety, and mood, which were highly prevalent and shown to impact physical activity and pain.

7.10.1 Implication for future research

Longitudinal studies are needed to investigate the trajectory of association between physical activity, physical function, and pain. While it is plausible to speculate that lower physical activity is associated with increased pain in people with fibromyalgia in this study, it is also plausible that increased pain leads to lower physical activity. Cross-sectional studies cannot be sure of these associations as data is collected once and cannot make causal inferences (Boyko, 2013; Faraoni & Schaefer, 2016; Song & Chung, 2010). Although this study provides preliminary data on the association between physical activity and pain and the impact of biopsychosocial factors on the association, this can be further investigated using a multiple observation design. Longitudinal designs may unravel the pattern of association between physical activity, physical function and symptoms' complexity and establish a cause-effect relationship that will improve identifying specific targets for physical activity interventions.

There is a need for more qualitative inquiries to explore the impact of social factors such as family support, environmental and socioeconomic challenges associated with unemployment which were a dominant theme in the qualitative study of this thesis. Although these were dominant factors that appear to impact physical activity behaviour significantly, unemployed people have lower income affecting participation in exercises of choice, such as attending swimming classes, to improve their physical activity behaviour. Given that the aim of this study was not limited to social factors and their impact on pain and physical activity, a deeper exploration of social challenges may help designing physical activity behaviour. This will also help identify critical social variables for theoretical studies.

The impact of psychological treatment on physical activity participation and adopting a helpful coping strategy to self-manage pain and fatigue was highlighted in the qualitative study. However, given that qualitative study findings cannot be generalised, there is a need for experimental studies to investigate the combined effect of psychological intervention with conventional treatment such as medications and physical activity. This will enable identifying the efficacy of multimodal treatment on physical activity in people with fibromyalgia.

7.10.2 Implication for clinical practice

Physical activity interventions for people with fibromyalgia should take a multidisciplinary, holistic and patient-centred approach. This should involve recommending physical activity on an individual basis based on physical function and psychological impact. In this thesis, psychological symptoms such as depression, anxiety, and mood, which are highly prevalent in people with fibromyalgia and shown to impact physical activity and pain, should be considered by exploring psychological and behavioural interventions when designing physical activity recommendations. Social factors such as occupation, living status, and environmental should be incorporated in physical activity interventions with different physical activity strategies for employed people, and those who are unemployed as people who are employed have shown a significant accumulation of physical activity than those who are not employed.

The participant's preferred choice of physical activity or exercise should be utilised to encourage accumulating short bouts of physical activity. For example, participants who enjoy walking, gardening, or other physical activities such as Zumba, dancing, cycling, as shown in the qualitative studies, should be encouraged on such physical activities rather than structured exercises such as strengthening or aerobic exercises, which are contained in exercise recommendations in evidence-based guidelines (Busch et al., 2013). However, exercise or physical activity should be attenuated and paced to counter excessive fatigue and prevent immediate increasing pain after activity.

Furthermore, there is a need for patient education on physical activities and exercises, emphasising the intensity and frequency of physical activity to achieve maximum benefits of physical activity and exercise. Lack of education on adopting an appropriate physical activity led to sedentary behaviour resulting in severe pain and fatigue. Patient education on self-management strategies and in addition to the general education of fibromyalgia, which is recommended by the evidence-based guidelines as the first line of action immediately after the diagnosis of fibromyalgia, should be encouraged.

7.11 Conclusion

This thesis comprises three studies investigating the association between physical activity behaviour and pain in people with fibromyalgia. The systematic review found an inconsistent association between physical activity categories and pain in people with fibromyalgia. The quantitative survey discovered a lower physical activity pattern in people with fibromyalgia associated with higher pain perception. The biopsychosocial factors such as depression, anxiety, and fatigue impact the association between pain and physical activity. The qualitative study corroborates fatigue, lack of exercise education and guidance, anxiety, and depression to lowering physical activity and increasing pain perception.

A multimodal approach, incorporating patient education with behavioural components, is essential to increase adherence to exercise and physical activity interventions to support self-management strategies in fibromyalgia. There is a need for a tailored physical activity recommendation for fibromyalgia, emphasising non-structured physical activity such as walking to accumulate short bouts of physical activity rather than traditional structured exercises. Fatigue management and attenuation of physical activity to avoid increased pain perception leading to increased sedentary behaviour should be incorporated in physical activity recommendations for people with fibromyalgia.

Personal and contextual factors such as living status, employment status, and social support need to consider potential determinants and physical activity barriers while designing an individualised physical activity recommendation for people with fibromyalgia. There is a need for health care professionals to have targeted discussions and guides on adopting an active lifestyle and consider personal factors and the impact of medications on physical activity behaviour.

Appendices

Appendix 1- Search results for systematic review

Date of search	***Database***	***Search***	***Database Years searched***	***Documents obtained***	***Duplicates***
27/03/2018	Web of Science	SI- Fibromyalgia* S2- physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg* S3- Pain*, chronic widespread pain, *pain S4- SI AND S2 AND S3	1990- Date	1227	14
3/22/2018	CINAHL	SI- Fibromyalgia* S2- physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg* S3- Pain*, chronic widespread pain, *pain S4- SI AND S2 AND S3	1990- Date	1,283	12
26-Mar-18	British Nursing index	SI- Fibromyalgia* S2- physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg* S3- Pain*, chronic widespread pain, *pain S4- SI AND S2 AND S3	1990- Date	732	220
22/03/2018	Psych INFO ALL RESOURCES	SI- Fibromyalgia* S2- physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg*	1990- Date	10538	3112

		S3- Pain*, chronic widespread pain, *pain S4- SI AND S2 AND S3			
05/04/2018	Cochrane library	SI- Fibromyalgia* AND - physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg* AND Pain*, chronic widespread pain, *pain	1990- Date	44	0
3/28/2018	Medline EBsco	SI- Fibromyalgia* S2- physical, physical activit* OR, sedentary* OR physical behavi*, OR walk* OR free living OR excer* OR *excer, OR walk*, *walk, dancing*, gardeni* jogg* S3- Pain*, chronic widespread pain, *pain S4- SI AND S2 AND S3	1990- Date	1518	494

Appendix 2- Quality Assessment of RCTs- systematic review

No	**Reference**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	Quality

1.	Fontaine 2010	✓	✗	✓	✗	✗	NR	✓	✓	✓	✓	✓	✓	✓	Good
2.	Fontaine 2007	✓	✗	✓	✗	✗	NR	✓	✓	✓	✓	✓	✓	✓	Good
3.	Kaleth 2013	✓	✗	✓	✗	✗	NR	✓	✓	✓	✓	✓	✓	✓	Good
4.	Kaleth et al. 2014	✓	✗	✓	✗	✗	NR	✓	✓	✓	✓	✓	✓	✓	Good
5.	Rasmussen-2017	✓	✓	✓	✓	✓	NR	✓	✓	✓	✓	✓	✓	✓	Strong
6.	Steiner 2015	✓	✓	✓	✓	✓	NR	✓	✓	✓	✓	✓	✓	✓	Strong

NR- Not reported

1. Was true randomization used for assignment of participants to treatment groups?
2. Was allocation to treatment groups concealed?
3. Were treatment groups similar at the baseline?
4. Were participants blind to treatment assignment?
5. Were those delivering treatment blind to treatment assignment?
6. Were outcomes assessors blind to treatment assignment?
7. Were treatment groups treated identically other than the intervention of interest?
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?
9. Were participants analysed in the groups to which they were randomised?
10. Were outcomes measured in the same way for treatment groups?

11. Were outcomes measured in a reliable way?
12. Was an appropriate statistical analysis used?
13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomisation, parallel groups) accounted for in the conduct and analysis of the trial?

Appendix 3 - Quality assessment of observational studies- systematic review

No	References	1	2	3	4	5	6	7	8	Quality
1.	Segura-Jiménez 2017	✓	✓	✓	✓	✓	✓	✓		Strong
2.	Segura-Jiménez 2017	✓	✓	✓	✓	✓	✓	✓		Strong
3.	Umeda 2015	✓	✓	✓	✓	✓	✓	✓		Strong
4.	Merriweather 2018	✓	✓	✓	✓	✓	✓	✓		Strong

1. Were the criteria for inclusion in the sample clearly defined?
2. Were the study subjects and the setting described in detail?
3. Was the exposure measured in a valid and reliable way?
4. Were objective, standard criteria used for measurement of the condition?

5. We’re confounding factors identified?
6. Were strategies to deal with confounding factors stated?
7. Were the outcomes measured in a valid and reliable way?
8. Was appropriate statistical analysis used?

Appendix 4- Ethics approval

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

4 December 2019

Dear Kabir,

RE: ETHICS APPLICATION–HSR1819-025 The Association between Physical Activity Behaviour and Chronic Widespread pain in people with Fibromyalgia

Based on the information that you have provided, I am pleased to inform you that application HSR1819-025 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
Deputy Chair of the Research Ethics Panel

Appendix 4- Amended Ethics approval

Amendment Notification Form

Title of Project:

Association Between Physical Activity Behaviour and Chronic Widespread Pain in People with Fibromyalgia

Name of Lead Applicant:	**School:**
Kabir Isah Mayana	Health & Society

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?**
11/06/2019	HSR1819-025	Yes

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:*

Following the outcome and feedback from my Internal Evaluation and discussion with my supervisors, considering the time line of my PhD and feasibility of double observation especially in people with Fibromyalgia, we have decided to have one observation, cross-sectional, instead of two observations. Therefore, participants will not be contacted to complete the second observation as described in the Participant Information Sheet.

PIS – The section that says " you will be contacted after three months to complete the section observation is removed.

All the amendments in the PIS and online consent form are highlighted and renamed with new version control

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:

There are no new ethical issues. All the ethical considerations that were mentioned previously in the original ethical application will be relevant for the amended changes.

Appendix 5- Social media invitation (tweet)

PATH-FM 2 Study

Are you diagnosed with fibromyalgia? 18 years and above? Please kindly participate in our survey “Physical Activity Behaviour and Pain in Fibromyalgia” Please see the click the link below for more information xxxxx

Appendix 6- Participant Invitation letter (Survey)

Rehabilitation Research Group,
L701 Allerton (OT),
School of Health and Society,
University of Salford,
Frederick Road,
Salford M6 6PU

Dear Sir/Madam

Re: Physical Activity Behaviour and Pain in Fibromyalgia [PATH-FM 2]

We are asking you if you would kindly consider taking part in this study. You were identified through patient organisations such as Versus Arthritis, Fibromyalgia Action UK, and social media groups. This study might be of interest to you if you wish to take part.

According to the guidelines for the management of Fibromyalgia, non-drug treatment should be a priority and exercise is highly recommended to manage the common symptoms instead of medication. Nevertheless, people with Fibromyalgia report low tolerance of exercise due to severe pain and fatigue, and therefore either refrain or do not continue with exercise regimes in the long term. This presents an issue with adherence to the recommended treatment plans. In addition, people with Fibromyalgia are thought to lead more sedentary lifestyles due to the level of pain and fatigue experienced. However, there is no evidence to support this. Although structured exercise can be deemed as difficult to adhere, one argument would be that increased physical activities in daily life e.g., walking more and taking the stairs instead of the lift, can derive similar benefits to exercise. To do this, we need to have a better understanding of the personal, environmental, and contextual factors impacting the level of physical activities people with Fibromyalgia can sustain. So, the purpose of this study is to ascertain factors affecting your pain and physical activity levels. This will help us to identify targets for interventions to improve future outcomes.

In this study, you will need to sign an online consent form by email to show you have agreed to take part in the study. Following this, you will need to log on to an online platform, where you will be directed to fill in the online questions about your age, gender, time of diagnosis, height, weight, medicines, physical activity, tiredness, mood, sleep, and pain. Following consent, you will be provided with a study ID to log onto the online system and complete this survey, so you will not be personally identifiable in any of the data collected online. Only the research team will have access to your personal information, which will be kept electronically in a secure University server.

There is an information sheet attached telling you more about the study and what you would be asked to do. It is up to you to decide whether to take part.

Next step

Please let us know if you are interested in taking part by responding to this email. If you have any questions prior to receiving further information you can also contact us as below. We will be very happy to answer any questions you may have.

Yours Sincerely,

Ph. D Candidate
xxxxxxx

Appendix 7- Participant Information Sheet Survey

PATH-FM Survey

Page 1: Information sheet

Introduction

We would like to invite you to take part in a research study. The study is conducted by the Centre of Health Sciences Research, University of Salford. Before you decide to take part or not, you will need to understand why the research is carried out and what it will involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. I will be happy to go through the information sheet with you. I can answer any question you may have, please contact me via telephone on 07535548453. Alternatively, you can contact my research supervisor, 01612950211 who will be happy to speak to you. Please ask if there is anything that is not clear to you or if you would like more information. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

According to the guidelines for the management of Fibromyalgia, non-drug treatment should be a priority and exercise is highly recommended to manage common symptoms instead of medication. Nevertheless, people with Fibromyalgia report low tolerance to exercise due to the level of pain and fatigue, and therefore either refrain or do not continue with exercise regimen in the long term. This presents an issue with adherence to the recommended treatment plans. In addition, people with Fibromyalgia are thought to lead a more sedentary lifestyle due to the level of pain and fatigue experienced. However, there is no evidence to support this. Although structured exercises can be deemed as difficult to adhere, one argument would be that increased physical activity in daily life, e.g. walking more and taking the stairs instead of the lift, can derive similar benefits to exercise. To this date, we need to have a better understanding of the personal, environmental and contextual factors impacting the level of physical activities people with Fibromyalgia can sustain. So, the purpose of this study is to ascertain factors affecting your pain and physical activity levels. This will help us to identify interventions to improve future outcomes.

People to take part

We are asking people to take part who have:

1. Diagnosed with Fibromyalgia
2. Aged 18 years and older
3. Can read and write in English
4. Have access to a computer and internet connection

Do I have to take part?

It is up to you to decide. Take your time to do so. Participation is voluntary, and you are free to withdraw from the study at any time without giving any reason. However, if you withdraw after a month of completing the survey, please note that we may retain your anonymised data. If you need any clarification on the survey, please do not hesitate to contact me as above.

Would there be any financial incentive?

Your participation in this project is voluntary as there are no costs attached to completing the online surveys. Although we appreciate you taking your time to complete the surveys, due to limited funds, we are not able to offer any financial incentives to compensate for your valuable time spent in this study. Your participation will help to improve future outcomes for people with Fibromyalgia, and we really appreciate your support in this study.

What will happen to me if I take part?

If you decide to take part: You will need to sign an online consent form by ticking the box to show you have agreed to take part in the study. You will need to provide your unique identification, so you will not be personally identifiable in any of the data collected online. Following this, you will be directed to fill in the online survey. The survey includes Patients Reported Outcome Measures (PROMs) to measure your health and physical activity outcomes (such as the symptom of pain, medications, work ability, tiredness, stress, mood, and physical function), demographic factors (such as work status, and lifestyle factors).

What are the possible benefits of taking part?

This study may provide you with the opportunity to become more self-aware of the factors affecting your pain perception and other symptoms involved. It may also help you to adapt more helpful behaviours to cope with pain and other symptoms associated with fibromyalgia over time. Overall, you will be helping to shape the research around the factors impacting the relationship between pain and physical activity behaviour in people with Fibromyalgia, which will help to identify targets for interventions and increase access to patient education on helpful behaviours to cope with pain.

What will happen if I don't carry on with the study?

Your participation is entirely voluntary. You are free to withdraw from the study at any time without giving a reason, and your right to access to any other community groups or NHS rehabilitation services will be unaffected, and the information you provided will be kept confidential. However, the data collected up to the point of withdrawal will remain part of the study.

What will happen to the results of the research study?

The results of the study will be used as part of a Doctor of Philosophy (PhD) project to write a thesis, articles, and conference presentations. This will help to share the new knowledge, which may lead to an improvement in the lives of people with Fibromyalgia.

Who is organising or sponsoring the research?

This research is organised and sponsored by the University of Salford, as part of a PhD project to identify links between chronic pain and physical activity in people with Fibromyalgia.

Further information and contact details:

If you have any questions, would like more information, or would like to volunteer please do not hesitate to contact:

Name of Researcher: Kabir Isah Mayana

Contact number: 07535548453

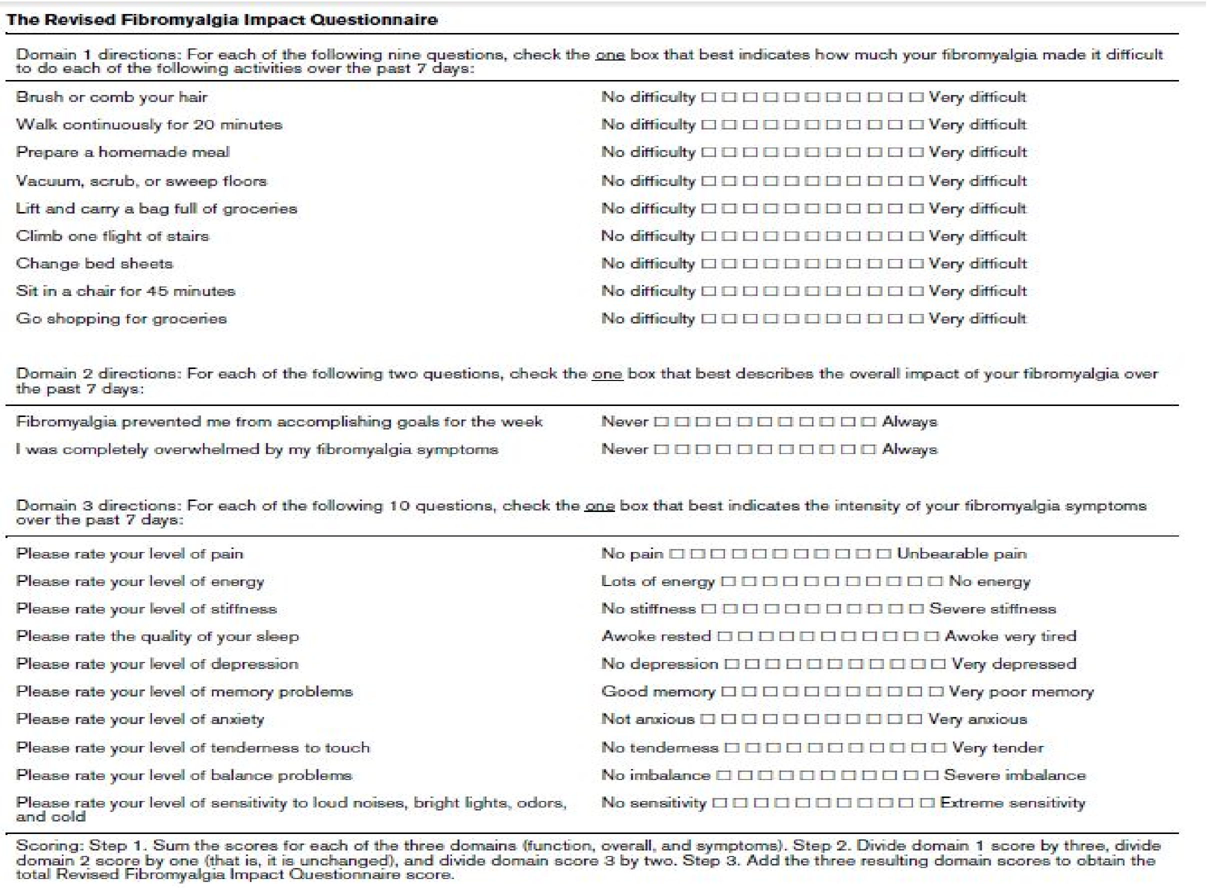
Name of Research Supervisor: Dr Yeliz Prior

Contact number: 01612950211

What if there is a problem?

If you would like to complain about the way you have been dealt with during the study or have any concerns about any possible harm you might suffer, please in the first instant kindly contact the **Research Supervisor Dr Yeliz Prior at the University of Salford** on Tel: **01612950211** or Email: y.prior@salford.ac.uk. And if you are not satisfied with how your complaint was addressed, you can contact Prof Andrew Clark, Chair of the Health Research Ethical Approval Panel Email: A.clark@salford.ac.uk.

Appendix 8-Fibromyalgia Impact Questionnaire (Revised)



The Revised Fibromyalgia Impact Questionnaire

Domain 1 directions: For each of the following nine questions, check the one box that best indicates how much your fibromyalgia made it difficult to do each of the following activities over the past 7 days:

Brush or comb your hair	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Walk continuously for 20 minutes	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Prepare a homemade meal	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Vacuum, scrub, or sweep floors	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Lift and carry a bag full of groceries	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Climb one flight of stairs	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Change bed sheets	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Sit in a chair for 45 minutes	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult
Go shopping for groceries	No difficulty ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very difficult

Domain 2 directions: For each of the following two questions, check the one box that best describes the overall impact of your fibromyalgia over the past 7 days:

Fibromyalgia prevented me from accomplishing goals for the week	Never ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Always
I was completely overwhelmed by my fibromyalgia symptoms	Never ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Always

Domain 3 directions: For each of the following 10 questions, check the one box that best indicates the intensity of your fibromyalgia symptoms over the past 7 days:

Please rate your level of pain	No pain ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Unbearable pain
Please rate your level of energy	Lots of energy ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ No energy
Please rate your level of stiffness	No stiffness ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Severe stiffness
Please rate the quality of your sleep	Awoke rested ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Awoke very tired
Please rate your level of depression	No depression ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very depressed
Please rate your level of memory problems	Good memory ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very poor memory
Please rate your level of anxiety	Not anxious ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very anxious
Please rate your level of tenderness to touch	No tenderness ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Very tender
Please rate your level of balance problems	No imbalance ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Severe imbalance
Please rate your level of sensitivity to loud noises, bright lights, odors, and cold	No sensitivity ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extreme sensitivity

Scoring: Step 1. Sum the scores for each of the three domains (function, overall, and symptoms). Step 2. Divide domain 1 score by three, divide domain 2 score by one (that is, it is unchanged), and divide domain score 3 by two. Step 3. Add the three resulting domain scores to obtain the total Revised Fibromyalgia Impact Questionnaire score.

Appendix 9- Summary of variables and measurements

Variable	Description	Item	Type of variable

Pain Intensity	The FIQR pain scale was used to measure the severity of pain. The pain subscale has a minimum score of 0 and a maximum of 10 with lower scores indicating lower pain and a higher score indicating severe pain.	**1**	**Continuous variable**
Pain Interference	Pain interference was measured using the Brief Pain Inventory SF (BPI). The questionnaire measures pain intensity and pain interference scale. The pain interference scale has seven items- general activity, mood, walking ability, normal work, relation with other people, sleep, and enjoyment of life. Each item has a score of 0-10. 0 indicating no interference and 10 indicating interferes completely, with 70 indicating the maximum interference.		Continuous variable
Physical activity	IPAQ-SF was used to measure perceived physical activity levels over the past week. The IPAQ SF measure time spent on low, moderate, and vigorous physical activity. Data on physical activity was summarised in two categories: total activity and IPAQ defined activity (low, moderate, high). The total activity is calculated by a reported continuous variable as Metabolic Equivalents (METS), multiplied by the minutes spent	**12**	Continuous variable and categorical

	on physical activity throughout the week. The IPAQ defined activity category levels of physical activity based on the total score of reported physical activity in a week. • Higher physical activity is defined as either achieving three or more days of vigorous physical activity of at least 1500 METs per week for seven days or moderate activity totalling 3000 METS min/week. • Moderate physical activity is defined as 30 or more minutes of moderate-intensity physical activity per day for five days or at least 600 MET/minute a week • low activity or sedentary behaviour is defined as not meeting moderate or higher activity categories (Guidelines for processing and scoring IPAQ, 2005).		
Physical function	Physical function was measured using the FIQR function domain. The Function domain has a total of 9 questions assessing the difficulty of doing essential physical function like brushing the hair, preparing a meal, vacuum, groceries, stair climbing, changing	9	Continuous variable

	bedsheet, and sitting in a chair were scored 0-10. 0 indicates no difficulty and 10 indicating very difficult. A higher score indicates a worse function.		
Mood	Mood was measured using the Brief Pain Inventory scale. The scale measures the intensity of anxiety on a 0-10. With 0 indicates no mood disturbance and 10 indicates severe mood disturbance	1	
Anxiety	Anxiety was measured using the FIQR anxiety scale. The domain measures the intensity of anxiety on a 0-10 scale 0, indicating not anxious and 10, indicating extremely anxious.	1	Continuous variable
Depression	Depression was measured using the FIQR depression subscale. The subscale measures depression on a scale of 0-10; the higher scores indicate more depression over the past seven days.	1	
Fatigue	Fatigue intensity was measured using a single item of the FIQR that measures energy. The scale has a 0-10 range that measures energy with 0 indicating lots of energy and 10 indicating No energy.	1	Continuous variable
Sleep	The FIQR was used to measure sleep quality. The sleep quality scale has a score of 0-10, with 0	1	Continuous variable

	indicating waking up well-rested and ten indicating waking up tired—higher scores indicating poor sleep quality and lower scores indicating a better sleep quality.		
Disease impact	The impact of fibromyalgia was measured using the FIQR, which comprises of 21 items with a 0-10 numerical rating scale for each item. The FIQR aggregate score ranges from 0-100. A lower score indicating less effect and higher score, indicating a more significant effect on the individual's life.	21	Continuous variable

Appendix 10- International Physical Activity Questionnaire-SF

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ **days per week**

☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**
_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**
_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

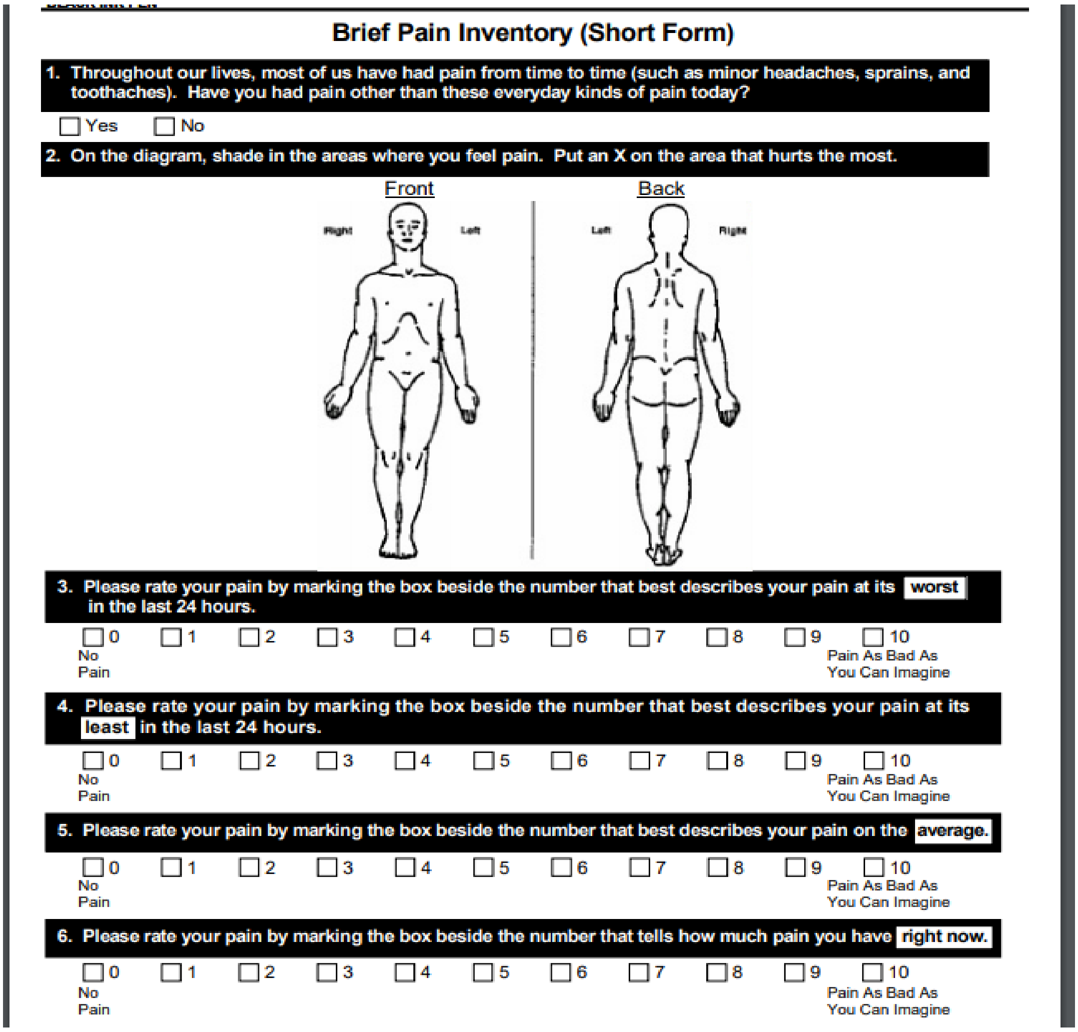
_____ **hours per day**
_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

Appendix 11- Brief Pain Inventory (Short Form)



Brief Pain Inventory (Short Form)

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain today?

☐ Yes ☐ No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.

3. Please rate your pain by marking the box beside the number that best describes your pain at its worst in the last 24 hours.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

4. Please rate your pain by marking the box beside the number that best describes your pain at its least in the last 24 hours.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

5. Please rate your pain by marking the box beside the number that best describes your pain on the average.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

6. Please rate your pain by marking the box beside the number that tells how much pain you have right now.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

7. What treatments or medications are you receiving for your pain?

8. In the last 24 hours, how much relief have pain treatments or medications provided? Please mark the box below the percentage that most shows how much relief you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
No Relief										Complete Relief

9. Mark the box beside the number that describes how, during the past 24 hours, pain has interfered with your:

A. General Activity

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

B. Mood

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

C. Walking ability

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

D. Normal Work (includes both work outside the home and housework)

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

E. Relations with other people

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

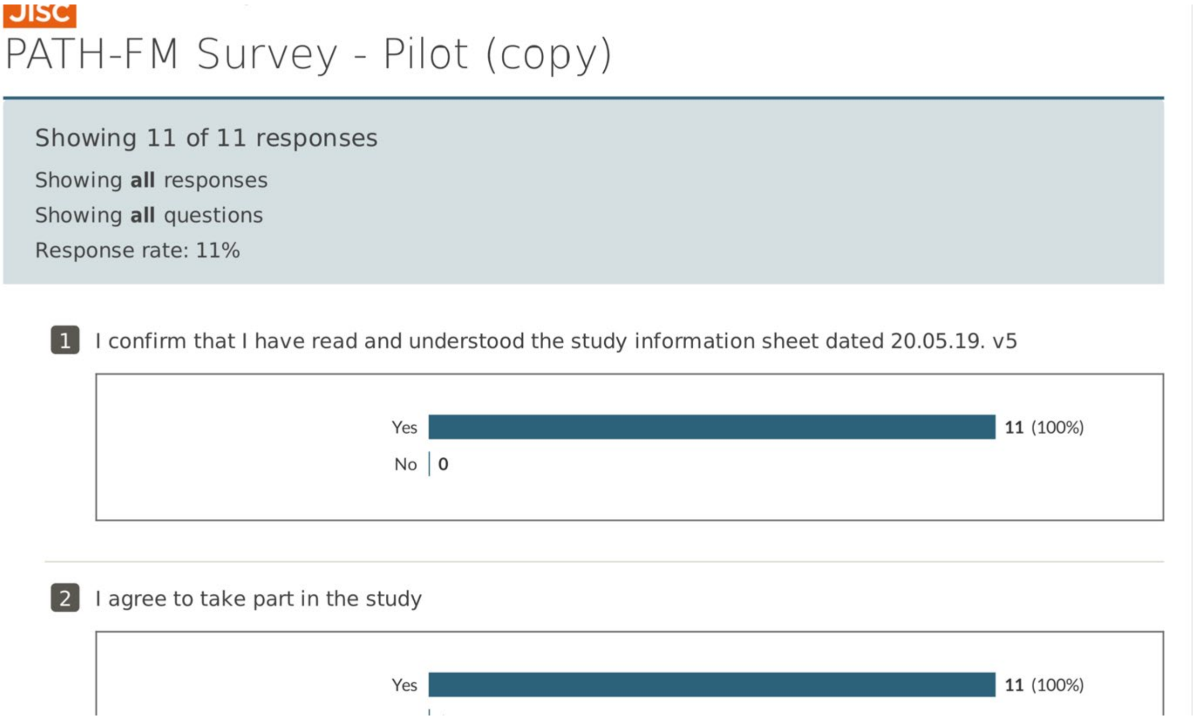
F. Sleep

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

G. Enjoyment of life

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10
Does Not Interfere										Completely Interferes

Appendix 12- Pilot survey



PATH-FM Survey - Pilot (copy)

Showing 11 of 11 responses

Showing **all** responses

Showing **all** questions

Response rate: 11%

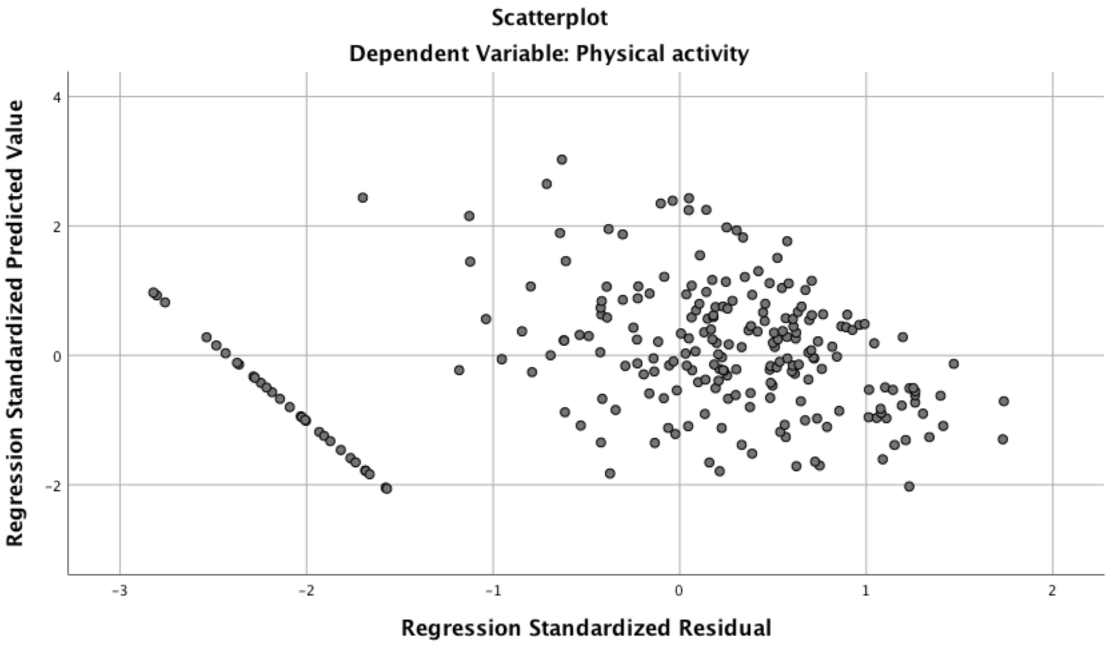
1 I confirm that I have read and understood the study information sheet dated 20.05.19. v5

Yes	**11** (100%)
No	**0**

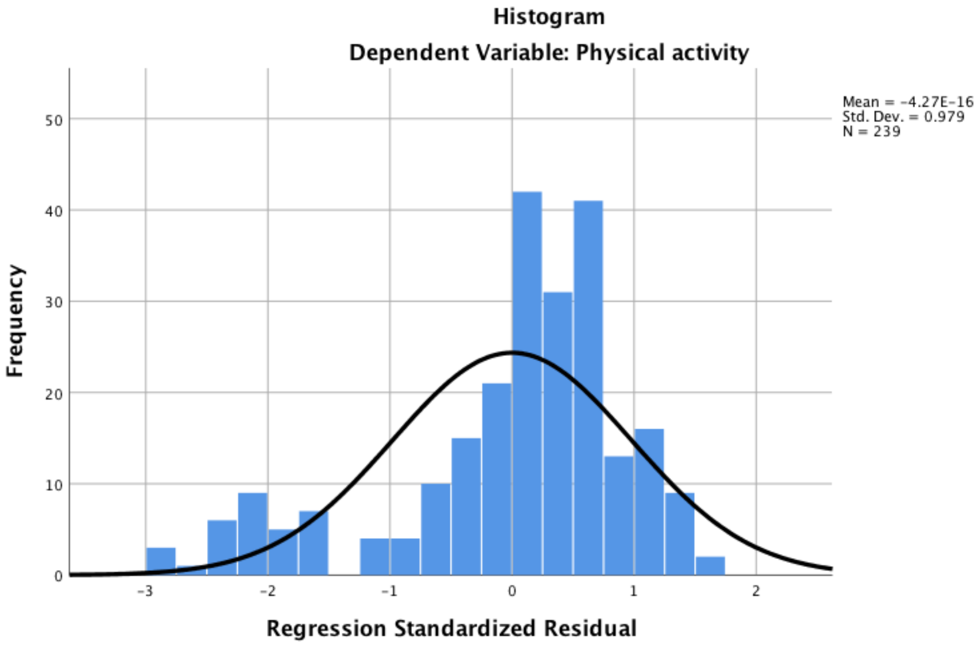
2 I agree to take part in the study

Yes	**11** (100%)

Appendix 13- Assumptions for Linear regression


Scatterplot

Dependent Variable: Physical activity


Histogram

Dependent Variable: Physical activity

Appendix 14- Participant Invitation letter (interviews)

Appendix 15- Participant Information Sheet (qualitative study)

Title of study: Physical Activity Behaviour and Pain in Fibromyalgia [PATH-FM 1]

Name of PhD Candidate: xxx
Name of Research supervisor: xxx

Introduction

We would like to invite you to take part in a research study. The study is conducted by the Centre of Health Sciences Research, University of Salford. Before you decide, you need to understand why the research is carried out and what it will involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. I will be happy to go through the information sheet with you. I can answer any question you may have, please contact me via telephone on xxx. Alternatively, you can contact my research supervisor on xxxx who will be happy to speak to you. Please ask if there is anything that is not clear to you or if you would like more information. Take time to decide whether you wish to take part.

What is the purpose of the study?

According to the guidelines for the management of Fibromyalgia, non-pharmacological treatment should be a priority and exercise is highly recommended to manage the common symptoms instead of medication. Nevertheless, people with Fibromyalgia report low tolerance of exercise due to severe pain and fatigue, and therefore either refrain or do not continue with exercise regimes in the long term. This presents an issue with adherence to the recommended treatment plans. In addition, people with Fibromyalgia are thought to lead more sedentary lifestyles due to the level of pain and fatigue experienced. However, there is no evidence to support this. Although structured exercise can be deemed as difficult to adhere, one argument would be that increased physical activities in daily life e.g., walking more and taking the stairs instead of the lift, can derive similar benefits to exercise. To do this, we need to have a better understanding of the personal, environmental, and contextual factors impacting the level of physical activities people with Fibromyalgia can sustain. So, the purpose of this study is to explore your personal views on factors affecting your pain and physical activity levels. This will help us to identify targets for interventions to improve future outcomes.

People to take part.

We are asking people to take part who have:

1. Diagnosed with fibromyalgia
2. Aged 18 years and older
3. Can speak in English

Do I have to take part?

It is up to you to decide. Take your time to do so. Participation is voluntary, you are free to withdraw from the study at any time (within a month of the interview) without giving any reason. If you need any clarification on the study, please do not hesitate to contact me as above.

What will happen to me if I take part?

You will be required to participate in a telephone interview at a mutually convenient time. The interview may last up to half an hour. As a reminder, the interview will be audio recorded to help us to transcribe the conversation. Any recordings and transcriptions will be securely saved under your study ID, and you will not be identified personally during the interview or any transcription. Data will be analysed qualitatively, in which, original quotes may be used to highlight important themes, but these will be anonymised, and you will not be personally identifiable in any study reports or publications arise.

Would there be any financial incentive?

Your participation in this project is voluntary and there are no costs attached to taking part in the telephone interviews. Although we appreciate you taking your time to partake in these interviews, due to limited funds we are not able to offer any financial incentives to compensate for your valuable time spent in this study. Your participation will help us to improve future outcomes for people with Fibromyalgia and we really appreciate your support in this study.

What are the possible benefits of taking part?

This study may provide you with the opportunity to become more self-aware of the factors affecting your pain perception and other symptoms involved. It may also help you to adapt more helpful behaviours to cope with pain and other symptoms associated with Fibromyalgia over time. Overall, you will be helping to shape the research around the factors impacting the relationship between pain and physical activity behaviour in people with Fibromyalgia, which will help to identify targets for interventions and increase access to patient education on helpful behaviours to cope with pain.

What will happen if I don’t carry on with the study?

Your participation is completely voluntary. You are free to withdraw from the study at any time without giving a reason, and your rights to access to any other community groups or NHS rehabilitation services will be unaffected. However, the data collected up to the point of withdrawal will remain part of the study, and the information you provided will be kept confidential.

What will happen to the results of the research study?

The results of the study will be used as part of a Doctor of Philosophy (PhD) project to write a thesis, scientific articles, and conference presentations. This will help to share the new knowledge acquired, and lead to the improvements in people with Fibromyalgia's lives.

Who is organising or sponsoring the research?

This research is organised and sponsored by the University of Salford, as part of a PhD project to identify links between chronic pain and physical activity in people with Fibromyalgia.

Further information and contact details:

If you have any questions, would like more information, or would like to volunteer please do not hesitate to contact:

Name of Researcher:
Contact number: XXXX

Name of Research Supervisor:
Contact number: XXXX

What if there is a problem?

If you would like to complain about the way you have been dealt with during the study or have any concerns in relation to any possible harm you might suffer, please in the first instant kindly contact **my Research Supervisor xxx at the University of Salford** on Tel: 0161 XXXX or Email: xxxxx@salford.ac.uk, and If you are not satisfied with how your complaint was addressed you can also contact to Dr Andrew England, Chair of the Health Research Ethical Approval Panel, Room , Allerton, Frederick Road Campus, University of Salford, Salford, M6 6PU. Tel: xx Email: A.England@salford.ac.uk.

Appendix 16- Interview appointment confirmation

University of
Salford
MANCHESTER

TELEPHONE INTERVIEW APPOINTMENT CONFIRMATION LETTER

Date:

Dear ….

RE: Physical Activity Behaviour and Pain in Fibromyalgia **[PATH-FM 1] Study**

Thank you very much for agreeing to take part in a telephone interview about your experience on factors impacting the relationship between physical behaviour and chronic widespread pain in Fibromyalgia.

Please kindly note the date and time for this interview.

dd/mm/fibromyalgia

fibromyalgia/mm

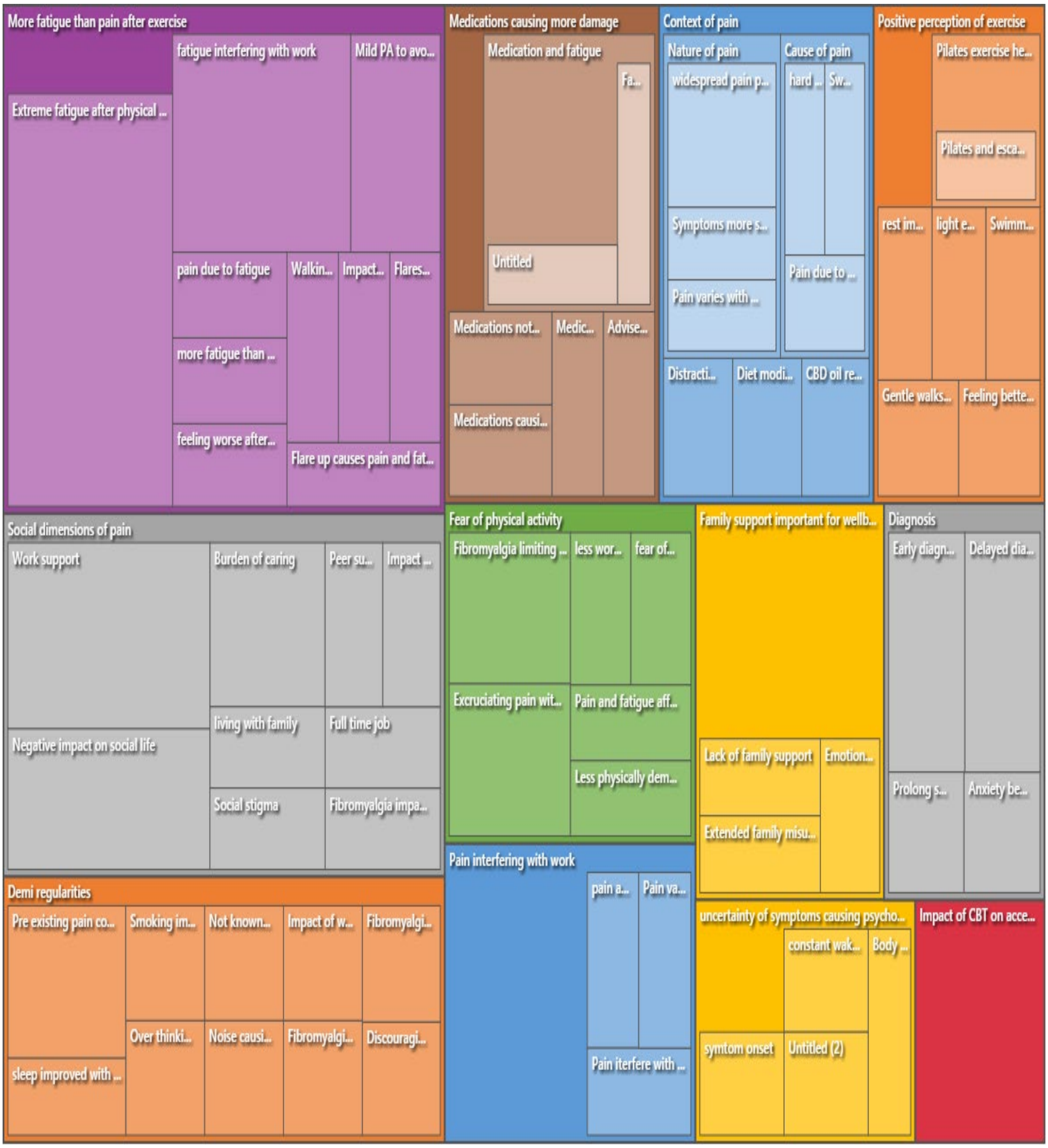
Please note that I will telephone you at the arranged date and time above, and the interview may last half an hour. As a reminder, the interview will be audio recorded to help us to transcribe the conversation. Any recordings and transcriptions will be securely saved under your study ID, and you will not be identified personally during the interview.

Please, do not hesitate to contact me as below if you need to make any changes to the agreed date or time.

Yours sincerely,
PhD Candidate

Telephone Number:
Email Address: xxx

Appendix 17- Codes maps (NVIVO)


More fatigue than pain after exercise
Extreme fatigue after physical ...
fatigue interfering with work
Mild PA to avo...
pain due to fatigue
Walkin...
Impact...
Flares...
more fatigue than ...
feeling worse after...
Flare up causes pain and fat...
Medications causing more damage
Medication and fatigue
Fa...
Untitled
Medications not...
Medic...
Advise...
Medications causi...
Context of pain
Nature of pain
widespread pain p...
Symptoms more s...
Pain varies with ...
Cause of pain
hard ...
Sw...
Pain due to ...
Distracti...
Diet modi...
CBD oil re...
Positive perception of exercise
Pilates exercise he...
Pilates and esca...
rest im...
light e...
Swimm...
Gentle walks...
Feeling bette...
Social dimensions of pain
Work support
Negative impact on social life
Burden of caring
Peer su...
Impact ...
living with family
Full time job
Social stigma
Fibromyalgia impa...
Fear of physical activity
Fibromyalgia limiting ...
less wor...
fear of...
Excruciating pain wit...
Pain and fatigue aff...
Less physically dem...
Family support important for wellb...
Lack of family support
Emotion...
Extended family misu...
Diagnosis
Early diagn...
Delayed dia...
Prolong s...
Anxiety be...
Demi regularities
Pre existing pain co...
Smoking im...
Not known...
Impact of w...
Fibromyalgi...
sleep improved with ...
Over thinki...
Noise causi...
Fibromyalgi...
Discouragi...
Pain interfering with work
pain a...
Pain va...
Pain iterfere with ...
uncertainty of symptoms causing psycho...
constant wak...
Body ...
symtom onset
Untitled (2)
Impact of CBT on acce...

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