The effectiveness of an exercise programme on dynamic balance in patients with medial knee osteoarthritis: a pilot study

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ABSTRACT

Background: Dynamic and quiet standing balance are decreased in knee osteoarthritis (OA), with dynamic balance being more affected. This study aims to investigate the effectiveness of a group exercise programme of lower extremity muscles integrated with education on dynamic balance using the Star Excursion Balance test (SEBT) in knee OA.

Methods: Experimental before-and-after pilot study design. Nineteen participants with knee OA attended the exercise sessions once a week for six weeks, in addition to home exercises. Before and after the exercise programme, dynamic balance was assessed using the SEBT in the anterior and medial directions in addition to hip and knee muscle strength, pain, and function.

Results: Fourteen participants completed the study. Raw balance data and those normalised to leg length on the affected side demonstrated significant improvements in dynamic balance in the anterior and medial directions ($p=0.02$ and $p=0.01$, respectively). The contralateral side demonstrated significant improvements in dynamic balance in the anterior direction ($p<0.001$). However, balance in the medial direction did not change significantly ($p=0.07$). Hip and knee muscle strength, pain, and function significantly improved ($p<0.05$) after the exercise programme.

Conclusion: This is the first study to explore the effect of an exercise programme on dynamic balance using the SEBT in knee OA. The exercise programme was effective in improving dynamic balance which is required in different activities of daily living where the patients might experience the risk of falling. This might be attributed to the improvement in muscle strength and pain after the exercise programme.

Keywords: knee osteoarthritis, dynamic balance; exercise; star excursion balance test

1. INTRODUCTION

Knee osteoarthritis (OA) is a common musculoskeletal condition. Balance deficits were found in knee OA with dynamic balance being more affected than quite standing balance [1, 2]. Dynamic balance is the ability to maintain a stable base of support whilst performing a movement or a prescribed reaching or leaning task [3] whereas quiet standing balance is the ability to maintain the centre of gravity within the limits of the base of support with minimal movement [4]. Although a correlation was not found between radiographic severity and dynamic balance in knee OA [5], decreased balance increases the risk of falling in the elderly [6]. Specifically, the risk of falls increased in people with arthritis compared to healthy as they had significantly more falls [relative risk (RR) 1.22, 95% CI 1.03–1.46] and injurious falls (RR 1.27, 95% CI 1.01–1.60) in the previous 12 months [7]. Therefore, one would expect that knee OA rehabilitation programmes should address this issue to reduce the risk of falling.

A systematic review by Silva et al. [8] explored the effect of different therapeutic interventions on both quite standing and dynamic balance in knee OA. The results of nine randomised controlled trials (RCTs) were reported of which eight had high methodological quality according to the Physiotherapy Evidence Database (PEDro) scale [9]. The treatments included: strengthening and aerobic exercises, balance exercises, hydrotherapy, Tai Chi exercises, and whole body vibration exercises. A wide range of outcome measures were used to assess balance including the step test, force platforms, and timed functional tests e.g. time to climb stairs and get up and go tests. This systematic review concluded that these treatments significantly improved quite standing and dynamic balance in knee OA. However, four of the included studies assessed physical function using timed functional tests rather than balance [10-13]. Although a correlation exists between the two [14], these are different outcome measures. Therefore, the results of this review should be considered carefully because it investigated the effectiveness of exercises on balance and physical function.

Dynamic balance is usually assessed in knee OA research using the step test [2, 15, 16]. In this test, the participant stands on the tested leg while stepping with the other for 15 seconds on a 15cm-height step. The number of steps taken during this time is recorded [17]. Dynamic balance was decreased in knee OA using this test compared to healthy participants [2]. Few studies have investigated the effect of exercise on dynamic balance using the step test in knee OA [15, 16]. Quadriceps strengthening exercises did not significantly change dynamic balance (using the step test) in individuals with knee OA and neutral or varus lower limb alignment [15]. In an RCT investigating a 6-week aquatic strength and balance exercise programme in patients with hip and knee OA, dynamic balance (using step test) did not change significantly immediately after the exercise programme. Six weeks later, following continued independent exercising, balance significantly improved [16]. This might be as a result of improved endurance rather than stability. Moreover, the step test assesses dynamic balance in one direction only which does not reflect on the balance needs of the activities of daily living (ADL).

Another test for the assessment of dynamic balance is the Star Excursion Balance Test (SEBT) [18]. In this test, the participants balance on one leg while reaching with the other leg in eight different directions as far as they can, then return to double support without losing balance [18]. Dynamic balance is assessed in this test as the participants are required to perform a reaching task while maintaining a single stable base of support. These directions include: the anterior, anterior-lateral, anterior-medial, medial lateral, posterior, posterior-lateral, and posterior-medial. This test had excellent inter-rater reliability in all directions on healthy individuals between 18-

50 years of age [19]. Moreover, Bouillon and Baker [20] reported healthy middle aged-adults (40-54 years) had a significantly lower reach distances in the anterior-medial, medial, and posterior-medial directions compared to healthy young adults (23-39 years). The SEBT test has most commonly been used to assess dynamic balance in knee joint injuries such as anterior cruciate ligament deficiency [21]. While the SEBT might be a more difficult test for individuals with knee OA to complete, mainly due to the population being older with balance problems, it is likely to challenge the neuromuscular system more than the step test and would be considered a true dynamic balance test as you are testing them in different directions. However, no such studies have been performed in individuals with knee OA, nor whether an exercise intervention alters dynamic balance using this method.

Therefore, the purpose of this study was to examine the effect of an exercise programme involving open and closed kinetic chain exercises of lower extremity muscles, combined with self-management education, on dynamic balance using the SEBT, pain and muscle strength.

2. MATERIAL AND METHODS

A pilot experimental before-and-after study design was used to investigate the immediate effects of a six-week exercise programme. Prior to the study starting, ethical approval was obtained from the North West Research Ethics Committee and University Research and Governance Ethics Committee and informed written consent was obtained from each participant.

2.1. Participants

Participants were approached from the physiotherapy waiting lists at a local Hospital by a member of the Physiotherapy team. Inclusion criteria included a diagnosis of predominant medial knee OA either clinically by meeting the American College of Rheumatology (ACR) criteria for knee OA [22] and/or radiologically as reported by a musculoskeletal radiologist. The clinical classification criteria of the ACR is a common method used in clinical practice to identify symptomatic knee OA, in which knee pain on most of the days of the previous month is the key feature. In addition to knee pain, the patient has to meet at least three out of six of the following criteria to be diagnosed with knee OA: age more than 50 years, morning stiffness for less than 30 minutes, crepitus with movement, bone tenderness, bone enlargement, and no palpable warmth [22]. Medial knee OA was determined clinically by tenderness and pain in the medial compartment only and not the lateral or patellofemoral compartments during weight bearing activities. Radiographic classification of knee OA severity was determined using the Kellgren and Lawrence scale (K/L) [23]. This scale consists of five grades (0-4): 0 = normal; 1 = possible osteophytes; 2 = definite osteophytes, possible joint space narrowing; 3 = moderate or multiple osteophytes, definite narrowing, some sclerosis, possible attrition; 4 = large osteophytes, marked narrowing, severe sclerosis, definite attrition. Knee OA is usually classified when K/L grade ≥ 2 [24, 25]. Patients were excluded from the study by the lead author if they had previous realignment surgery, gross ligament instability, a diagnosis of patellofemoral or lateral knee OA more than medial clinically and radiographically, wore or used an assistive device to help mobility, had severe cognitive, cardio-respiratory, musculoskeletal, or neurological problems other than knee OA, is taking medications or received corticosteroids in the knee in the last three months that may limit participation in the exercise programme and/or assessments. Participants were also excluded if they participated in other treatment programmes that might affect the results of this study, such as other exercise programmes.

2.2. Assessment procedure

Before the exercise programme, demographic data of all participants were recorded. In order to progress the participants' exercise regimen, an initial weight assessment was done in the first assessment session only, where each participant was asked to hold a weight (dumbbell) with both hands and do one bilateral squat. They were asked about the task difficulty and the weight was increased accordingly until the maximum weight they could hold while squatting was reached, which is referred to as their 1RM (Repetition Maximum). Then, 75% of this 1RM was used to determine each participant's 10RM [26], which was used in the first exercise session.

Dynamic balance, pain, and muscle strength were assessed at the start of the six-week exercise programme and within one week after the end of it. Both the affected and contralateral sides were assessed. The affected side was identified as the most symptomatic side in unilateral or bilateral knee OA and the contralateral side as the least affected.

The participant wore loose clothing and performed the test barefoot so as to remove any factors impeding their balance. Dynamic balance was assessed using a modified SEBT, Sport Performance Measurement Ltd, UK (www.star-excursion.com). It used the same principle as the test described by Robinson and Gribble [27], i.e. the participants have to balance on one foot and reach with the other as far as they can in different directions then return to double support without losing balance. The difference between the modified SEBT and the one used by Robinson and Gribble [27] is the way the directions are represented. In Robinson and Gribble [27], they were represented by lines taped on the ground in a star shape and participants had to stand in the centre on one leg and reach with the other as far as they can in each direction barely touching the line and return to double stance. However, to perform the test quickly and in a variety of locations, instead of taping lines to the ground we used a newly developed more convenient and portable platform to which a ruler that is marked at regular intervals (millimetres) is attached with a small block on it (Figure 1).

Insert Figure 1 about here

To simplify the test clinically and determine the effect of interventions on dynamic balance in patients with knee OA, the most relevant directions were tested. The anterior (A), and medial (M) directions, relative to the supporting limb, were chosen as hip abductors and quadriceps weakness alongside altered activation patterns were found in elderly populations with knee OA [28-30]. The anterior direction mainly activates the vastus medialis obliqus [31] hence it could show improvements in quadriceps activation and strength. Improvements in the medial direction might give an indication of improvements of muscle strength and activation of the hip abductors muscles. Also, the exercise protocol was designed to target these muscles.

Moreover, before the start of this study, the test re-test reliability of the raw and normalized balance data (to leg length) of both lower limbs were assessed on ten healthy volunteers; six women and four men (mean age 46 (SD 5.23) years; mean height 165 (SD 6.32) cm; mean weight 71.8 (SD 20.83) Kg). They attended the two testing sessions separated by 14 (SD 5) days. All participants signed a consent form before starting the study. Two-way-mixed average measures (ICC3,3) was used to assess balance assessment reliability. The standard error of measurement (SEM) was calculated as “pooled standard deviation x $\sqrt{1 - \text{ICC}}$” [32]. The 95% CI of SEM was calculated as “95% CI = ± 1.96 x SEM” to determine the range in which the participant’s true score lies [33]. Also, 95% minimal detectable change (MDC) was calculated as “SEM x 1.96 (the z value of 95% CI)” [34]. The result was then multiplied by 1.41 (the square root of 2) to make up for measurement error incurred in two testing occasions [35]. The lead author established high reliability in assessing dynamic balance using the modified SEBT. Both raw and normalised distance excursions demonstrated high reliability (ICC> 0.75) with SEM and 95% CI ranging from 1.94±3.81 cm to 3.00 ± 5.86 cm for raw data and from 2.34±4.60% to 3.49 ± 6.85% for normalised data. Also, the 95% MDC of raw and normalised data ranged from 5.39 cm to 8.29 cm and from 6.5% to 9.69%, respectively (Table 1). These findings are the first concerning the reliability of the modified SEBT in 40-60 year olds. Although balance data in the lateral direction were highly reliable, the healthy participants performed the test with difficulty. Therefore, it was not assessed in the patients diagnosed with knee OA in this study.

Insert Table 1 about here

The participants stood on the platform and, depending on the direction to be tested, they would stand either facing the ruler (A) or with their side to the ruler (M) (Figure 2). Their stance leg had to be placed on the crosshair on the platform. To increase reliability of stance foot placement on successive tests, the midpoint of each foot was marked. The midpoint was determined as the cross point of the foot length and width [36]. At the start of each test this mark on the stance foot was positioned as accurately as possible over the crosshair at the centre of the balance platform. Next, the participants were asked to first push the block using the most distal part of their other foot as far as possible, then touch the ruler and return their foot to the platform without losing balance. The farthest distance they could reach was marked by the location of the pushed block on the ruler, which is marked at regular intervals (centimetres and millimetres).

Insert Figure 2 about here

The participants were instructed to: keep the heel of their stance leg on the platform at all times; to push the block and not slide it by stepping on it; to control their movement and not push the block suddenly; and not to put too much weight on the ruler before returning to the platform. If any of these criteria was not met, the trial was repeated.

To account for leg length variation between participants, balance data was normalised to lower limb length which was measured in supine from the anterior superior iliac spine to the medial malleolus [37]. To decrease the possibility of learning effects; the leg to start with and the direction to start with were randomised [38]. The dominant leg was not determined in this study as dominance did not affect dynamic balance results on the original SEBT in all directions [39]. However, the focus in this study was on the most and least affected sides.

Each participant started with four practice trials in the two directions (A and M) [27, 39], then three test trials were performed in each direction for one leg, with one minutes rest between directions followed by the other leg, after having five minutes rest in between.

The average peak torque of the knee flexors and extensors and the hip abductors was assessed using the Biodex system 3 isokinetic dynamometer (Biodex Medical Systems, Shirley, N.Y., USA). Based on the results of a previous reliability study, knee flexors and extensors were assessed concentrically at 60°/s and isometrically at 45°, whereas the hip abductors were assessed isometrically at 0°. Data were normalised to body mass.

The pain and function in daily living activities subscales of the Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire [40] were assessed at baseline and after six weeks. Adherence was monitored by recording the participants' attendance to the treatment sessions.

2.3. Exercise programme

Participants attended a six-week group exercise programme once a week. Each session included a 20 minute self-management education session followed by 60 minutes of exercises.

The self-management education sessions provided the patients with information on the management of knee OA; including how to improve knee pain, muscle weakness, morning stiffness, and teaching them to pace their activities. These sessions also developed skills such as problem solving, decision making, resources utilisation, forming a partnership between the participant and their health care professional and taking action [41].

A circuit training exercise programme that focused on bilateral strengthening of lower extremity muscles was delivered. It consisted of ten exercises including: bilateral, split, and unilateral squats, step-ups, side lowers, side lying hip abduction, clam, bridging, knee extension exercises, and cycling on a stationary bike. Each of the squats, step-ups, and side lower exercises consisted of five levels to increase difficulty starting by performing the exercise supported (holding a surface for stability e.g. table), then unsupported, then the exercise was performed against resistance, then it was performed on a wobble board to challenge balance without resistance, and finally challenged balance with resistance. Dumbbells, ankle cuffs, and Theraband™ were used. The 10 RM determined the initial weight used by the patients. As the patients improved, the resistance was increased based on a modified Daily Adjustable Progressive Resistive Exercise (DAPRE) technique [42] and the participant's condition (appendix A). The modified DAPRE differed from the original in the frequency of exercise progression (weekly rather than daily) and the number of sets of each exercise (three instead of four sets) to decrease stresses on the knee joint. For a programme of three sets of 10 repetitions, the participants will do 10 repetitions of an exercise with their resistance for the first two sets, and then for the last set they will be asked to do as much repetitions as they can manage. From the number of repetitions in the last set, it will be determined if any changes to their resistance should be done in the next session (Table 2).

Insert Table 2 about here

Between the weekly exercise sessions home exercises were performed daily for 10-15 minutes. The patients were provided with weights, Therabands™, and an information booklet about OA and how to do the same exercises performed in class correctly to facilitate exercising at home. In addition, participants were asked to complete diaries to record the time and frequency of how much they exercised at home.

2.4. Statistical analyses

Data were checked for normality using the Kolmogorov-Smirnov test. Normally distributed data were assessed using paired t-tests to evaluate any changes in outcome measures pre-to post-exercise. Mean differences, which were calculated by subtracting the pre-exercise from the post-exercise data were utilised to enable comparison with future studies. Wilcoxon-sign rank test was used to assess the KOOS Pain and Function sub-scales data, and the median (range) to describe them as data is ordinal. It was also used to assess the demographic differences between the participants who completed the study and those who dropped out. All statistical tests were performed using SPSS (SPSS 16, IBM, New York, USA, version 16) and level of significance was set at $p<0.05$.

3. RESULTS

Of the 79 patients diagnosed with knee OA on the physiotherapy waiting list, a convenience sample of 19 participants enrolled in the study; 43 individuals did not respond to the invitation, 7 declined to participate, and 17 did not meet the inclusion criteria. Two-group exercise programmes were completed, with ten participants in the first and nine in the second group. Fourteen participants completed the study; twelve women and two men. Five participants dropped out; reasons included a car accident (n=1), family death (n=1), family commitment (n=2), previous medical condition (n=1). Baseline demographic data are presented in Table 3. The characteristics of the five who dropped out did not significantly differ to those completing the programme ($p>0.05$).

Insert Table 3 about here

On average, participants attended 5.36 (SD 0.84) of the six sessions with eight participants attending all six sessions (44%). Diaries showed good adherence to home exercises.

After the exercise programme, the affected side demonstrated significant improvements in dynamic balance in the A and M directions ($p=0.02$ and $p=0.01$, respectively) with a mean difference of -4.50 (6.38)cm and -5.81 (6.91)cm for raw balance data, and -5.06 (7.27)% and -6.59 (7.77)% for normalized data in the A and M directions, respectively (Table 4).

As for the contralateral side (least affected), balance data demonstrated significant improvements in the A direction ($p<0.001$) with a mean difference of -5.30 (4.52)cm, and -5.58 (5.35)% for raw and normalised data, respectively. However, balance in the M direction did not change significantly with a p-value and mean difference of 0.07, -3.85 (7.32), and 0.2, -2.99 (8.22) for raw and normalised data, respectively (Table 4).

Insert Table 4 about here

Bilateral concentric muscle strength of the knee flexors and extensors at 60°/s, isometric strength at 45°, and the isometric strength of the hip abductors at 0° significantly improved after the exercise programme ($p\leq0.001$) (Table 5 and 6).

Insert Tables 5 and 6 about here

Dynamic balance in knee osteoarthritis

Figure 3 represents the changes in balance and muscle strength on the affected and contralateral sides

Insert Figure 3 about here

After the exercise programme, there was a significant reduction in pain ($p<0.001$) with a median and range of 51.50 (47.00 - 62.50) at six weeks compared to 34.50 (29.25 - 41.25) at baseline. Also, function in daily living activities significantly improved ($p<0.001$) with a median and range of 55.50 (46.75 - 74.25) at six weeks compared to 39.00 (28.25 - 45.25) at baseline.

4. DISCUSSION

Strengthening lower extremity muscles using an exercise programme, in addition to an education programme to promote self-management, improved dynamic balance in the A and M directions (using the modified SEBT) on the affected side in knee OA.

The majority of literature on knee OA has assessed quiet standing balance only, i.e., postural sway [1, 43, 44] although dynamic balance was found to be impaired in fallers compared to non faller which might increase the risk of falling [45]. In this limited research, dynamic balance was assessed using the step test [17] which lacks the multi-directional challenge.

This is the first study to the authors' knowledge to investigate the effectiveness of exercises on dynamic balance using a modified SEBT in people with medial knee OA. Dynamic balance was assessed in the anterior and medial directions as they relate to functional activities such as walking straight ahead or sideways and turning to reach for something which might be associated with increased risk of falling in the elderly. The improvements in dynamic balance could be related to the decrease in pain and the increase in hip and knee muscle strength as strong muscles are needed to maintain the centre of gravity within the base of support [1]. Also, an observational study reported concentric and eccentric strength of the knee muscles accounted for 18.4% of the variability in dynamic balance, which was measured by leaning forward and backward as far as possible on force platforms in elderly population with chronic knee pain [5, 46]. They found weaker knee muscles at baseline resulted in greater decrease in balance after 30 months and stronger knee and ankle muscles predicted better balance. Furthermore, pain resulted in poorer balance in the presence of weak knees.

Alternatively, Thorpe and Ebersole [47] reported that strength does not significantly affect excursion distance using the SEBT, whereas muscle activation patterns and the participant's training condition potentially do. They assessed athletic and non-athletic healthy female participants only who did five test trials of the SEBT after two familiarisation sessions of six practice trials (one 48-72 hours before the test and one immediately before the test). This might have limited their results as familiarisation with the test could reduce the possibility of detecting muscle strength contribution to the excursion distance.

In the current pilot study, muscle strength and pain significantly improved with a significant increase in excursion distances. Therefore, these preliminary results suggest muscle strength and pain affect dynamic balance. In addition, function in daily living activities significantly improved after the exercise programme. A positive correlation was found between concentric knee muscle strength at 60°/s and function in knee OA [48]. Therefore, the enhanced function is likely to be a result of the increase in knee muscle strength after the pilot exercise programme.

As the SEBT might require neuromuscular control and co-contraction of the muscles of the stance leg to increase excursion distance and knee antagonist muscles co-contraction is increased in knee OA [49], the reported decrease in muscle co-contraction after the current exercise programme might have affected the excursion distances [50]. The relationship between muscle co-contraction and dynamic balance has not been investigated. It might be that the exercises enhanced the co-ordination between the different muscles of the lower leg, so they are activated only when they are needed and this improved balance. The mechanisms behind dynamic balance deficits need further investigation.

The SEBT has not been used previously in knee OA research, although it has been used with other knee pathologies, such as anterior cruciate ligament injury [21]. However, this study demonstrates that the use of the SEBT potentially offering a unique way of assessing multi-directional balance, although a larger study is needed to determine the effectiveness of exercises on dynamic balance measured with the SEBT in knee OA.

This pilot study is also the first to investigate the effect of exercises on dynamic balance of the contralateral side in knee OA. After the current exercise programme, dynamic balance on the contralateral side significantly improved in the A direction only. Balance in the M direction demonstrated an increase, but it was not significant. The M direction might need the neuromuscular control and muscle strength of the hip abductors in addition to the knee muscles. Hip abductors are weaker on the affected side in knee OA compared to healthy participants [28], but this was not assessed on the contralateral side. It might be that the hip abductors on the contralateral side are not as involved as those on the affected side (i.e. they are stronger), which resulted in an insignificant change in balance in the M direction. In addition, lack of significant difference in the M directions might be due to the small sample size.

Although dynamic balance significantly improved, this improvement might not be clinically significant. MDC values reported in the reliability study, which was performed on healthy 40-60 year olds, were larger than the change in dynamic balance in the A and M directions after the exercise programme. These values are expected to be higher in people with knee OA therefore this should be further investigated.

An experimental before-and-after pilot study design with a small sample size (n=14), where clinical and not radiographic assessment of knee OA was performed in three participants, is a limitation to this study. In addition, a systematic review has reported a small to medium correlation between core muscle strength and balance in healthy populations [51]. However, this was not assessed in this study which might have affected the results. Moreover, an assessment of fall risk in individuals with knee OA was not performed. Therefore, the effectiveness of the exercise programme should be explored in an RCT with proper radiographic assessment of knee OA severity, assessment of core muscle strength and risk of falls, blinding and allocation concealment. The participants showed good adherence to the programme. Five participants dropped out of the study, however this would not question the validity of the exercise programme as their reasons for dropping out were not related to the exercises. The exercise programme was feasible, it was delivered based on usual practice, experience, and the resources available.

5. CONCLUSION

A six-week exercise programme targeting the lower extremity muscles, integrated with education session, significantly improved dynamic balance in patients diagnosed with knee OA. As knee OA population are at high risk of falling as a result of aging and the changes associated with their condition, this programme may have the potential for decreasing the rate of falling by improving their dynamic balance. This should be further investigated in larger studies.

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BILATERAL SQUAT





1. Supported

- Hold on to a stable surface.
- ***Slowly*** bend your knees as if you are going to sit down and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.

2. Unsupported

- Do not hold on to anything
- ***Slowly*** bend your knees as if you are going to sit down and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.

3. Unsupported with weight

- Hold the weight your physiotherapist chose for you.
- ***Slowly*** bend your knees as if you are going to sit down and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions

4. On a cushion

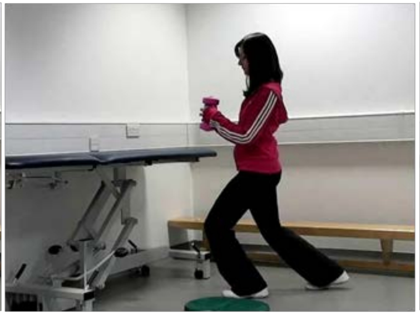
- Stand on a cushion.
- Without any support ***slowly*** bend your knees as if you are going to sit down and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions

5. On a cushion with weight

- Hold the weight your physiotherapist chose for you.
- Stand on a cushion.
- Without any support ***slowly*** bend your knees as if you are going to sit down and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.

- Do not lower yourself so far that you cannot straighten back up by yourself or that you feel pain in your knees.
- Your exercise should ***always*** be pain free (minor discomfort).
- If you could not do 3 groups of 10 repetitions, start with 3 groups of 5 repetitions and increase the repetitions as you get fitter.
- Do not change the weight your physiotherapist picked for you as it is chosen based on your condition.

SPLIT SQUAT



1. Supported

- Hold on to a stable surface.
- Move one of your legs backward with the toes touching the ground.
- ***Slowly*** bend your knees and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat with the other leg moved backward.

2. Unsupported

- Do not hold on to anything
- Move one of your legs backward with the toes touching the ground.
- ***Slowly*** bend your knees and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat with the other leg moved backward

3. Unsupported with weight

- Hold the weight your physiotherapist chose for you.
- Move one of your legs backward with the toes touching the ground.
- ***Slowly*** bend your knees and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat with the other leg moved backward

4. On a cushion

- Stand with one leg on a cushion and the other moved backward with the toes touching the ground.
- Without any support ***slowly*** bend your knees and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat with the other leg moved backward

5. On a cushion with weight

- Hold the weight your physiotherapist chose for you.
- Stand with one leg on a cushion and the other moved backward with the toes touching the ground.
- Without any support ***slowly*** bend your knees and then straighten them up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat with the other leg moved backward

UNILATERAL SQUAT





1. Supported

- Hold on to a stable surface.
- Stand on one leg.
- ***Slowly*** bend your knee and then straighten it up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat the exercise on the other leg.

2. Unsupported

- Do not hold on to anything
- Stand on one leg.
- ***Slowly*** bend your knee and then straighten it up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat on the other leg.

3. Unsupported with weight

- Hold the weight your physiotherapist chose for you.
- Stand on one leg.
- ***Slowly*** bend your knee and then straighten it up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat on the other leg.

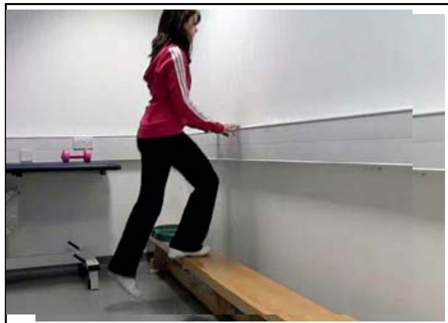
4. On a cushion

- Stand on one leg on a cushion.
- Without any support ***slowly*** bend your knee and then straighten it up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat on the other leg.

5. On a cushion with weight

- Hold the weight your physiotherapist chose for you.
- Stand on one leg on a cushion.
- Without any support ***slowly*** bend your knee and then straighten it up.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat on the other leg.

STEP UP



1. Supported

- Stand in front of a step.
- Hold on to a stable surface (for example the wall).
- Place one foot on the step (This foot will not move throughout the exercise).
- With your other leg ***slowly*** step up till your foot is on the step too.
- ***Slowly*** step down with the same leg.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat the exercise on the other leg.

2. Unsupported

- Stand in front of a step
- Do not hold on to anything.
- Place one foot on the step (This foot will not move throughout the exercise).
- With your other leg ***slowly*** step up till your foot is on the step too.
- ***Slowly*** step down with the same leg.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat the exercise on the other leg

3. Unsupported with weight

- Stand in front of a step.
- Hold the weight your physiotherapist chose for you.
- Place one foot on the step (This foot will not move throughout the exercise).
- With your other leg ***slowly*** step up till your foot is on the step too.
- ***Slowly*** step down with the same leg.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat the exercise on the other leg

4. On a cushion

- Stand in front of a step.
- Place a cushion on the step in front of you.
- Place one foot on the cushion (This foot will not move throughout the exercise).
- Without any support ***slowly*** step up with your other leg till your foot is on the step too.
- ***Slowly*** step down with the same leg.
- Repeat this exercise as 3 groups of 10 repetitions.
- Repeat on the other leg.

5. On a cushion with weight

- Stand in front of a step.
- Place a cushion on the step in front of you
- Hold the weight your physiotherapist chose for you.
- Place one foot on the cushion (This foot will not move throughout the exercise).
- ***Slowly*** step up with your other leg till your foot is on the step too.
- ***Slowly*** step down with the same leg
- Repeat as 3 groups of 10 repetitions.
- Repeat on the other leg.

SIDE LOWER

1. Supported

- Stand sideway near a step.
- Hold on to a stable surface (for example a wall).
- Place the foot closer to the step on it (This foot will not move throughout the exercise).
- ***Slowly*** move your other leg upward till it is on the same level as the foot on the step.
- ***Slowly*** move it down without touching the ground and repeat.

2. Unsupported

- Stand sideway near a step
- Place the foot closer to the step on it (This foot will not move throughout the exercise).
- ***Slowly*** move your other leg upward without holding anything till it is on the same level as the foot on the step.
- ***Slowly*** move it down without touching the ground and repeat.

3. Unsupported with weight

- Stand sideway near a step and hold the weight your physiotherapist chose for you.
- Place the foot closer to the step on it (This foot will not move throughout the exercise).
- ***Slowly*** move your other leg upward till it is on the same level as the foot on the step.
- ***Slowly*** move it down without touching the ground and repeat.

4. On a cushion

- Stand sideway near a step.
- Place a cushion on the step.
- Place the foot closer to the step on the cushion (This foot will not move throughout the exercise).
- ***Slowly*** move your other leg upward without holding anything till it is on the same level as the foot on the step.
- ***Slowly*** move it down without touching the ground and repeat.

5. On a cushion with weight

- Stand sideway near a step and hold the weight your physiotherapist chose for you.
- Place a cushion on the step and put the foot closer to the step on it (This foot will not move throughout the exercise).
- ***Slowly*** move your other leg upward till it is on the same level as the foot on the step.
- ***Slowly*** move it down without touching the ground and repeat.

Do the exercises above on both legs as 3 groups of 10 repetitions. If you could not, start with 3 groups of 5 repetitions and set a goal to reach 10 repetitions. Have short rests between groups and between legs.

CLAM EXERCISES

1. Without resistance

- Lie on your side and bend your arm for support.
- Keep your feet together.
- ***Slowly*** move your upper knee away from your bottom leg with your feet still together.
- ***Slowly*** bring your knee down and repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

2. Small range (thera-band)

- Lie on your side.
- Place the band your physiotherapist gave to you around your thighs just above your knees.
- Keep your feet together
- ***Slowly*** move your upper knee away from your bottom leg for a small distance with your feet still together.
- ***Hold*** 3-5 seconds
- ***Slowly*** bring your knee down and repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

3. Big range (thera-band)

- Lie on your side.
- Place the band your physiotherapist gave to you around your thighs just above your knees.
- Keep your feet together
- ***Slowly*** move your upper knee away from your bottom leg as far as you can with your feet still together.
- ***Hold*** 3-5 seconds
- ***Slowly*** bring your knee down and repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

4. Small range (weight)

- Lie on your side.
- Place the weight your physiotherapist gave to you around your upper thigh just above your knees.
- Keep your feet together
- ***Slowly*** move your upper knee away from your bottom leg for a small distance with your feet still together.
- ***Hold*** 3-5 seconds
- ***Slowly*** bring your knee down and repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

5. Big range (weight)

- Lie on your side.
- Place the weight your physiotherapist gave to you around your upper thigh just above your knees.
- Keep your feet together
- ***Slowly*** move your upper knee away from your bottom leg as far as can with your feet still together.
- ***Hold*** 3-5 seconds
- ***Slowly*** bring your knee down and repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

- When you lie down on your side, support yourself on your elbow and keep your back straight. You upper leg only should be moving and not your trunk.
- The band will give resistance to your movement which will strengthen your muscles.

Hip abduction




1. Small range without weight

- Lie on your side and bend your arm and bottom leg for support.
- Keep the upper leg straight and in line with your body.
- ***Slowly*** raise your upper leg up for a small distance (see picture). ***Hold*** briefly and relax.
- Repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

2. Big range without weight

- Lie on your side and bend your arm and bottom leg for support.
- Keep the upper leg straight and in line with your body.
- ***Slowly*** raise your upper leg up a little more than the previous step (see picture). ***Hold*** briefly and relax.
- Repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

3. Small range, weight on thigh

- Lie on your side and bend your arm and bottom leg for support.
- Place the weight your physiotherapist gave you around your upper thigh just above your knee.
- Keep the upper leg straight.
- ***Slowly*** raise your upper leg up for a small distance. ***Hold*** briefly and relax
- Repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

4. Big range, weight on thigh

- Lie on your side and bend your arm and bottom leg for support.
- Place the weight your physiotherapist gave you around your upper thigh just above your knees.
- Keep the upper leg straight.
- ***Slowly*** raise your upper leg up a little more than the previous step (see picture). ***Hold*** briefly and relax
- Repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

- When you lie down on your side, support yourself on your elbow and keep your back straight. Your upper leg should be the only part moving and not your trunk.
- Do not bring your upper leg in front of you as you move it. It should always be a little bit behind you with your foot pointing up.

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Continued Hip abduction

5. Small range, weight above ankle

- Lie on your side and bend your arm and bottom leg for support.
- Place the weight your physiotherapist gave you just above your ankle.
- Keep the upper leg straight and in line with your body.
- ***Slowly*** raise your upper leg up for a small distance (see picture). Hold briefly and relax.
- Repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

6. Big range, weight above ankle

- Lie on your side and bend your arm and bottom leg for support.
- Place the weight your physiotherapist gave you just above your ankle.
- Keep the upper leg straight and in line with your body.
- ***Slowly*** raise your upper leg up a little more than the previous step (see picture). Hold briefly and relax.
- Repeat as 3 groups of 10 repetitions.
- Roll over and repeat on the other side.

Bridging exercises

1. On both legs without resistance

- Lie on your back with knees bent and feet a small distance apart.
- ***Slowly*** move your back away from the ground as far as you can.
- ***Slowly*** lower your back and repeat.
- Repeat as 3 groups of 10 repetitions.

2. On both legs with band

- Lie on your back with knees bent and feet a small distance apart.
- Place the band your physiotherapist gave you around your thighs just above your knees.
- ***Slowly*** move your back away from the ground as far as you can and at the same time move your knees away from each other against the band.
- ***Slowly*** lower your back and repeat.
- Repeat as 3 groups of 10 repetitions.

3. On one leg

- Lie on your back with knees bent and feet a small distance apart.
- Straighten one leg and s***lowly*** move your back away from the ground as far as you can.
- ***Slowly*** lower your back and repeat.
- Repeat as 3 groups of 10 repetitions
- Repeat on the other side.

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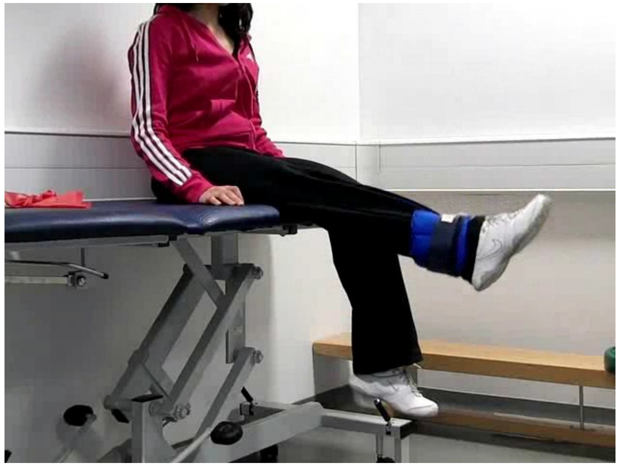
Knee extension



- Place the weight your physiotherapist gave you on your leg just above the ankle.
- Sit on a chair and slowly move your leg away from you till your leg is straight.
- Slowly bend your knee and repeat
- Repeat as 3 groups of 10 repetitions.
- Repeat on the other side.