The Knee 23 (2016) 849–856

Contents lists available at ScienceDirect

The Knee

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

Lara Al-Khlaifat [a,b,*], Lee C. Herrington [a], Sarah F. Tyson [c], Alison Hammond [a], Richard K. Jones [a]

[a] School of Health Sciences, University of Salford, Salford M66PU, UK
[b] Faculty of Rehabilitation Sciences, The University of Jordan, 11942 Amman, Jordan
[c] School of Nursing, Midwifery and Social Work, University of Manchester, Manchester M13 9PL, United Kingdom

ARTICLE INFO

Article history:
Received 10 January 2015
Received in revised form 3 May 2016
Accepted 17 May 2016

Keywords:
Knee osteoarthritis
Dynamic balance
Exercise
Star Excursion Balance Test

ABSTRACT

Background: Dynamic balance and quiet standing balance are decreased in knee osteoarthritis (OA), with dynamic balance being more affected. This study aimed 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. Dynamic balance on the affected side demonstrated significant improvements 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.

Conclusions: 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.

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 while 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 to 1.46] and injurious falls (RR 1.27, 95% CI 1.01 to 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

☆ Disclosure of funding: this study was funded by The University of Jordan and The University of Salford.

* Corresponding author at: Room 304, Faculty of Rehabilitation Science, Physiotherapy Department, University of Jordan, 11942 Amman, Jordan. Tel.: +962 796161493.
E-mail addresses: L.Khlaifat@ju.edu.jo, L.Al-Khlaifat@edu.salford.ac.uk (L. Al-Khlaifat).

http://dx.doi.org/10.1016/j.knee.2016.05.006
0968-0160/

while stepping with the other for 15 s on a 15 cm-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 six-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 and 50 years of age [19]. Moreover, Bouillon and Baker [20] reported that healthy middle aged-adults (40 to 54 years) had a significantly lower reach distances in the anterior-medial, medial, and posterior-medial directions compared to healthy young adults (23 to 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 this test 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 are 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 min, 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.

On the other hand radiographic classification of knee OA severity was determined using the Kellgren and Lawrence scale (K/L) [23]. This scale consists of five grades (0 to 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, and 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).

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