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ORIGINAL ARTICLE

Feasibility of a Home-Based Therapeutic Exercise Program in Individuals With Knee Osteoarthritis

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ABSTRACT

Objectives: This study aims to evaluate the feasibility and potential benefits of a four-week home-based therapeutic exercise program for individuals with osteoarthritis (OA) of the knee.

Patients and methods: Feasibility outcomes, namely the recruitment rate, retention rate, exercise adherence and adverse events, as well as pain, knee muscle strength, range of motion, functional mobility, physical function, and postural sway were assessed on 15 individuals (4 males, 11 females; mean age 62.8±2.5 years; range 55 to 83 years) with knee OA before and after a four-week home-based therapeutic exercise program.

Results: The main results indicated that this program was feasible, as indicated by recruitment, adherence, and safety outcomes. The retention rate was 80% and the overall exercise adherence for those completing the program was 93%. The exercise program improved significantly pain intensity (Visual Analog Scale: 5.8±2.8 to 3.8±2.4 cm, p=0.006), functional mobility, muscle strength, and physical function (Knee injury and OA Outcome Score-Physical Function Short-form: 53.8±21.0 to 41.3±13.9 points, p=0.011).

Conclusion: This home-based therapeutic exercise program is feasible for individuals with OA of the knee and seems to improve pain intensity, functional mobility, muscle strength, and physical function.

Keywords: Exercise, physical function, physical therapy, osteoarthritis.

Osteoarthritis (OA) is the most frequent joint disorder and accounts for high functional sequelae and economic impact, interfering with daily living, recreational and occupational activities.[1,2] The clinical features of OA include joint pain, crepitus, stiffness after immobility, and limitation of movement that are not always associated with radiographic alterations.[2-4] Obesity, joint injury, and impaired muscle function are modifiable risk factors for the development of OA, which tends to develop slowly and last a decade or more.[1]

Osteoarthritis is a chronic disease frequently overlooked by health-care professionals, who see "joint death" as an inevitable stage and wait passively for it.[1] Knee OA as a chronic condition should not be an exception and should be prevented and treated early with a comprehensive approach. The guidelines for the non-surgical management of knee OA emphasize the importance of reducing pain and stiffness, and preserving mobility, leading to an improved functionality and quality of life.[5] Exercise (land-based and water-based) and strength training are among the therapeutic

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options recommended to all individuals with knee OA.[5-7]

Exercise proved to be effective and is highly recommended; however, patients have to participate in exercise programs to get the benefits. The availability of excise programs is often an issue, particularly in small towns and rural areas. Indeed, a supervised exercise program performed at gyms or rehabilitation clinics may not be available for all patients due to several different reasons (e.g. lack of offer - rural areas without access to a program; financial restraints; lack of time to attend supervised classes). Thus, a home-based intervention may be a good option, as it overcomes several barriers to exercise, namely exercise-related costs, lack of transportation, facilities/equipment, and time. Previous studies provided encouraging results by showing that better adherence to home exercises was associated with better patient outcomes of pain, physical function, and self-perceived effect.[8]

With the growing aging population and increasing prevalence of obesity, the number of individuals with knee OA is likely to increase in coming years,[9] increasing the burden of the disease and putting pressure in the physiotherapy services and exercise care providers. Therefore, there is a need to develop home-based, low-cost, time-efficient exercise interventions targeting particular muscle groups in order to increase strength, functional mobility, and physical function in this group of individuals. In the present study, we designed a low-cost (the only material needed was an elastic band) and time-efficient exercise intervention to be performed at home and without supervision. Still, benefits from such exercise interventions should not be expected without adherence to the program. In this sense, we first attempted to show that this particular program is feasible and patients can and are willing to perform it. Therefore, in this study, we aimed to evaluate the feasibility and potential benefits of a four-week home-based therapeutic exercise program for individuals with OA of the knee.

PATIENTS AND METHODS

Fifteen patients (4 males, 11 females; mean age 62.8±2.5 years; range 55 to 83 years) with OA of the knee participated in the present study that took place at Hospital Da Luz Clínica De Oiã between May 2015 and July 2015. Potential candidates were identified in the clinical files of the Hospital Da Luz Clínica De Oiã. Then, candidates were invited to participate by telephone or face to face, and those who agreed were subsequently screened according to the following *inclusion criteria*: >50 years of age and knee OA assessed according to the clinical criteria of the American College of Rheumatology. *Exclusion criteria:* physical disabilities precluding autonomous exercise, knee replacement, cancer, uncontrolled hypertension or diabetes, auto-immune or psychiatric/cognitive disorders, anti-inflammatory and/or analgesic medication. The study protocol was approved by the Hospital Da Luz - Aveiro Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

In addition to the feasibility variables, we assessed the following variables: anthropometric, clinical, pain, muscle strength, range of motion, functional mobility, postural sway, and physical function measurements at baseline and 48 hours after the last session.

The participants were familiarized with the experimental protocol and apparatus. Each participant completed all data collection in one session. Each variable was assessed by the same examiner, not blinded to the study purpose. In cases of bilateral knee OA, the knee assessed was that with more pain complaint at baseline.

The feasibility outcomes included the assessment of the recruitment rate, retention rate, exercise adherence, and adverse events. An examiner registered the number of participants ineligible for study participation or refusing to participate (recruitment rate), number of dropouts, patients completing all the assessments (retention rate), and occurrence of adverse events. Exercise adherence (including the number of sessions, exercises per session, sets, and repetitions) was registered by the participants on exercise log sheets. Adherence was considered as the relationship of intended exercise sessions and the number of actually completed sessions.

Demographic and clinical data were obtained from health records and consisted of age, education, marital status, occupation, present

and past health conditions, medication, previous physiotherapy or medical treatments to knee OA.

Height and weight were measured (Seca 285, Seca, Birmingham, United Kingdom) and Body Mass Index was calculated. Participants were asked to rate pain intensity using a 10 cm Visual Analog Scale (VAS) anchored with "no pain" and "worst pain imaginable".[10]

Functional mobility was assessed using the Timed Up and Go (TUG) test. Before the assessments, participants were asked to perform two TUG test trials to familiarize themselves with the test. Participants were told to stand up from a chair, walk three meters as quickly and as safely as possible, cross a line marked on the floor, turn around, walk back, and sit down. The time taken for participants to rise from a chair, walk, turn, and return to the chair was measured (in seconds).[11] Time taken was attained by taking the best of the three trials.

A dynamometer (Advanced Force Gauge 2500N, Mecmesin Limited, West Sussex, UK) was used to assess the maximal isometric strength of the knee flexors and extensors. The force generated was measured with the force transducer of the dynamometer attached to the participant at the level of the distal third of the tibia. The participant was asked to sit on a chair with the back supported, hips flexed at ~95° and knee flexed at 90°. Before the assessment, three practice trials were given for each movement. Then, participants were asked to perform three maximal isometric voluntary contractions of the knee flexors and extensors. Each trial lasted five seconds, so the subjects could be instructed to increase their strength to maximum over that period. The rest between trials was of 30 seconds. The best of the three measurements was used for data analysis.

The measurement of the active range of motion of the knee joint was performed using a standard goniometer as previously described.[12] Participants were placed on dorsal and ventral decubitus for measurement of knee extension and flexion, respectively. Then, they were asked to perform three flexion or extension movements actively. The best value of the three trials was taken for analysis.

Postural sway was assessed in a force platform (AMTI BP400600-2000, AMTI, Watertown, MA, USA) with a Bertec digital amplifier AM6500 (Bertec Corp., Columbus, OH, USA), according to the recommendations.[13] Participants were asked to stand, barefoot, as still as possible over the force platform with their eyes opened, arms loosely hanging along the body and knees at full extension. Three practice trials were allowed before testing. Participants were asked to perform three valid double-leg stance trials of 30 seconds with a 15-second resting period in-between. Postural sway data were sampled at 500 Hz. A custom MATLAB R2014a (MathWorks, Madrid, Spain) program was used for data reduction. Variables derived from the analysis were center of pressure (CoP) displacement (antero-posterior [CoPa-p] and medio-lateral [CoPm-l]), CoP speed, and total CoP displacement.

Physical function was assessed with the Knee injury and Osteoarthritis Outcome Score-Physical Function Short-form (KOOS-PS).[14] KOOS-PS is a joint-specific measure of perceived health status composed by seven items that rate the degree of difficulty experienced over the previous week due to knee problems, with respect to: *(i)* rising from bed, *(ii)* putting on socks/stockings, *(iii)* rising from sitting, *(iv)* bending to the floor, *(v)* twisting/pivoting on injured knee, *(vi)* kneeling, and *(vii)* squatting. The items are scored on a five-point Likert scale (none, mild, moderate, severe, extreme) from 0-4. The KOOS-PS is scored by summing the raw response and then converting the raw score to a true score from 0 to 100 in which 0 represents no difficulty and 100 extreme difficulties.

The program was composed by range of motion and strength training exercises with an elastic band (TheraBand™, Akron, OH, USA), targeting knee muscles, namely quadriceps, improving the stability of the knee, and decreasing the symptoms of knee OA.[2] The program consisted of a total of 20 sessions with five sessions per week. The participants received a detailed handout with pictures and descriptions of the exercises together with an option of telephone contact with a physiotherapist whom they could call in case of any doubt.

At the first meeting, a physiotherapist taught the exercises to the participants and gave them a black elastic band, a printed handout, a training

diary, and an exercise log to register the sessions. In this meeting, the physiotherapist confirmed that the participant performed the exercises correctly and understood the program to be performed at home.

The program included five exercises: *(i)* isometric knee extension; the participant lying on the back with his legs straight out in front of him was told to squeeze his knee down towards the ground, while actively dorsiflexing the ankle, and to hold it for five seconds. *(ii)* Straight leg raising with the participant lying on the back; the position was held for five seconds, before the leg was lowered slowly back to the floor. *(iii)* Active range of motion exercise; the participant, lying prone, was asked to slowly bend and straighten the knee through its full range of motion and to hold the position of maximum flexion and extension for five seconds. *(iv)* Isometric knee extension at 90° with an elastic band; the participant was sitting comfortably in a chair with the hips and knees in 90° of flexion; the elastic band was tied to form a circle and placed around the distal third of the leg and around the leg of a piece of heavy furniture. The participant was facing away from the piece of furniture, the elastic band was stretched at the initial position, and then the participant was told to extend the knee tightening the elastic band and to hold that position for five seconds. *(v)* Isometric knee flexion at 90° with an elastic band; the participant was sitting comfortably in a chair with the hips and knees in 90° of flexion; the elastic band was tied to form a circle and placed around the distal third of the leg and around the leg of a piece of heavy furniture. The participant was facing the furniture, the elastic band was stretched at the initial position, and then the participant was told to pull his leg back tightening the elastic band and to hold that position for five seconds. The exercise protocol was performed as follows: in the first week, the participants performed one set of 10 repetitions of each exercise (duration of the session: 12 minutes); in the second week, they performed two sets of 10 repetitions (duration of the session: 24 minutes), in the third week, three sets of 10 repetitions (duration of the session: 36 minutes), and in the fourth week, three sets of 12 repetitions (duration of the session: 43 minutes). The resting period between repetitions and exercises/sets was five seconds and one minute, respectively.

Statistical analysis

Statistical analysis was performed using IBM SPSS statistics version 21.0 (IBM Corp., Armonk, NY, USA). The normality of data distribution was tested with the Shapiro-Wilk test and histograms. Variables normally or not normally distributed were reported as mean ± standard deviation and median (interquartile range), respectively. Student's paired t-test or Wilcoxon signed-rank test was performed for within-group comparisons. The level of significance was set as $p \leq 0.05$.

RESULTS

Baseline characteristics of the participants were described in Table 1. Of the 15 participants eligible for the study, 15 (100%) completed the baseline testing and received the intervention. With regard to retention rate, three participants withdrew before the final assessment. The reasons given included being on vacation at the time of the second assessment (n=2) and exacerbated pain due to a fall not related to the program (n=1). Therefore, 12 participants (80%) completed the program.

According to the exercise logs returned by the participants, the overall exercise adherence for the 12 participants completing the program was 93%; in average, they performed all exercises in 18 out of 20 sessions. Eight participants performed all sessions scheduled and all exercises,

Table 1. Baseline characteristics of study participants

	n	%	Mean±SD
Age (year)			62.8±2.5
Weight (kg)			79.9±13.9
Height (m)			1.6±0.1
Body Mass Index (kg/m^2)			31.9±5.3
Level of education			
4° year	4	33.3	
6° year	3	25	
9° year	3	25	
University degree	2	16.7	
Health conditions			
Hypertension	5	41.7	
Hip osteoarthritis	2	16.7	
Dorsal spondyloarthritis	4	33.3	
Cervical spondyloarthritis	2	16.7	
Cardiovascular disease	5	41.7	
Respiratory disease	1	8.3	
Depression	1	8.3	

SD: Standard deviation.

Table 2. Effects of exercise program on functional mobility, physical function, range of motion, pain, muscle strength and postural sway

	Baseline			Final			
	Mean±SD	Median	Interquartile range	Mean±SD	Median	Interquartile range	*p*
TUG (s)		9.7	4.1		8.8	2.1	0.023
KOOS-PS (points)	53.8±21.0			41.3±13.9			0.011
Knee flexion ROM (°)	87.9±14.0			90.3±14.3			0.078
Knee extension ROM (°)		-4.0	3.0		-3.0	2.0	0.252
VAS (cm)	5.8±2.8			3.8±2.4			0.006
Knee flexor strength (kg)		10.0	7.8		11.3	7.1	0.008
Knee extensor strength (kg)	22.7±10.4			27.5±9.4			0.022
COPa-p (mm)	22.5±6.1			23.9±5.1			0.543
COPm-l (mm)	15.7±6.5			13.7±5.6			0.395
Total COP (mm)	269.2±110.8			252.1±89.4			0.572
COP speed (mm/s)	89.7±36.9			82.8±31.8			0.503

SD: Standard deviation; TUG: Timed up and Go test; KOOS-PS: The Knee injury and Osteoarthritis Outcome Score-Physical Function Short-form; ROM: Range of motion; VAS: Visual analog scale; COPa-p: Antero-posterior displacement of center of pressure; COPm-l: Medio-lateral displacement of center of pressure; Total CoP: Total distance of center of pressure; CoP speed: Speed of center of pressure.

sets and repetitions. Two participants missed one session; one participant missed one session and did not perform the isometric exercises at 90° in two sessions. One participant missed two sessions; did not perform the exercises at 90° in nine sessions, and did not perform the active range of motion exercise in one session. The reason for not performing the entire session was knee pain during these exercises. No adverse events were reported besides pain during those exercises.

The four-week home-based therapeutic exercise program improved significantly pain intensity, functional mobility, muscle strength, and physical function (Table 2). Three participants reported no changes on pain, while the other nine (75%) had a minimal improvement of ≥1 on VAS. The program did not change body weight (79.9±13.9 to 79.9±14.1 kg, p=0.965), knee range of motion or postural sway (Table 2).

DISCUSSION

The main findings of this study indicate that the four-week home-based therapeutic exercise program was feasible, safe, and acceptable among potentially eligible participants with OA of the knee. The retention rate and the intervention adherence were good.

The effectiveness of a therapeutic exercise program depends on good adherence, which may be quite challenging to achieve and maintain for those with knee OA. The adherence in our study was similar to that of Bruce-Brand et al.,[15] who compared the effects of a six-week home-based resistance training and neuromuscular electrical stimulation on patients with moderate to severe knee OA and reported an exercise adherence of 91% and 83%, respectively. Steinhilber et al.[16] reported an adherence of 99% to a progressive home-based strengthening exercise program; nonetheless, these individuals also attended a supervised institutional exercise therapy session per week. Adherence is particularly relevant in this clinical condition, as a previous study showed that higher exercise adherence was associated with greater improvements in physical function and disability.[17]

Our program had a completion rate of 80%, which is slightly higher than reported by others.[15] Of the three non-completers, two participants reported to have performed the first three weeks of the program, but missed the final assessment due to being on vacation. One participant dropped out prior to the final assessment due to lower limb pain in consequence of a fall not related to the program. Chaipinyo and Karoonsupcharoen[18] used a design similar to ours, i.e. they assessed the effects of a four-week home-based strength exercise program, 30 repetitions/leg/day × 5 days/week, and reported a slightly lower completion rate (75%) in the strength group; in their study, six (25%) participants did not complete the study.

This modality of intervention may represent a more realistic approach towards knee OA

rehabilitation in those patients with low to moderate symptoms, as it does not require supervision or specialized equipment and, compared to supervised interventions, has lower financial costs, is less labor-intensive and time-consuming, and provides more schedule flexibility. Another advantage of a non-supervised intervention is that it reflects more realistically how treatment can be continued at home after a period of in-hospital/clinic/gym supervised treatment. Despite being home-based, a physical therapist is required to instruct participants, ensure that they know how to perform the exercises safely, and respond to any doubt in the treatment progression. A limitation of this kind of intervention relates to the difficulties in controlling and ensuring identical relative training loads and progressions between participants.

The preliminary positive results on pain, functional mobility, muscle strength, and physical function suggest that this simple and low-cost intervention is potentially effective and is worthy of further investigation. Pain decreased significantly after the intervention in nine participants, i.e. a minimum reduction of 0.9 in VAS.[19] A recent systematic review with meta-analysis comparing land-based therapeutic exercise with a non-exercise control showed that therapeutic exercise improves pain, physical function, and quality of life of those with knee OA.[9] A recent study also demonstrated a significant pain reduction after a six-week group exercise program integrated with self-management education.[20] Nonetheless, a meta-analysis of randomized controlled trials indicated that the effects on pain are maximized when manual mobilization or strength training is added to exercise therapy.[21]

The improvements observed in muscle strength are in line with the results of previous studies.[15,16,22] Lun et al.[22] recently showed that both isolated hip or leg strengthening exercises improve knee pain, physical function, and quality of life in patients with knee OA. Indeed, there is evidence that supervised resistance exercise is beneficial in terms of reducing pain, alleviating stiffness, and improving physical function in patients with knee OA.[23] Our results in clinical outcomes should be considered as preliminary and read carefully, since this study did not encompass a control or comparison group. Without a control group, we were unable to determine the effect of the intervention versus that of natural course of the disease or the placebo effect. Our results may be used to inform future randomized controlled trials, single or multi-center, that can address these limitations and enable further analyses of the (cost-) effectiveness of this program for patients with knee OA.

Some limitations of this study should be acknowledged. Being a feasibility study, we did not include a control group, which is a limitation with respect to determining the effects of the program. Nonetheless, this initial pilot work for this particular home-based treatment of patients with knee OA generated outcomes that can be used to determine the sample size in subsequent randomized controlled studies aiming to ascertain the positive findings of this study. We enrolled mainly females, thus our results could not exclude any different responses from males.

In conclusion, this four-week home-based therapeutic exercise program for individuals with OA of the knee is safe, well-accepted, and feasible. The preliminary results show overall increases in pain, functional mobility, muscle strength, and physical function in over four weeks. Still, this promising clinical improvement should be interpreted cautiously given the lack of a control group and the small sample size.

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Declaration of conflicting interests

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