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Original Article

Effect of a physiotherapy rehabilitation program on knee osteoarthritis in patients with different pain intensities

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Abstract. [Purpose] To examine the effect of physiotherapy rehabilitation program on moderate knee osteoarthritis in patients with different pain intensities. [Subjects and Methods] Sixty subjects (37 men and 23 women) with moderate knee osteoarthritis participated in the current study. Randomization software was used to select the participating subjects' numbers from the clinic records. They were classified into three groups according to pain intensity: mild, moderate, and severe pain groups. All groups underwent a standard set of pulsed electromagnetic field, ultrasound, stretching exercises, and strengthening exercises. Pain intensity, knee range of motion, knee function, and isometric quadriceps strength were evaluated using the visual analogue scale, universal goniometer, Western Ontario and McMaster Universities osteoarthritis index, and Jamar hydraulic dynamometer, respectively. The evaluation was performed before and after a 4-week rehabilitation program. [Results] All groups showed significant differences in pain intensity, knee range of motion, isometric quadriceps strength, and knee function. The score change in moderate pain group was significantly greater than those in mild and severe pain groups. [Conclusion] Pain intensity is one of the prominent factors that are responsible for the improvement of knee osteoarthritis. Consequently, pain intensity should be considered during rehabilitation of knee osteoarthritis.

Key words: Knee osteoarthritis, Pain intensity, Quadriceps strength

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INTRODUCTION

Degenerative joint arthritis is the most common joint disorder that is caused by biomechanical stresses affecting both the articular cartilage and subchondral bone. Degenerative osteoarthritis (OA) is the most common form of arthritis and is a major cause of morbidity and functional limitation, especially in elderly patients[1)]. The incidence of knee OA is expected to increase over the next decades[2)]. Knee OA is directly related to disabilities due to pain, quadriceps dysfunction, and impaired proprioception. Moreover, knee OA is responsible for the impaired ability of the quadriceps muscle to control force in patients with OA. Nevertheless, exercise therapy is effective in reducing the pain and improving the function of patients with knee OA[3)].

Unlike many other pain conditions in which the underlying injury typically heals or resolves, OA is a disease that does not resolve. Thus, OA is typically accompanied by chronic pain. Whether, and to what degree, this ongoing chronic pain (i) plays an important nociceptive role, (ii) represents maladaptive pain, or (iii) reflects other aspects of the pain experience are not clear[4)].

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Pain is one of the most commonly reported and prominent factors that are responsible for physical inactivity in patients with knee OA[5]. This impairment in physical activity associated with knee OA has important implications for aerobic power and cardiovascular health. Hence, patients with OA are at a particular risk of poor health outcomes[6]. Pain pattern and severity of knee OA as either absent, mild, moderate, severe, or very severe could affect the range of motion (ROM) that involves daily activities and quality of life[7].

Moreover, muscle weakness in knee OA usually results in joint stiffness and decreasing ROM that involves daily activities[8]. Quadriceps muscle impairment in knee OA is well documented in the literature. In addition, the differences in the magnitudes of muscle strength are caused by the differences in the subjects' characteristics, OA severity, pain severity, and definition of the control group[9–11]. Patients with knee OA experience chronic form of pain and show a declining ability to use their joints, which consequently weakens the muscles. Hence, these destabilise the joints and reduce the physical functions of patients; further, the motions required for the patients' daily activities become restricted[12].

Although pain is a symptom of OA that is present in almost all classification criteria for OA, there is often a discordance between reports of pain and radiologic OA[13–15]. It is suggested that this discordance applies, in particular, to the less severe grades of knee OA and that pain is more common in more severe grades of OA (1 and 2)[13, 14]. Moreover, Erden et al. reported that pain intensity and degrees of inaccuracy of knee joint position sense were positively correlated at 60° and 90° knee flexions. The relationship between pain intensity and knee joint position sense is very important for patients with OA in the improvement of rehabilitation programs[16]. Given these findings, only few studies have considered pain severity during rehabilitation programs for patients with knee OA. Therefore, the aim of this study was to examine the effect of a physiotherapy treatment program on moderate knee OA with different grades of pain intensity.

SUBJECTS AND METHODS

In this study, 78 patients with moderate bilateral knee OA were identified as potential participants based on the orthopaedic physical therapy clinic records. Seven patients did not meet the inclusion criteria, and five subjects refused to participate in the study. A total of 66 patients were recruited via convenience sampling. The participants were classified into three groups according to their pain intensity[17]: mild pain group (23 subjects), moderate pain group (21 subjects), and severe pain group (22 subjects). At the end of the 4-week treatment period, outcome data were available for 20/23 patients in the mild pain group, 20/21 in the moderate pain group, and 20/22 in the severe pain group. Some participants withdrew from the study and were lost to follow-up. Thus, 60 subjects (37 men and 23 women) participated in the current study. Their demographic data are shown in Table 1.

The inclusion criteria were as follows: age between 45 and 62 years, ≤grade 2 radiographic severity according to the Kellgren/Lawrence scale[18], diagnosis of moderate bilateral knee OA according to the American College of Rheumatology criteria[19], knee pain for more than 3 months in most days of the week, and patients are not obese. The criteria for the stages of knee OA are illustrated in Table 2. Conversely, the exclusion criteria were as follows: inflammatory knee disorders, metabolic bone disease, history of knee trauma, previous knee surgery, previous intra-joint injection, and use of analgesics in the past 3 months[20]. Written informed consent was obtained from all subjects. The study was conducted in accordance with the 1975 Helsinki Declaration principles, as revised in 1996. The study procedures were approved by the institutional review board of Faculty of Physical Therapy, Cairo University (Approval No. P.T.REC/012/001751).

The intensity of knee pain was evaluated using the visual analogue scale (VAS) after the patients have remained in a weight-bearing state for 5 minutes (walking or standing)[21]. The pain level was rated by each patient from 0 to 10 cm, where 0 represented 'no pain', and 10 represented 'unbearable pain'. The pain was also graded as follows: 0 to 4 mm, no pain; 5 to 44 mm, mild pain; 45 to 74 mm, moderate pain; and 75 to 100 mm, severe pain[17]. Based on these grades, the three groups of knee OA were created.

Measurement of active knee flexion ROM: While the patients were lying supine on an examination table, active knee flexion ROM was measured using a plastic universal goniometer with 25-cm arms, while the goniometer's pivot tip was placed on the femur's lateral epicondyle. The patients maintained maximum flexion of the knee joint with hip flexion. The angle between the maximum flexion and maximum extension was described as the excursion range. The range was measured thrice, and the mean value was calculated[21].

The patients' disability was evaluated using the valid and reliable modified Western Ontario and McMaster Universities osteoarthritis index (WOMAC)[22]. It is a questionnaire that evaluates disabilities in performing daily living activities. This method is relevant and appreciated for its simplicity and allows assessment of the patients' opinions of their functional disabilities.

The isometric quadriceps strength was measured using Jamar hydraulic dynamometer (Lafayette, IN 47903, USA). Such a device has been proven to have a good to excellent reliability in different populations[23, 24]. The patients were instructed to sit on the side of the bed with their back flat, arms crossed, hip at 90° flexion, and knee at 30° flexion. After ensuring stabilisation in these steps, the therapist held the dynamometer between his hand and the patients' limb segment. The dynamometer was positioned two finger widths above the lateral malleolus on the anterior aspect of the tibia, and the patients were then instructed to push the dynamometer with their maximum strength for 5 seconds. The mean value of the three repetitions with 2-minute intervals was calculated[25].

Table 1. Demographic data of participants

	Mild pain group (n=20)	Moderate pain group (n=20)	Severe pain group (n=20)	p value
Age (yrs)	55.90 ± 5.01	55.73 ± 5.80	56.10 ± 5.74	0.930
Height (cm)	170.14 ± 5.17	171.91 ± 4.34	170.34 ± 5.17	0.195
Weight(kg)	75.34 ± 5.94	76.17 ± 5.14	77.42 ± 6.53	0.274
Body mass index (kg/m^2)	26.14 ± 3.90	25.10 ± 3.72	26.00 ± 4.53	0.479
Gender (female/male)	8/12	6/14	9/11	0.610

Data are presented as mean ± standard deviation, $p<0.05$.

Table 2. Criteria of knee OA stages

Stage	Knee pain	Radiographic osteophytes	Age	Morning stiffness	Crepitus	Bony enlargement in physical examination
I	√	√	<40	-	-	-
II	√	√	>40	<30 min	√	-
II	√	√	>40	>30 min	√	-
IV	√	√	>40	>30 min	√	√

- Findings absent, √ Findings present.

In this study, the treatment program was firstly initiated for treating knee OA based on the Battecha and Soliman program[26]. All groups underwent a standard set of pulsed electromagnetic field (PEMF), ultrasound (US), and stretching and strengthening exercises. A PEMF device (ASA/Easy terza series, Italy) was used to provide electromagnetic therapy. The pulse frequencies were 50 Hz for the solenoids and up to 100 Hz for the applicators. The solenoid encircled the target limb segment at the level of the knee. Each patient was exposed to low-intensity 15 GPMF (Gauss permagnetic field) with a frequency of 50 Hz for 30 minutes per session. Thereafter, a US device (ITO, US/100, Japan) was used to provide deep heating therapy. Continuous US waves with a 1-MHz frequency and 1-watt/cm^2 power were applied using a 4-cm^2-diameter applicator. The US therapy lasted for 5 minutes per session[27]. Both PEMF therapy and US therapy were continued for three sessions weekly for 4 weeks.

Immediately after PEMF and US application, each patient was asked to perform stretching exercises and strengthening exercises in the following fixed sequence: hamstrings muscle stretching and calf muscle stretching. The physical therapist repeated the passive stretching exercises thrice per session. Each stretch was sustained for 30 seconds, with 10-second rest intervals[28]. After a rest period of 5 minutes, the patients were asked to perform the following: 1) isometric quadriceps contraction (quadriceps drill) in full knee extension maintained for 5 seconds, followed by a 5-second rest; the exercise was performed for 20 repetitions per session[29]; and 2) straight leg raising exercise in a crock lying position (the patients were asked to tense the quadriceps muscle, elevate the limb to 45° and maintain it for 6 seconds, and lower the limb slowly and then relax for 6 seconds; the exercise was performed for three sets of 10 repetitions per session)[28]. Both stretching and strengthening exercises were performed for three sessions weekly for 4 weeks. The evaluation and treatment procedures were done for the patients by the same therapist before and after the treatment period. They were instructed to maintain their activity levels during the study period[30].

Data were analysed using the Statistical Package for Social Sciences (IBM Corp.: Armonk, NY USA) version 20.0. A one-way analysis of variance was used to compare the effect of the physical therapy treatment on the VAS score, knee ROM, quadriceps strength, and WOMAC score among the three groups with knee OA. Score changes were also calculated. The level of significance was set at $p<0.05$.

RESULTS

The descriptive statistics of the VAS score, knee ROM, quadriceps strength, and WOMAC score of the three groups are presented in Table 3. The pre-intervention VAS score of the mild pain group was lower than those of the moderate and severe pain groups (p=0.001), and that of the moderate pain group was lower than that of the severe pain group (p=0.001). There was a significant reduction in pain intensity owing to the interventions in the three groups (p=0.001). The post-intervention VAS score of the mild pain group was significantly lower than those of the moderate and severe pain groups (p=0.001); further, the post-intervention VAS score of the moderate pain group was significantly lower than that of the severe pain group (p=0.001).

The pre-intervention ROM of the mild pain group was greater than those of the moderate and severe pain groups (p=0.001), without a significant difference between the pre-intervention ROMs of the moderate and severe pain groups (p=0.063). There was a significant improvement in the ROM owing to the interventions in the three groups (p=0.001). The post-intervention ROM of the mild pain group was significantly greater than those of the moderate and severe pain groups (p=0.008 and 0.001, respectively); moreover, the post-intervention ROM of the moderate pain group was significantly greater than that of the

Table 3. The values of pain intensity, knee ROM, quadriceps strength, and WOMAC of the three groups

Variables	Mild pain group (n=20)			Moderate pain group (n=20)			Severe pain group (n=20)		
	Pre	Post	Change score	Pre	Post	Change score	Pre	Post	Change score
Pain intensity	2.59 ± 0.63	1.45 ± 0.51	−1.14 ± 0.44	6.06 ± 0.51	4.04 ± 0.63	−2.02 ± 0.36	7.86 ± 0.43	6.50 ± 0.50	−1.36 ± 0.28
Knee ROM (°)	111.65 ± 8.34	122.50 ± 7.96	10.85 ± 3.20	101.65 ± 7.78	115.40 ± 10.30	13.75 ± 4.23	96.70 ± 7.05	107.20 ± 8.28	10.50 ± 4.51
Quadriceps strength (kg)	22.15 ± 4.08	26.25 ± 4.35	4.10 ± 1.78	19.23 ± 3.62	23.94 ± 4.17	4.72 ± 1.46	17.38 ± 3.02	21.03 ± 3.51	3.65 ± 1.25
WOMAC	28.40 ± 5.12	21.85 ± 4.46	−6.55 ± 1.70	46.85 ± 5.17	33.13 ± 5.27	−7.73 ± 1.48	57.13 ± 5.18	51.28 ± 4.88	−5.85 ± 1.26

Data are presented as mean ± standard deviation.

severe pain group (p=0.002).

The pre-intervention isometric quadriceps strength of the mild pain group was greater than those of the moderate and severe pain groups (p=0.019 and 0.001, respectively), without a significant difference between the moderate and severe pain groups (p=0.137). There was a significant improvement in the quadriceps strength of the three groups (p=0.001, 0.001, and 0.004, respectively). There was no significant difference between the post-intervention quadriceps strength of the mild and moderate pain groups (p=0.098). The post-intervention quadriceps strength of the mild and moderate pain groups was significantly greater than that of the severe pain group (p=0.001 and 0.012, respectively).

The pre-intervention WOMAC score of the mild pain group was lower than those of the moderate and severe pain groups (p=0.001), and that of the moderate pain group was lower than that of the severe pain group (p=0.001). There were significant improvements in the WOMAC scores owing to the interventions in the three groups (p=0.001). The post-intervention WOMAC score of the mild pain group was significantly lower than those of the moderate and severe pain groups (p=0.001), and that of the moderate pain group was significantly lower than that of the severe pain group (p=0.010).

The VAS score, knee ROM, and WOMAC score changes in the moderate pain group were significantly greater than those in the mild and severe pain groups (p=0.001, 0.001, 0.026, 0.013, 0.016, and 0.001, respectively). In the same context, there was no a significant difference between the mild and severe pain groups (p=0.064, 0.784, and 0.143, respectively).

There was no significant difference in the quadriceps strength score changes among the mild, moderate, and severe pain groups (p=0.203, 0.290 and 0.350, respectively). However, the score change in the moderate pain group was significantly greater than that in the severe pain group (p=0.030).

DISCUSSION

To the best of our knowledge, this is the first study to classify patients with moderate knee OA according to their pain intensity. The results of this study support the hypothesis that a physiotherapy treatment program has different effects in patients with moderate knee OA with different grades of pain intensity, indicating that the magnitude of pain is one of the prominent factors that are responsible for the improvement of knee OA. However, these results are not supported by the findings of Külcü et al. who reported that there is no relationship between VAS scores and regular physical activity habit and symptom duration in patients with knee OA[31].

The patient classification completely depended on the pain intensity, since many previous studies have shown that there is a discordance in the relationship between pain and radiologic OA. There are patients with a Kellgren/Lawrence grade of 3 or 4 for knee OA without any pain in the knee[13–15]. For example, 29.9% of patients with Kellgren/Lawrence grade 2 and 64.1% of those with Kellgren/Lawrence grade 3 in the knee in an open population study experienced pain at some points[32].

In the pretreatment condition, it was observed that the patients with knee OA with moderate and severe pain showed significant declines in the knee ROM, isometric quadriceps strength, and level of functional performance, which may be due to the level of pain that resulted in the weakening of muscle strength, instability of the knee joint, and decreased physical function[33]. Moreover, the impairments of muscle activation are magnified in subjects with knee OA ranging from 8 to 25% in populations of varying disease severities[34]. Reduced voluntary activation of the muscles and decreased contractile rates are meaningful as these explain the strength decline and changes in muscle size[35], which were experienced by the patients with knee OA with moderate and severe pain in the current study. However, a recent study discovered that pain did not influence the thigh muscle electromyogram (EMG) amplitudes or proprioceptive acuity in patients with mild and moderate knee OA during a stair climbing task[36].

The rehabilitation program decreased the pain intensity and improved the knee ROM, isometric quadriceps strength, and level of functional performance in all knee OA groups. In addition, it was clear that the rehabilitation program had more drastic effects in the moderate pain group. Thus, the levels of improvement in the moderate pain group were superior to those

in the other groups in all measurement outcomes. The compatibility of the results of the VAS and WOMAC is consistent with the findings of Riddle and Stratford who concluded that the WOMAC scores are most strongly associated with pain intensity in patients with unilateral and bilateral pain[37].

The significant improvement in the muscle strength of the three groups might be explained by the findings of Lewek et al. who reported that the arthrogenic inhibition of the quadriceps muscles of patients with knee OA may be corrected using exercise training[34]. Moreover, the results of the current study are in line with the findings of Knoop et al. who reported that all grades of knee OA severity can achieve improvement in pain and functional performance after an exercise therapy program[38]. However, it should be noted that this study included an exercise program only, which was applied in patients with knee OA with different grades (mild, moderate, and advanced knee OA); conversely, the current study included patients with moderate knee OA only, and the rehabilitation program included stretching exercises, PEMF, and US. The difference in the intervention and patient characteristics could explain the greater improvement in the moderate pain group than in the severe pain group.

The lesser improvement level in the severe pain group in all outcome measures may be explained by the greater inactivity caused by the higher pre-intervention pain levels experienced by the patients in this group, which had profound adverse effects on skeletal muscle function and metabolism in terms of weakness and atrophy[39]. In addition, the knee extensors have a prominent role in resisting gravity; they undergo a greater magnitude of weakness and atrophy than other groups of muscles during inactivity[40].

Conversely, the findings of this study revealed a trend toward greater improvements in the moderate pain group, which can be explained by the greater reduction in the score change in the pain in this group. In the same circumstances, the reduction of pain can improve the level of function, ameliorate physical impairment[41], and reduce the restriction of movements (knee ROM) as a protective mechanism in patients with knee OA[42]. In addition, the chronic form and level of pain can result in muscle weakness, and it seemed that the greater pain reduction and strengthening exercises in this group were responsible for improving the isometric quadriceps strength[33].

This study has several limitations. Firstly, it did not have a control over the daily activities of the patients. Secondly, the long-term effects of this treatment were not identified. Thirdly, the outcome measures of the study did not involve functional tests, such as the 6-minute walk test. Further research studies with longer durations evaluating the effects of physiotherapy rehabilitation programs should be conducted on patients with knee OA, especially those with severe pain. Finally, further studies are needed to examine the effects of rehabilitation programs on the hip and ankle joints of patients with OA with different degrees of pain, since previous studies have reported that examination of the hips may be indicated in patients with knee OA[43]. Moreover, knee OA leads to weakness of the ankle joints, plantar flexors, and dorsiflexors[44] and deficits in ankle proprioception[45].

In this study, all patients with moderate knee OA with different grades of pain can benefit from a physiotherapy rehabilitation program, which was shown to be highly effective in patients with moderate pain, although this effect might be reduced in patients with severe pain. Hence, the effects of physiotherapy treatment programs might be optimised by identifying the grade of pain and subgroups of patients.

Conflict of interest

No conflict of interest is declared by authors.

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