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The Effect of Balance Exercises on Knee Instability and Pain Intensity in Patients with Knee Osteoarthritis :A Randomized Clinical Trial

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ABSTRACT

Knee instability is considered as a common symptom in patients suffering from knee osteoarthritis and knee pain. The objective of current research is to examine the effect of balance exercises on knee instability and pain intensity in patients with knee osteoarthritis. in this one-blind randomized controlled clinical trial, 30 patients with knee osteoarthritis were selected using simple and convenient sampling method, and they were divided into two groups, including balance exercises group and control group. The treatment program in the balance exercises group included balance exercises, and in the control group, it included ultrasound, TENS(Transcutaneous Electrical Nerve Stimulation), and hot pack. Knee instability was measured according to the evidence of buckling, shifting or giving way through a questionnaire, and the pain intensity was measured by Visual Analogue Scale (VAS) in two periods of before and after treatment. Treatments in both groups lasted for 3 weeks and five times per week. Independent t-test and paired t-test were used for analyzing the data. The mean score of pain and knee instability in the balance group improved from 6.53± 2.32 to 4.60 ± 1.91 (P = 0.00) and from 1.80 ± 0.94 to 2.93 ± 0.79 (P = 0.00), respectively. The mean score of pain and knee instability in the control group improved from7.46± 1.92 to 5.40± 2.09(P=0.00) and from 1.40 ± 0.73 to 2.13 ± 1.06 (P = 0.01), respectively. Significant difference was found between the two groups in terms of mean score of knee instability (P <0.05). Inter-group comparison revealed significant difference between balance exercises group and the control group in terms of impact on mean score of knee instability. Intra-group comparison also revealed that mean score of pain and knee stability improved in both of the balance exercises group and control group.

Key words: Balance Exercises, Knee Osteoarthritis, Pain, Knee Instability

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INTRODUCTION

Osteoarthritis has been reported as the most common joint disease around the world. It is known as the major factor resulting in disability in elderly people (1). This diseases is associated with different complications, including pain, functional restriction, disability, and lower quality of life (2). Osteoarthritis often makes weight-bearing joints involved, including hip, knee, and ankle (3). Among the mentioned joints, the most common large joint that is involved in this disease is knee joints. It is characterized by difficulty in getting up from chair, climbing the stairs, kneeling, standing, and disabling walking (4). Knee osteoarthritis is more common among women compared to men. Its prevalence has been reported between 10 and 15% at age of 35 years and between 35 and 45% at the age of 65 (5). Knee osteoarthritis involves a great

dysfunction (6, 7), limited activity, (8) along with high socio-economic costs (7, 9). Knee osteoarthritis not only creates changes in the tissues within the joint cavity, but also influences ligaments, tendons, and tissues around the joint, such as muscles (6). It has been found that patients with knee osteoarthritis experience more disability and reduced proprioception compared to control group (10).

General muscle weakness, reduced activity of muscle fibers, and reduced proprioception are associated with knee osteoarthritis (11). It has been reported that large number of people suffering from knee osteoarthritis might complain of knee instability (12, 13). It has been stated that knee instability involves lack of ability to maintain a position or to control the movements of knee joint under various external loads. Recently, much research has been conducted on patients with knee osteoarthritis (14). Such patients often report knee instability under title of "knee buckling or giving way" during their everyday activities (15). The prevalence of knee instability has been reported to be around 11-44% in people with knee osteoarthritis, which it is associated with functional restriction and pain (12, 13, and 16). Existing evidence indicates that complaints of knee instability are associated with disorders such as knee pain, weakness in quadriceps muscle, restricted range of motion (12). The knee joint has been stabilized by a combination of neuromuscular control provided by the muscles and proprioception and passive restriction provided by ligaments and capsule (17). In patients with knee osteoarthritis, muscle weakness, proprioception disorder, high laxity, and excessive movements of knee during walking have been reported (14). These results might indicate that patients with knee instability suffer from defect in the neuromuscular system, and appropriate therapeutic program should be adopted in this regard. In a systematic review study, it was revealed that effects of exercise on pain and function of patients with knee osteoarthritis were moderate (18, 19). This result reflects the necessity of balance exercises as part of exercise program to improve knee instability and pain in patients with knee osteoarthritis. The goal of supplementary treatment in patients with knee osteoarthritis is to control the pain, improved function, and health-related quality of life (20). It has been shown that exercise therapeutic interventions reduce knee instability in patients with anterior cruciate ligament damage (21). These techniques include lower extremity strengthening, agility, and perturbation training (15). In a research carried out by G. Kelley Fitzgerald et al, agility and perturbation exercises were applied as an exercise program in patients with knee osteoarthritis. It was found that adding these types of exercise programs to standard rehabilitation programs was more effective in reducing dynamic knee instability, improved function, and reducing the pain compared to increasing the level of physical activity (21). In a research carried out by Fitzgerald et al, it was recommended that using knee stabilizing exercises are useful in patients with knee osteoarthritis (22). In a research conducted by Kanda Chaipinyo et al, they investigated the impact of home balance exercises and home strength exercises in patients with knee osteoarthritis and they found that both types of exercises led to reduced pain (22). In a clinical trial, Jesper Knoop et al examined the impact of knee joint stabilizing exercises in patients with knee osteoarthritis suffered from knee instability. They concluded that these patients received benefits from a treatment focused on knee stability and consequently on muscle strength and efficiency of everyday activities, compared to treatment that included only muscle strength or efficiency of everyday activities, and both of the treatment groups reported reduced activity restriction, improved knee instability, and pain (23).

Neuromuscular disorders such as muscle weakness (24) and defect in proprioception in knee osteoarthritis patients are highly associated with knee instability and disorder in postural control (25). In addition, there is limited evidence of association between knee instability and disorder in postural control (26). On the other hand, no study in the form of clinical trial has been conducted to examine the impact of balance exercises on knee instability and pain in patients with knee osteoarthritis. Therefore, the objective of this study was to examine the effect of balance exercises on knee instability and pain intensity in patients with knee osteoarthritis. It was hypothesized that both of the treatment methods would result in improved knee instability and pain, and the effect of balance exercises would be more effective in improving knee instability and pain compared to control group.

MATERIALS AND METHODS

Research design: This one-blind randomized clinical trial was carried out in Razmju Moghaddam

Clinic in Zahedan University of Medical Sciences in 2016. In the present study, 30 patients with knee osteoarthritis were randomly divided into two groups of balance exercises (n=15) and control (n=15). Subjects of the study were not aware of the two exercise groups. The treatment in both groups lasted for 3 consecutive weeks and 5 times per week (27). The variables of study were measured and recorded before and after treatment.

Population of study screening of patients: in this study, 30 patients with knee osteoarthritis were selected using simple and convenient sampling method. The inclusion criteria of study included, males and females with chronic knee pain for at least 3 months (28), age between 46 and 72 years (29), having grade between 1 and 4 according to modified Grade Scale (30) of kellgren Lawrence, morning joint stiffness improved usually after 30 minutes (22), lack of joint threatening diseases (osteonecrosis, osteoporosis, rheumatoid arthritis, and musculoskeletal disease (28). Exclusion criteria of the study included osteoporosis (22), physiotherapy intervention in knees during the last 6 months (22), having an experience of knee joint surgery (31), types of arthritis (32), previous leg fractures and neurological diseases such as stroke (32), peripheral neuropathy (33), and severe visual impairment (33). Patients were included to study after reading and signing the written informed consent form. This research was approved by the Scientific Committee of the Rehabilitation Department and the Ethics Committee of Zahedan University of Medical Sciences. The rights of subjects participated in the study were preserved at all stages of the research.

Data collection: in order to ensure that subjects of the study met the inclusion and exclusion criteria of study, they interviewed and examined. Meter with precision of centimeter was used to measure height of subjects, digital scale was used to measure weight of subjects (to calculate BMI), and evidence of buckling, shifting or giving way during the last 3 months was used to measure knee instability, and Visual Analogue Scale (VAS) was used to measure pain intensity.

Randomization: Randomly classification of subjects into two groups conducted by clinical physiotherapist in a consecutive manner.

Knee instability evaluation: Self-reported knee instability was measured according to buckling, giving way, and shifting evidence during the last 3 months by a questionnaire developed by Felson et al (16). Patients graded their knee instability intensity on a numerical scale ranged from 0 to 5 in response to the following question: what scale of knee giving way, buckling, and shifting influence the level of everyday activity?

Scoring was performed in this way: 5 = I have no symptom, 4 = I have symptom, but it does not influence everyday activity, 3 = Symptoms influence my activity slightly, 2 = symptoms influence my activity at moderate level, 1 = symptoms influence my activity strongly, 0 = symptoms prevent performing everyday activities (15). Questionnaire related to self-reported knee joint instability was recognized valid and reliable to measure knee instability (15, 16, 34). The test-retest reliability of this self-report rating of knee instability on 10 individuals with a variety of knee pathologies, including knee OA, was estimated using an intraclass correlation coefficient (ICC =1.00).

Pain intensity evaluation: Different scales have been used to describe the pain, and Visual Analogue Scale (VAS) was used in the current research to measure the pain intensity, which is more reliable than other scales. Accordingly, a set of descriptive phrases was used and the patient was asked to score his pain intensity based on ruler graded from 0 (no pain) to 10 (the most severe pain) (35). VAS was recognized to be valid and reliable to measure the pain intensity (36, 37).

Treatment method

Treatment in the intervention group lasted 3 weeks, 5 sessions per week and 15 sessions (38), each session lasted about 20 minutes and enough rest time was given between exercises. However, it lasted for 3 weeks, 5 sessions per week, and 15 sessions, and each session lasted 45 minutes in the control group. It noteworthy that warm-up exercises needed to be performed before the intervention. This research project was carried out in Razmju Moghaddam Physiotherapy Clinic at Zahedan University of Medical Sciences

Warm up exercises

Warm up exercises are performed for 10 minutes before starting the exercises and they include the following exercises: 1) walking slowly for 5 minutes, stretching exercises, including 2) the patient is in a supine position and the knees are smooth and in this position, he pulls himself to left of body by his right hand and keeps it for 10

seconds. Then, he performs this movement with another hand. 3) The patient is in the supine position and pulls her knees with one or two legs toward chest. 4) He performs the stretching movements related to hamstring muscles. 5) He performs stretching movements related to abductor and adductor muscles of hip joint. 6) He performs stretching movements of the muscles behind the leg.

- Intervention group:
All patients underwent physical evaluation before, and their medical and demographic information was collected. Balance exercises were performed for 3 weeks and 5 days per week, and 15 sessions in which each session lasted 20 minutes in the intervention group. These exercises were performed as follows:

Balance exercises
Standing on one leg: subject was asked to stand on one leg, while he was standing near a supportive level or table, and the other leg stood up and kneel down. Then, the subject balance was measured by standing on one leg (39). Every time that subject was not able to keep his balance, he stood on his two legs for a few seconds, then, he stood on the other leg, and this exercise was repeated in this way. It was performed for 2 minutes (40).

-stepping: it was performed by stepping forwards and backwards, then toward sides of each leg in 30 repetitions. Beside this 30-repetition exercise, subjects performed two-sided mini squat with a flexion angle of 15-30 degrees of knee in the painless range in order to strengthen the quadriceps muscles. Then, they performed it in standing position. Components of this balance exercise are as follows:
1) Stepping forwards and backwards with left leg (30 repetitions)
2) two-sided mini squat (10 repetitions)
3) Stepping forwards and backwards with right leg (30 repetitions)
4) two-sided mini squat (10 repetitions)
5) Stepping to left side (30 repetitions)
6) two-sided mini squat (10 repetitions)
7) Stepping to left side (30 repetitions)

-Control group:
Treatment in the control group lasted 3 weeks, 5 sessions per week, 15 sessions, in which each session lasted 45 minutes. In the control group, the common physiotherapy treatments included strength exercises of quadriceps muscles. Then, they were used along with electrotherapy modalities such as TENS and US. Then, strength exercises of quadriceps muscles were performed in 3 sets (10 repetitions in each set) with low intensity (42). Enough rest time was provided between each set.

These exercises were performed to strengthen the quadriceps muscle. These exercises were performed from easy to difficult and included exercises in three positions of supine, sitting, and standing. These exercises were performed for 20 minutes, while electrotherapy modalities lasted 25 minutes (41).

Strength exercises of quadriceps muscle in supine position:
In this position, both legs were placed smoothly on the ground and the patient was trained to push back of his knees back to ground, to hold it for 5 seconds, and to relax them (42).
- Exercises in sitting position:
At the beginning, knee was bent to 90 degrees. Then, the knee was maximally extended to 180 degrees and held for 5 seconds. Then, the patient was trained to contract his knee muscles in state of painless and to relax them (42).
- Exercises in standing position
In this position, the patient was asked to perform two-sided mini-squat in the painless range (15-30 degrees of knee flexion) to strengthen the quadriceps muscle (42).

-Electrotherapy modalities:
TENS: two channels and four electrodes were used for electrical stimulation. In electrical stimulation, using TENS, 100 Hz frequency, a pulse with width of 50 microseconds, and the intensity proportional to the sensory threshold of the person in micro-ampere and a duration of 20 minutes were used.
In TENS protocol, a folded towel was placed under the knee. In this state, electrodes were placed on the anterior-internal and anterior-exterior part of the knee for electrical stimulation (41).

US: US protocol of continuous ultrasonic waves with 1 MHz frequency and power of 0.8 watts per cm^2 was used. Then, patient was placed in supine position. A gel with conductivity capability and without any active pharmaceutical particles was used.

Then, US was applied to interior and exterior parts of the knee with circular movements to ensure maximum energy absorption. The duration of use

was estimated to be 3-4 minutes, which it depends on the knee size (41).

Sample size calculation: based on the previous studies, 30 patients with knee osteoarthritis were considered for the research, which they were divided into two groups (each group containing 15 patients).

Statistical analysis: SPSS16 software was used to analyze the data. Kolmogorov-Smirnov test was used to examine the normal distribution of data. Equality of variances was performed using Levine test. Paired t-test and independent t-test were used to compare intra-group and inter-group results. The significance level was considered to be less than 5%.

RESULTS

The mean age range, weight, height, and BMI in two balance and control groups are illustrated in Table 1. By reviewing the studies conducted before, the sample size was estimated to be 30 in two groups (each group containing 15). Normal distribution of data was examined using Kolmogorov-Smirnov test. Findings revealed that the distribution of data is normal (Table 1).

The mean and SD of data related to knee instability and pain score, comparing findings of after and before treatment in two groups and P value related to comparing the findings of before and after treatment and comparing the findings after treatment between the two groups and P value related to comparing the findings after the treatment are illustrated in Table 2.

Intra-group comparison:
In the balance exercises group, the mean score of pain and self-reported knee joint instability revealed a significant improvement ($P < 0.05$) (Table 2). In the control group, mean score of self-reported joint knee joint instability and pain intensity improved significantly ($P < 0.05$) (Table 2).

Inter-group comparison:
To ensure that the randomization process has been performed correctly, data before the study in two groups were compared. Findings revealed no difference between the two groups in terms of the variables studied and the patients of two groups were matched in terms of the variables studied ($P > 0.05$). Comparing the findings after treatment between the two groups revealed significant difference between two groups of balance and control exercises in the mean score of knee instability, associated with improvement in the balance exercises group (Table 2).

DISCUSSION

Findings of this research support a major part of the first hypothesis of research that states that balance exercises and treatment in the control group improve the mean score of knee pain and instability. In contrast to second hypothesis of research, no difference between was found between two methods of treatment in terms of the mean score of pain, but a part of the second hypothesis that states there is difference between the two groups in terms of improvement in mean score of knee instability was confirmed, which this improvement in the balance exercises group was higher compared to other group. Findings of this research revealed that balance exercises and treatment in the control group improved the mean score of knee pain and instability, while balance exercises caused more improvement in the knee instability score. Kanda Chaipinyo et al (2009) indicated that performing 4 weeks of home balance exercises and home strength exercises is effective in reducing pain in patients with knee osteoarthritis.While no significant difference was found between two groups in terms of pain variable, findings of this research are consistent with findings of our research. Findings of this research revealed that home balance exercises are comparable with home strength exercises in some cases, such as pain variable. In this research, it has been recommended that to see significant difference between two groups or show the effect of these exercises, a control group without any intervention or a long-term follow-up period to be used in order to control any natural changes in symptoms over time (22). G. Kelley Fitzgerald et al in their study concluded that both groups of standard exercises and agility and perturbation exercises in one group led to improvement in all variables, such as knee pain and instability, and no significant difference was found between two groups (15). Findings of the mentioned research are inconsistent with findings of our research, since no significant difference was found between the two groups considering the knee instability variable in our research. It was hypothesized in the present research that performing agility and perturbation exercises to be faced with motor challenges, which these challenges includes knee stability, balance, quick changes in direction, stops,

and quick and sudden starts and caused that cope with these problems better during performing everyday life activities (15). However, findings did not support additional impact of perturbation exercises compared to standard exercises (15). It has been reported in this research that baseline measurements might be required and patients having required instability might be needed to introduce them for agility and perturbation exercises in order to achieve significant findings [15]. Jesper Knoop et al reported that knee joint stabilizing exercises in patients with knee osteoarthritis and knee instability along with standard exercises (strength/functional exercises) in patients with strong muscle, but not in patients with weak muscle, might show additional effects (23). Findings of this research are in line with findings of our study, since significant improvement was reported in knee instability score of two groups, unlike the mean score of pain. This improvement might be due to the fact that assigning patients based on base strength of muscle could improve the variable of knee instability (23). In other words, a subset analysis shows that strength exercises was effective in patients with knee instability, especially muscle weakness, and these exercises should be prioritized to knee stability exercises. However, in patients with knee instability and powerful muscles, early knee stability exercises can be effective (23). In a small non-randomized study conducted by Diracoglu et al on 60 female patients with knee osteoarthritis, they showed significant effects of kinesthetic (proprioceptive) exercises and balance exercises when added to strength exercises, compared to strength exercises alone. However, due to high intensity of exercise in the experimental group, high rate of dropout (32%), and a lack of randomization, no evidence was found on additional effect of knee joint stability exercises (14). Findings of this research suggest no significant difference between the two groups, which they are not in line with findings of our study. Monika Ratsepsoo et al examined the impact of home exercises program in women with severe knee osteoarthritis and they reported that these exercises led to reduced pain. These findings are in line with findings of our research. It was reported in this research that there is a significant relationship between postural stability and pain intensity. Thus, the pain might result in muscle dysfunction and movement control disorders, and this can reduce the muscle ability in maintaining the postural stability. This reflects that pain reduces by improvement in postural stability (43).

The cause for improvement in the variables of knee pain and knee instability might be explained by the fact that neuromuscular control by the interaction between proprioception and muscle activity and passive restricting system (ligaments and capsule) is responsible for knee stability (14). Hence, when upper leg muscles are weakened, other biomechanical factors involved in knee stability are also disturbed, resulting in knee instability and severe restricted activity based on the neuromuscular model [14]. Pain might result in muscle dysfunction and weakness and provide the conditions for reduced postural stability. On the other hand, evidence shows a relationship between knee instability and disorders such as knee pain and muscle weakness in quadriceps (12, 43). Thus, reduced knee instability might result in pain reduction. A treatment program affecting the neuromuscular factors involved in knee joint stability might be useful in these people (14). On the other hand, imbalance is associated with increased risk of falling, knee instability and neuromuscular deficiency that including muscle weakness and proprioception deficiency, which might result in reduced postural control and restricted activity (25). Considering what was said, it can be stated that balance exercises in patients with knee osteoarthritis are useful to improve knee instability and pain intensity. Balance exercises caused an improvement in knee instability compared to the control group. While no significant difference was reported between two groups in mean pain score, this might be due to the short period of exercises, so it is recommended that longer period of exercises to be used in future studies to better understanding of the effect of these exercises. On the other hand, it is recommended that exercises proportional to grade of patients with knee osteoarthritis to be planned in order to determine the impact of balance exercises. In addition, majority of patients in this research were female, so it is recommended that both genders to be included equally in future studies and to control any symptom during the treatment period, it is better than a follow-up period to be considered. In addition, it is recommended that other interventions to be used in patients with knee osteoarthritis and their impacts on knee instability and pain to be compared.

Table1.comparing demographic characteristics between two groups

Variable	balance exercises (n=15)	Control group (n=15)	*p value
Age (year)	49.20±8.80**	51.93±6.64	0.34
Weight (kg)	76.13±12.30	72.40±10.80	0.38
Height (m)	1.58 ±0.10	1.57 ±0.07	0.67
Body mass index (kg per square meter)	31.01±8.15	29.65 ±5.87	0.60

** P<0.05 is significant*

*** Data were stated in the form of SD±mean*

Table 2. comparing mean of data before and after treatment of self-reported knee joint instability and pain intensity in two groups and comparing the results after treatment between two groups

	First group (balance exercises) (n=15)			Second group (control) (n=15)			Comparing the results after intervention
Variable	Before intervention	After intervention	P value	Before intervention	After intervention	P value	P value
Pain intensity	6.53±2.32	4.60±1.91	0.00*	7.46±1.92	5.40±2.09	0.00*	0.28
Self-reported knee joint instability	1.80±0.94	2.93±0.79	0.00*	1.40±0.73	2.13±1.06	0.01*	0.02*

** P<0.05 is significant*

*** Data were stated in the form of SD±mean*

CONCLUSION

findings of this research revealed no significant difference between the balance exercises and treatment in the control group in terms of mean score of pain, while balance exercises caused an improvement in self-reported knee joint instability score compared to control group.

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