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Effects of three Combined Training Methods on Pain and Function of Patients with Knee Osteoarthritis

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Background: Knee osteoarthritis is a common disease that causes pain and impairment of normal performance. The aim of this study was to compare the effects of the three combined training methods on pain and function in patients with knee osteoarthritis.
Methods and Materials: This study is a semi-experimental research, and it makes use of pretest and posttest methods in which 30 male patients were selected and randomly assigned into three groups, namely the experimental group 1, the experimental group 2 and the experimental group 3. The groups underwent an 8-week period of training. Pain severity and functions were measured via Visual Analogue Scale (VAS) and function through Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaires before and after exercise. Data were analyzed using variance analysis (ANOVA) ($P < 0.05$).
Results: The ANOVA demonstrated a significant difference between groups about pain ($F_{(2, 27)} = 35.12$, ($P < 0.01$) and function ($F_{(2, 27)} = 32.7$, ($P < 0.01$)). Post hoc analysis revealed significant differences between experimental groups 1 and 2 ($P < 0.05$) and experimental groups 1 and 3 ($P < 0.01$) regarding pain and function, but there was no significant difference between experimental group 2 and 3 for pain and function ($P > 0.05$).
Conclusion: Following the intervention, three groups showed a reduction in pain and improvement in function. The rate of recovery in the first experimental group was higher than other groups, and that a new approach in the treatment of patients suffering from severe pains was introduced in patients with patellofemoral pain syndrome.

Keywords: Knee Osteoarthritis, Core Stability Training, Abductor and External Rotator Muscle, Pain

Introduction

Knee Osteo Arthritis (KOA) is recognized as a degenerative arthritis and it is the most prevalent type of arthritis engaging the joints and it can lead to chronic pains and the patients' functional impairments (Barati, 2012). in such a way that the knee is considered as the most malfunctioning-prone area in the human body after fingers and vertebras (Flugsrud, 2010). Based on radiological findings, osteoarthritis prevalence rate in the western countries in the individuals below the age of 45 is 2%, in the individuals between 45 years of age to 64 it is 35% and in older individuals (> 65) this prevalence rate increases to over 68%. Furthermore, the prevalence rate is found higher in women than in women (Foley et al., 2003). The

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main specificity of the KOA pathology are damage to the joint cartilage at the lower end of the thigh and the cartilage at the upper section of the tibia, the increase in the activity level under the cartilages and the formation of osteophytes at the flanks of the joint (Hiligsmann, Cooper & Arden, 2013). The disease follows a slow trend and it lasts several years (Fransen et al, 2015). Osteoarthritis is a complex deformity which can be identified with several risk factors like gender, age, weight, height, inheritance, body mass index, racial differences, a history of impact, extreme stress on the joint (Lange, Vanwanseele & Fiatarone Singh, 2008) ligament looseness, the inefficiency of the anterior cruciate ligament, meniscal lesions and vocational pressures (Ferreira, 2015). Of course, it is constantly observed that the strengthening of the knee area muscles can improve the knee pain and performance in the patients with osteoarthritis (Altman, 1991). Thus, the individuals with osteoarthritis are recommended to perform exercise movements in an extensive manner (Bosomworth, 2009). However, a great majority of the studies have been carried out focusing on the role of quadriceps vigor in knee arthritis with a little concentration on the other lower extremities' musculature. Thus, myasthenia in the quadriceps muscles in the early stages of knee osteoarthritis is indicative of a preliminary risk factor for such patients (Simms, 2007). The extant literature shows that the misalignment generated in the knee influences the load bearing capacity of the knee joint (Bennell, Hunt & Wrigley, 2010) and it can further augment the damage in the joint cartilage which acts as a contributing factor to the progress of the osteoarthritis (Fahlman, Sangeorzan & Chheda, 2014) In the recent years, the studies have demonstrated that the myasthenia and weakness in the musculature at the periphery of the thigh joint may cause knee osteoarthritis (Hortoba´gyi, Westerkamp, & Beam Rana, 2005) showed that the muscular myasthenia at the periphery of the thigh joint can be taken into consideration as an important factor in the emergence of the knee osteoarthritis (Rana et al., 2010) New approaches to treatment are laid upon the foundation of the principle that the joints more distant to the affected one should be focused on so as to be able to reach to better treatment efficiency and elevated recovery rates (Foroughi et al., 2011) On the other hand, the body center of gravity stability is predominantly preserved through the active performance of the musculature structures, namely the abdominal muscles from the front, iliac and paravertebral muscles from the back and the muscles at the bottom of pelvis and at the periphery of the thigh from below (Bennell, Hunt & Wrigley, 2010). Furthermore, it has been defined as the body ability to keep the correct curvature of the dorsal-pelvis-thigh system and that the body center of gravity stability is, in fact, the basis of the body steadfastness which allows for the generation, transfer and controlling of the force and movement to the lower movement chain including knee joint (Zazulak et al., 2007). Barati et al (2012) showed in a study that the exercises targeting the body center of gravity can cause a significant improvement in pain and performance of the individuals with knee osteoarthritis (Barati, 2012). It was also demonstrated that central body stability exercises bring about an improvement in pain in the individuals with knee osteoarthritis (Sartipzadeh, Moazami & Mohammadi, 2016) As it is observed, there are various studies performed on the pain and performance in the patients with knee osteoarthritis in such a way that each of them has exclusively investigated the effect of a certain training program on the pain and performance in the individuals with knee osteoarthritis and none of the training programs have, in the first place, compared the effects of three types of exercises; moreover, in the second place, no study was found dealing with the comparison of the three training programs in a combined manner, thus the present study aims at comparing the effects of three methods of combined exercises on pain and performance in patients with knee osteoarthritis.

Methods and Materials

The present study is a semi-experimental research and it makes use of a pretest-posttest method. Thirty individuals -based on Morgan's table diagnosed with knee osteoarthritis by a physiotherapist were selected from the male patients who had referred to since and movement clinic, in Ilam Province of Iran. The patients were randomly assigned to three groups, namely first experimental group, second experimental group and third experimental group. The study population was assigned to three 10-people groups. All of the patients were asked to complete a letter of agreement for participating in the study. The study inclusion criteria, based on other studies, incorporated the followings: being in an age range from 50 to 65 years of age, being diagnosed with knee osteoarthritis and passing the qualifications for having the degree II and degree III

osteoarthritis symptoms confirmed by a physiotherapist, having knee pain for a period of at least three months (chronic pain), a lack of historical knee operation, lack of taking inter-joint injections for the past three months, in case of undergoing physiotherapy it must have been elapsed a two-year period since the last time, having no sport activity during the recent two years, no addiction to alcohol and being a nonsmoker, having no history of joint threatening diseases, not being diagnosed with diseases in visual system and neurologic problems. Study exclusion criteria were: patients' inability for a regular referral, announcing tendency to discontinue treatment, performing inter-joint injections and undergoing knee surgery during the study period and the exacerbation of the symptoms (Sartipzadeh, Moazami & Mohammadi, 2016). All of the individuals were debriefed about the study objective and the method of performing the exercises. The measurements were undertaken by the tester in the format of pretests and posttests. There was made use of a wall meter with an accuracy of one centimeter to measure the patients' height and to measure the patients' weight a Brouyer Digital Scale (made in China with an accuracy of 100 grams) was used. To evaluate the pain levels, Visual Analog Scale (VAS) was applied the reliability of which for the individuals with knee osteoarthritis has been reported to be in a range from 85% to 95% and it was delineated in the form of a continuum from zero to ten and the higher quantities were indicative of higher pain levels (Jensen, Karoly & Braver, 1986). Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)) was used to assess the knee function. (Mokkink et al, 2005). The scale's reliability and validity have been calculated and confirmed in the prior studies and its reliability has been reported in a range of 88% to 96% and it takes the form of a questionnaire for the patients with knee pain. It contains 24 questions and covers three parts, namely pain, stiffness and daily activities which are scored from a minimum of zero to a maximum of 96. The higher values are indicative of lower function (Lawrence et al., 1989).

Exercises were performed in an eight-week period, three sessions a week and each session lasted about 45 minutes. The combined training protocol was based on the previous research and studies performed so far in such a way that the first experimental group was assigned with body center of gravity exercises engaging the quadriceps and the patients were asked to perform movements such as the followings: 1) half sit-ups: the individual take a position on the mat for performing sit-ups and tries to touch the chest with his or her chin and stays tilted over the knee taking a posture of half sit-up until the lower part of the shoulder is lifted from the ground; 2) side sit-up: it is quite similar to sit-up only differing in that the individual moves the elbow towards the opposite leg during performing the exercise; 3) side bridge: the individual lies on his or her side, places one hand under the body and tries to lift his or her body from the ground aided by the body muscles; 4) prone bridge (plank exercise): the individual lies down in a prone position and supports his or her body by placing the hands palms touching the ground and then tries to lift his or her body aided by the hand's power and constricting the body muscles in such a manner that only the toes and the forearms are remained in touch with the ground. The quadriceps strengthening exercises were carried out by an American made exercise tube (the Hygienic Corporation, Akron, OH, USA) and it is offered in four colors, namely red, green, dark blue and black. Before commencing the exercise, all of the tastes were evaluated so as to determine the exercises' intensities and the appropriateness of tube exercise and they carried out the multiple repetitions maximum method up to fatigue threshold, then, each patient, based on the preliminary evaluations, initiated doing the exercises by means of a tube colored according to his vigor. In the next stage, two moves were performed to strengthen the quadriceps in the first move of which the individual was asked to stand relying his back on a wall and then pressing a ball placed between his knees and he had to keep his knees from undergoing any turns inward or outward and press the ball in half-squat with his legs bent to a 30-degree angle. Of course, before undertaking the exercise, the individual was asked to perform half-squat up to a 30-degree angle so as to determine the half-squat move domain. In the next move, the individual was asked to sit on a bench and perform the knee extension and flexion move in a 30-degree angle of maximum extension in such a manner that a tube was fixed on the one end to the upper section of the ankle and on the other end it was fastened to the bottom section of the bench (table 1). In the second experimental group which also was asked to perform abductor muscles and exterior thigh rotator along with quadriceps exercises, the individual, in the first stage of the exercises, took a position of lying on his side and was fixed to a bench with strips appropriate for supporting the pelvis and one end of an

American made exercise tube (the Hygienic USA Corporation, Akron, OH) was connected to the upper section of the ankle and the other end was fixed to the bench and the individual was to perform abduction moves in a 30-degree angle. The individuals performed the exterior thigh rotator muscles' strengthening exercises sitting on a bench with the knee undergoing a 90-degree flexion in such a manner that one end of the tube was fixed to a post and the participant was asked to carry out the exercise in a 30-degree domain length of motion (Table 1) (Margaret, Mphty & Pity, 2016). In the next stage of the exercises, this group was asked to perform the quadriceps muscles training similar to the first group. Combined training protocol in the third experimental group, which was also asked to perform the body center of gravity stabilization enhancement exercises and the abductor and rotator muscles of the exterior thigh, was similar to the collection of the moves which was undertaken by the first and second experimental groups.

The normality of the variables distribution was investigated by making use of Shapiro-Wilk test. To analyze the data, there was made use of simple variance analysis statistical tests (ANOVA) and the extracted data were evaluated by the use of SPSS ver.22 (made by IBM Company, in New York, USA) in a significance level of $P < 0.05$.

Results

Descriptive statistics pertaining to the tastes' consistency before the training interventions have been presented in Table (2).

The results of the simple ANOVA tests, presented in Table (2), indicated that there is no significant difference between the means obtained for all of the physical attributes of the experimental groups prior to undertaking the exercises ($P > 0.05$). Therefore, it can be concluded that the three groups are homogenous and matching in terms of their physical characteristics and they have been subjected to identical test conditions. Based on Shapiro-Wilk test and according to the significance level, $P > 0.05$, it was made clear that the data attained for all of the studied variables enjoy a normal distribution. Table (3) compares the scores pertaining to pain and performance acquired pre- and post-training program for each of the experimental groups.

Table 1. Groups' training protocol.

Exercises type	Exercises performed	Duration and repetition
Body center of gravity stabilization	1. Half sit-ups	2 sets of ten sit-ups (first and second week)
	2. Side bridge	2 sets of 13 reps (weeks three and four)
	3. Side sit-ups	3 sets of 15 reps (weeks five and six)
	4. Bridge in prone position	3 sets of 20 reps (weeks seven and eight)
Strengthening the abductor and rotator muscles of the exterior thigh	1. isometric contraction	2*10 reps and 10 sec (weeks one and two)
	2. thigh outward rotation	2*15 reps and 15 sec (weeks three and four)
	3. thigh abduction	2*20 reps and 20 sec (weeks five and six)
		3*20 reps and 25 sec (weeks seven and eight)
Strengthening the quadriceps	1. isometric contraction	2*10 reps and 10 sec (weeks one and two)
		2*15 reps and 15 sec (weeks three and four)
	1. performing extension in a 30-degree angle	2*20 reps and 20 sec (weeks five and six)
		3*20 reps and 25 sec (weeks seven and eight)

Table 2. Description of the participants' characteristics of the three intervention groups.

Variables	First experimental group (N = 10)	Second experimental group (N = 10)	Third experimental group (N= 10)	P
	M ± SD#	M ± SD	M ± SD	
Age (years)	55.13 ± 2.4	56.31 ± 2.12	57.2 ± 3.15	0.62
Height (cm)	178 ± 1.12	179 ± 1.06	179 ± 2.14	0.05
Weight (kg)	68.10 ± 6.40	65.43 ± 4.46	64.11 ± 3.54	0.52
Body mass index (kg/m2)	21.55 ± 0.7	20.44 ± 1.08	20.03 ± 2.11	0.24

M ± SD: Mean ± Standard Deviation.

Findings tabulated in Table 3 are suggestive of the variations happened in the three groups. In other words, it is reflective of the changes occurring in two of the groups in comparison to one another and it is expressive of the likely superiority and effectiveness of the groups' training programs in respect to each other. AS it is observed in Table 3 the simple variance

analysis test regarding the pain and performance variables indicated that there is a significant difference between the three groups. To accurately recognize the differences shown between the intergroup pain and performance variables Bonferroni's follow-up test has been used and the results have been provided in Tables 4 and 5.

Table 3. Information pertaining to the descriptive findings and variance analysis tests.

Variable	Group	Pretest # M ± SD	Posttest M ± SD	ANOVA
Pain scores (VAS) based on a 0-10 scale	First experimental group (10 individuals)	8.15 ± 1.02	4.6 ± 0.17	F = 35.12 P = 0.001
	Second experimental group (10 individuals)	6.2 ± 1.05	4.04 ± 1.1	
	Third experimental group (10 individuals)	6.4 ± 1.95	4.75 ± 1.03	
Performance scores (WOMAC) based on a 0-96 scale	Group one exercises (10 individuals)	67.12 ± 1.35	51.5 ± 1.4	F = 32.7 P = 0.001
	Group two exercises (10 individuals)	65.5 ± 2.2	53.2 ± 1.02	
	Group three exercises (10 individuals)	65.95 ± 2.11	56.75 ± 3.1	

M ± SD: Mean ± Standard Deviation ANOVA: Analysis Of Variance.

Table 4. Bonferroni's follow-up test for comparing the pain levels.

	Groups	Mean difference	P
First experimental	Second experimental	1.39	0.412
	Third experimental	1.9	0.05
Second experimental	Third experimental	0.51	0.459

Table 5. Bonferroni's follow-up test for the comparison of performance rate.

	Groups	Mean difference	P
First experimental	Second experimental	3.32	0.014
	Third experimental	6.42	0.013
Second experimental	Third experimental	3.1	0.401

Discussion

The objective of the present study was the comparing the effects of three combined exercises on pain and performance in the individuals with knee osteoarthritis. A significant difference was observed in terms of pain intensity and performance in the three exercise groups before and after accomplishing the training program; in addition, the three of the groups experienced a mitigation of the pain and improvement in performance but the pain amelioration and performance enhancement was higher in the first experimental group in contrast to the second and third groups. Also, the results of the study indicated that there is a significant difference between the first experimental group with the second and third experimental groups but no significant difference was seen between the second and third experimental groups.

Myasthenia and weakness in the lower extremities is an indicator hinting to the knee joint deformities in the individuals with knee osteoarthritis. Several studies have shown that the individuals with knee osteoarthritis demonstrate 20% to 40% weakness in the quadriceps stamina in comparison to their healthy counterparts (Bennell, 2008). Although few studies have directly dealt with the comparison of the vigor of the muscles at the periphery of the thigh joint in the individuals with knee osteoarthritis and, of course, some of the researches have focused on the weakness in the muscles pertaining to the body center of the gravity, but regarding the strength exercises effects on each of the thigh quadriceps muscles, abductor muscles and exterior thigh rotator muscles and the muscles of the body center of gravity the researches have been performed in such a manner that they have dealt only with evaluating the effects of a single training program on the individuals with knee osteoarthritis and there is no report at hand indicative of taking the combined effects of such training programs into consideration. This is while in the present study strength exercise

programs have been applied in a combined form. In terms of the intra-cohort findings, it is observed that the exercises have exerted a significant effect in the three of the groups in connection to the pretests. In this regard, the results of the present study are consistent with the results obtained in a study conducted previous researchers who have found strength training of body center of gravity stabilization effective on the pain and performance improvement in the individuals with knee osteoarthritis (Barati, 2012). Also, Margaret et al (2016) indicated that a reduction in the hip muscles vigor is traceable in the individuals with knee osteoarthritis and in designing training programs for these individuals the strengthening of the thigh muscles should be taken into consideration (Margaret, Mphty & Pity, 2016). Song et al (2016) demonstrated, in a study, that the lower limbs musculature vigor should be concentrated on as a key factor in improving pain in the individuals with knee osteoarthritis (Sang-Kyoon, Dylan, & Reed, 2016). Mikael et al (2016), in their study, realized weakness in the muscles of the thigh region as an important factor in reducing the performance and increasing the pain in the individuals with knee osteoarthritis (Michelle et al., 2016). In another study, Ferreira et al (2015) realized that thigh region muscular strength is of a great effect in managing the treatment program in the individuals with knee osteoarthritis (Ferreira et al., 2015). All of these researches and studies have come to the conclusion that the strength training is effective on pain and performance improvement in the individuals with knee osteoarthritis. The researchers have expressed the idea that the body center of gravity and lower limbs stabilization acts as an essential moderating factor to counteract the pressures imposed on as well as the uprightness of the lower limbs while performing dynamic activities. The central stabilizers of the body and thigh might be activated for the body balancing movements and the correct postures of the lower extremities. As it is also observed in the current research paper, the exercises performed by the first experimental group which included the combined exercises for training the body center of gravity and quadriceps were indicative of a higher effectiveness in respect to the other training programs and it seems that the individuals' knees in this type of the exercises had assumed a better posture in contrast to the other two exercise. The individuals with knee osteoarthritis have shown the bearing of a fraction of load for about 13% to 32% by the entire pelvis, knee and tarsal muscle. Barret et al (2013) measured the fraction of strength in the abductor muscles belonging to the thigh in the individuals with knee osteoarthritis (Baert et al., 2013). It was shown that reduction in the knee strength in the individuals with knee osteoarthritis (Hinman et al., 2010)

As for the inter-group findings which are indicative of the idea that the exercises in the first experimental group (body center of gravity along with quadriceps) are more effective than the two other groups, the results of the present study are corresponding to the results obtained in a study by Piva et al (2011) who figured out that the quadriceps exercises are important in helping the improvement of the symptoms in the individuals with knee osteoarthritis and, of course, it was, additionally, showed by them that thigh area muscles reinforcement can be more effective than the muscles in the vicinity of the quadriceps (Piva et al., 2011). Also, Kobsar et al (2015) suggested, in a study, that the best method that can be of great use for the individuals with knee osteoarthritis is that besides strengthening the thigh region muscles, the reinforcement of the muscles belonging to the body center of gravity should be placed atop of the training agenda (Kobsar et al., 2015). All of the aforementioned studies know the strength training programs as effective in the individuals with knee osteoarthritis. The important theme that should be taken into consideration here is that the various muscles' controlling role on the knee joint is to be considered as a key point in the emergence of knee osteoarthritis. The appropriate performance of the body center of gravity muscles and the thigh region muscles play a fundamental role in the correct placement of the pelvis in neutral positions. This posture might greatly help the thigh bone assume a natural position which will be, consequently, followed by a good status of the knee joint. In case that the knee joint takes an appropriate position this will bring about a decline in the pressures imposed on the articular cartilage as well as a reduction in the pain along with an amelioration of the knee joint performance. Also, due to the fact that the knee joint is naturally placed in between two bones, namely the femur and the tibia, the solidity of the limbs in the upper and lower position to this joint is of a far greater influence in the knee joint solidification than the time it is only dealt with the fortification of this joint.

In addition to the strength points, there were some limitation for this study. One of the constraints in performing the current research paper was that no single study was found in the literature dealing with the survey of combined effects of three training method all at the same time. Therefore, the present study suffers from the scarcity of the study background. Furthermore, being self-report was another limitation of this study.

Conclusion

In the present study, the reason why the body center of gravity stabilization and quadriceps training program are found more effective than the other training programs is that the muscles supporting the body center of gravity stability play a better controlling role in comparison to the abductor and exterior thigh rotator muscles; furthermore, when a combination of body center of gravity stabilization training programs are pooled together with the thigh quadriceps exercise programs, such a controlling effect will be doubled a phenomenon which was observed to a lesser extent for the second and third empirical cohorts. The results concluded the effectiveness of the combined exercises undertaken targeting the body center of gravity along with the thigh quadriceps on the reduction of pain and improvement of the performance in the individuals with knee osteoarthritis and the reason why these combined exercises outperformed the exercises conducted by the other training groups is to be attributed to the better controlling role and more effective placement of the thigh bone on the knee cartilage on the tibia.

Conflict of interest

No conflict of interest declared.

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Author contribution

FRZ designed the research and conducted all stages of the study and drafted the manuscript.

SA supervised the study and verified the manuscript.

All the other authors cooperated with the study implantation and verified the manuscript.

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