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Effectiveness of Eccentric Strengthening Exercises on Pain and Functional Abilities in Patients with Knee Osteoarthrosis: A Randomized Clinical Trial

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Abstract:

Purpose: to investigate how eccentric and concentric strengthening exercises affected patients with knee OA in terms of their VAS, WOMAC, TUG score, and knee flexion and extension range of motion.

Methods: 60 patients with knee OA had their VAS, WOMAC, TUG scores, knee flexion, and extension ranges of motion measured before, after six weeks, and after 12 weeks of eccentric and concentric strengthening activities.

Results: In groups A and B, the mean values of the VAS, WOMAC, TUG score, and knee flexion and extension range of motion significantly increased post-6 weeks and post-12 weeks compared to the pre-test condition, according to the results of the 3x2 Mixed Design MANOVA and the subsequent multiple pairwise comparison tests. Furthermore, the 3x2 mixed design MANOVA showed that Group B had significantly lower post-6-week and post-12-week mean values of VAS, WOMAC, and TUG scores than did Group A. However, across the 3 testing situations, there were no discernible variations in group A and group B's knee flexion and knee extension range of motion.

Conclusions: In knee OA cases, the eccentric strengthening exercise program is more successful in reducing pain intensity and increasing functional capacity.

Keywords: Knee osteoarthrosis, VAS, WOMAC, TUG, Eccentric exercise, Concentric exercises.

1.Introduction:

Osteoarthrosis (OA) of the knee is a common degenerative multifactorial joint disease that is characterized by pain, stiffness, and weakening of the muscles in the lower extremities along the joint lines **(1).**

These deficiencies are believed to have a detrimental effect on the performance and level of function in knee OA patients. It is believed that quadriceps muscle weakness brought on by muscular atrophy or inhibition hastens the degradation of the cartilage and the disease's progression **(2).**

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Hamstrings and proximal hip muscles are also weak in patients with knee OA in addition to the quadriceps **(3)**.

The quadriceps muscles contract eccentrically (ECC), which governs how much the knee joint bends during walking. This is when knee OA-related functional limitations become visible. According to isokinetic strength tests, patients with knee OA saw a 76% drop in the torque of the ECC leg extensor and an 11%–56% decrease in the torque of the concentric (CON) extensor**(4)**. Patients with knee OA may experience less discomfort and have the greater functional capacity by strengthening their quadriceps **(2)**.

In people with knee OA, eccentric strengthening activities were believed to lessen discomfort and enhance functional performance **(5)**. However, there is conflicting evidence that ECC strengthening activities help people with knee OA feel less pain and perform better **(2,4,5,6)**. Additionally, it was noted that practically all of the research that had been published had been restricted to looking at how ECC strengthening exercises affected people who had osteoarthritis in their knees in terms of pain and physical function **(2,4,5)**. To the best of the author's knowledge, only a few studies have looked into how they affected knee joint range of motion (ROM), even though a restricted range of motion in the knee is predicted to be linked to impaired knee function **(7)**.

Patients with knee OA frequently experience decreased knee joint ROM, which can disturb knee mechanics and lead to functional problems **(8,9)**. Therefore, the goal of this study was to examine the impact of eccentric and concentric strengthening exercises on patients with knee OA's pain level, functional ability, and range of motion (ROM) in knee flexion and extension.

2.Materials and Methods:

2.1.Participants:

Following approval from Cairo University's supreme council for postgraduate studies and research (P.T.REC/012/002811), 65 knee OA cases were enrolled in the study. Five patients were not included in the study: two did not follow up after initial enrollment, and three did not match the requirements for inclusion. As a result, an examination of data from sixty patients was taken into consideration.

Randomization:

Cases were sub-categorized into two equal groups at random (group A and group B). Each patient was allowed to choose at random between two folded sheets that were contained in a container that represented the two tested groups, ensuring that the patients would be randomly assigned to either of the tested groups.

An orthopedic surgeon aware of the inclusion and exclusion criteria for subjects made patient referrals. According to the Kellgren and Lawrence OA severity grading scale **(10)**, patients were considered for inclusion in the trial if they were between the ages of 40 and 60, had radiographic evidence of grade II or III knee OA, and experienced crepitus with active knee range of motion. Patients with rheumatoid arthritis, peripheral neuropathy, prior knee surgery or injury, intra-articular corticosteroid injection within the previous month, and any symptoms of acute inflammation or effusion were excluded from the study **(11)**.

Sample size estimation:

Based on a power analysis of the pilot research's data, the sample size for the current investigation was established. Four patients had their responses to the ECC and CON activities measured. The a priori computed needed sample size is 52 patients, with a power of 80%, an effect size (ES) of 1.1, and an alpha value of 5%. (G-Power statistical software, Version 3.03). To determine the impact of eccentric and concentric strengthening exercises on VAS, WOMAC, TUG score, and knee flexion and extension range of motion in patients with knee OA, a randomized, clinical trial with two parallel groups (Group A and Group B) were conducted.

2.2.Procedures:

Following a 12-week period in which group A received a conventional physical therapy program along with CON strengthening exercises and group, B received the same conventional physical therapy program along with ECC strengthening exercises, participants in both groups underwent three tests: once before, once after six weeks, and once after the 12 weeks. Upon arrival, processes were described, and informed consent was obtained by guidelines established by Cairo University's Supreme Council of Postgraduate Studies and Research and its Human Research Ethics Committee. Patients' medical histories, the Western Ontario and McMaster University Osteoarthritis (WOMAC) score, the Time up and Go test (TUG) score, and the knee flexion and extension range of motion were all obtained. Following testing, group A and group B underwent the following treatments before being told to return in six and twelve weeks, respectively.

2.3.Outcome assessment tools:

To evaluate the impact of ECC and CON strengthening exercises on patients with knee OA, the

following variables were measured: VAS, WOMAC, TUG score, knee flexion, and extension range of motion (using an electronic goniometer). The same examiner gathered the measured variables at the testing time points on day one, after six weeks, and after 12 weeks. The assignment procedure and the treatment programs rendered the examiner blind.

2.4.Interventions:

Subjects in group A began their training with a conventional physical therapy regimen, which was followed by the two main concentric strengthening exercises, the standing hamstring curl, and the long arc quadriceps exercise. The standard physical therapy regimen included applying a heated pack and transcutaneous electrical nerve stimulation (TENS) for 15 minutes, followed by three sets of 30-second hamstring stretches in each leg. Each patient started the concentric strengthening exercise program after completing the standard physical therapy exercise program.

The patients were told to sit at the edge of the bed with their knees flexed 90 degrees for the long arc quadriceps exercise. Just above the patient's ankle, a cuff weight equal to 5% of body mass **(12)** was attached. To fully extend the knee joint during the long arc quadriceps exercise, the leg was raised. At each session, the patients were instructed to complete 3 sets of 15 repetitions. Thera Bands were affixed to one of the bedstands as the patients performed the standing hamstring curl exercise while facing the treatment bed. TheraBand resistance **(13)** (5% of body mass **(12)**) was then applied, and the patients were instructed to flex their knees. At each session, the patients were instructed to complete 3 sets of 15 repetitions.

Cases in group B began their training with the same conventional physical therapy regimen as group A, which was followed by the ECC quadriceps exercise, ECC squat exercise, and ECC hamstring exercise, three key eccentric strengthening exercises. Each patient started the eccentric strengthening exercise program after completing the standard physical therapy exercise program. Patients were instructed to lie supine with the tested knee at the edge of the bed when performing the eccentric knee extension exercises. Just above the patient's ankle, a cuff weight equal to 5% of body mass **(12)** was fastened. After then, patients were told to fully extend their knees. The patients were then instructed to slowly bend their knees to contract their quadriceps in an eccentric manner **(2)**.

Each session required the patients to complete 3 sets of 15 repetitions. Patients were taught to slowly flex their knee joints to 90 degrees of flexion during the eccentric squat exercise to load their quadriceps eccentrically. They were then instructed to use both legs to slowly return to the beginning position. At each session, patients performed eccentric squats in three sets of 15 slowly. Patients had to complete each repetition in under 3 seconds and were instructed to take a 2-minute break in between sessions **(14)**.

Patients were lying on their backs with a cuff weight attached proximally to the ankle joint during the eccentric hamstring activity. The knee joint was then instructed to bend against the back of the thigh before being progressively straightened back to its initial position. At each session, the patient did eccentric hamstring movements for 3 sets of 15, which totaled 15 repetitions. Exercises to strengthen the concentric and eccentric muscles were performed twice weekly for a total of 12 weeks in this study.

Statistical analysis

The statistical software for social science (SPSS) version 23 for Windows was adopted for the statistical analysis of the current study. The Kolmogorov-Smirnov and Shapiro-normality Wilk's test was used to check the data for normality assumptions.

Additionally, the presence of considerable skewness, kurtosis, and extreme scores was examined in the data. Additionally, the homogeneity of variance assumption was checked against the data. As soon as it was determined that the data did not deviate from the assumptions of normality and homogeneity of variance, a parametric analysis of the data was conducted. Therefore, a 3x2 Mixed Design MANOVA was performed to compare the means of the tested variables in each of the two tested groups for the pre-test, post-test, post-6 weeks, and post-12 weeks, as well as to compare the pre-test and post-test conditions for each of the tested variables. The alpha level was initially set at 0.05.

Ethical approval

The review board of the Faculty of Physical Therapy, the supreme council for postgraduate studies and research at Cairo University, approved the research for human use after it complied with all pertinent national regulations, institutional policies, and the principles of the Declaration of Helsinki (P.T.REC/012/002811). The Pan African Clinical Trial Registry has received this study's registration, which complies with all consort standards (PACTR202203890283588).

Informed consent

Informed consent has been obtained from all cases recruited in the current study.

3.Results:

According to the unpaired t-tests, there was no clear variance ($p>0.05$) in the mean values of age, weight, height, and body mass index between groups (**Table 1**).

Table 1. Mean (SD) for the participants' demographic data and between groups p-value.

Characteristics	Group A (n=30)	Group B (n=30)	p-value
Age (years), X ± SD	54.76 ± 5.78	53.56 ± 5.87	0.42
Weight (kg), X ± SD	90.1 ± 14.55	87.93 ± 12.33	0.53
Height (cm), X ± SD	163.73 ± 11.41	165.8 ± 8.06	0.42
Body mass index (kg/m²), X ± SD	33.78 ± 5.46	32.2 ± 5.46	0.26

X: Mean, SD: Standard deviation, p-value: Probability value.

The 3x2 Mixed Design MANOVA with the subsequent multiple pairwise comparison tests indicated that there were no clear variances in mean values of VAS, WOMAC, TUG, knee flexion, and knee extension range of motion between group A and group B in the pre-test phase. However, there were noticeable decreases in mean values of VAS ($p<0.05$ **Tables 2**), WOMAC ($p<0.05$ **Tables 2**), and TUG ($p<0.05$ **Tables 2**), post-6 weeks and post-12 weeks in group B compared with group A. Moreover, there was no clear disparity in knee flexion and knee extension range of motion between group A and group B in either of the 3 testing phases ($p>0.05$ **Tables 2**). The mean values of VAS, WOMAC, TUG, and knee flexion and knee extension range of motion noticeably improved, post-6 weeks and post-12 weeks of strengthening exercises in both group A and group B ($p<0.05$ **Table 2**).

4.Discussion:

Patients with knee osteoarthrosis display suboptimal muscle function, particularly in the quadriceps, which causes functional impairment. Exercises that strengthen the hip and knee muscles are known to relieve pain and stiffness while enhancing functional capability in those with knee OA.

Men and women both experience a decline in muscular strength as they age, with women maintaining their eccentric muscle strength levels to a higher extent than men.

Previous research found that young adults maintained their strength longer following strength training than did senior participants. Both women and men experience a decline in flexor and extensor muscle strength as their osteoarthritis of the knees worsens. Gender differences exist in strength increases and the way muscles react to various forms of training **(4)**.

There is much debate on the type of strengthening activities that are most effective for rehabilitating patients with knee O **(5)**. Exercises that are both eccentric and concentric have been shown to improve function, lessen pain, and strengthen the flexion and extension muscles. Most daily tasks require the activation of eccentric muscles to provide support and absorb shock. When a muscle contract eccentrically as opposed to concentrically, more torque is generated. As a result, unfamiliar eccentric activities may result in muscle injury or delayed pain.

Table 2. Mean (SD) of groups, mean (SD) within groups for VAS, WOMAC, TUG, knee flexion, and knee extension range of motion in Group A and Group B in the "pre" and "post" test phases.

Outcome measures		Pre-test	Post-6 WKs (Post I)	Post-12 WKs (Post II)	Within groups p-value		
					pre vs post I	pre vs post II	post I vs post II
VAS	**Group A**	6.7 ±1.8	5.2 ±1.73	4.16 ±1.72	.001*	.001*	.001*
	Group B	7.1 ± 2.13	4.03 ±1.71	2.76 ±1.59	.001*	.001*	.001*
Between groups p-value		.39	.009*	.002*			
WOMAC	**Group A**	61.2 ± 5.8	51.9 ±10.16	42.6 ±10.73	.001*	.001*	.001*
	Group B	59.7 ± 6.9	45.4 ±9.06	35.13 ±8.02	.001*	.001*	.001*
Between groups p-value		.38	.01*	.003*			
TUG	**Group A**	17.8 ± 3.47	14.3 ± 2.74	12.1 ± 2.19	.001*	.001*	.001*
	Group B	18.73 ± 2.3	12.2 ± 2.51	10.43 ± 2.75	.001*	.001*	.001*
Between groups p-value		.25	.002*	.009*			
Knee flexion ROM	**Group A**	104.6 ± 12.12	113.5 ± 12.9	120.6 ± 12.2	.001*	.001*	.001*
	Group B	103.9 ± 8.28	116.66 ±8.53	122.6 ± 9.01	.001*	.001*	.001*
Between groups p-value		.78	0.26	0.47			
Knee extension ROM	**Group A**	-11.46 ± 4.68	-8.73 ± 3.38	-6.23 ± 2.63	.001*	.001*	.001*
	Group B	-11.23 ± 5.37	-7.36 ± 4.12	-5.6 ± 3.73	.001*	.001*	.001*
Between groups p-value		.85	.16	.45			

***Significant at alpha level < 0.05, Post I: post 6 weeks, Post II: post 12 weeks.**

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Subsequently, exercise trainers offer advice to practice eccentric activities. Eccentric contraction results in less cardiovascular stress, making it a better mode of contraction for people with cardiovascular issue **(4)**. The purpose of this study was to compare the effects of eccentric and concentric strengthening exercises on knee flexion and extension range of motion (ROM), WOMAC, TUG, and VAS in patients with knee OA.

The results of this study demonstrated that, when compared to the pre-test condition, both groups had significantly improved mean values for the VAS, WOMAC, TUG, and knee flexion and extension range of motion. However, compared to the CON exercises group, the ECC exercises group did not significantly differ in knee flexion and extension range of motion (ROM), VAS, WOMAC, or TUG rating post-6 or post-12 weeks. A reduction in VAS score made the improvement in pain severity evident after therapy with ECC strengthening exercises. Group A and group B initially reported comparable VAS scores (6.7 and 7.1). After 6 weeks, group B's VAS score was reduced by 3 points, while group A's decreased by 1.5 points, and after 12 weeks, group B's VAS score decreased by 4 points, while group A's decreased by 2.5 points.

The reductions in WOMAC and TUG scores following treatment with ECC exercises were a clear indication of the improvements in functional ability. When compared to the concentric exercise group, the eccentric strengthening exercise group showed significantly more improvement in the WOMAC and TUG scores post-6 weeks (WOMAC from 59.7 to 45.4; and TUG from 18.73 to 12.2) and post-12 weeks (WOMAC from 59.7 to 35.13; and TUG from 18.73 to 10.43). (WOMAC from 61.2 to 42.6; and TUG from 17.8 to 12.1).

The improvement in quadriceps strength following the use of ECC exercises may be responsible for these notable reductions in discomfort and increased functional capacity. According to one theory, the key risk factor for increasing knee pain decreased function, and the advancement of joint deterioration in knee OA patients is quadriceps weakness **(15)**. Patients with knee OA have reported less pain and improved function after strengthening their quadriceps muscles **(2).**

Strengthening the quadriceps reduces the strain placed on the knee, reducing joint deterioration as well as pain and inflammation. The decrease in the quadriceps muscle's hypertonicity with exercise may be responsible for the reduction in pain intensity **(16)**. Additionally, the fact that group B performed more eccentric exercises on the quadriceps muscles than group A did concentric activities on the quadriceps muscles may have contributed to group B's significantly greater reduction in pain and increase in functional ability. In the current investigation, two exercises—the eccentric quadriceps exercise and the eccentric squat exercise—were employed to strengthen the ECC, whereas, in the evaluated concentric strengthening exercises, the long arc quadriceps exercise was the only activity that primarily targeted the quadriceps muscles.

These results are in line with those by Vincent et al **(6)**, who for 4 months looked at the effects of ECC exercises and CON exercises on leg muscular strength and knee osteoarthrosis symptoms. In individuals with knee OA, both resistance exercises were successful in lowering pain, boosting leg strength, and extending walking distance, according to the study's findings. Similar results were shown when eccentric strengthening activities and TheraBand were used to increase eccentric quadriceps muscle torque **(2)**. In contrast to the present investigation, the researchers looked at samples that included healthy persons rather than patients with knee OA. The results of the current study also support those of a previous study **(4)** that examined the effects of ECC and CON strengthening exercises on WOMAC and leg strength in knee OA patients.

In a group of 54 cases with knee OA, Hernandez and his colleagues investigated the impact of eccentric and concentric strengthening activities. They saw improvements in both groups' WOMAC scores and leg strength. The VAS scale, diagnostic ultrasonography, isokinetic measurements of muscle torque, and a physical performance battery were all used during the four-month trial. The authors further stated that a 58-year-old male patient with bilateral knee OA showed significant improvements in pain, muscle morphology, strength, and physical performance after 12 weeks of eccentric strengthening activities for the knee flexors and extensors **(17)**.

The results of the current study, which aimed to compare the effects of eccentric and concentric strengthening exercises on knee joint flexion and extension range of motion (ROM), showed that strengthening exercises could improve knee joint mobility regardless of the type of muscle contraction. Specifically, neither post-6 weeks nor post-12 weeks revealed a non-significant difference between group A and group B.

The pain relief that underlies the increase in muscle strength may be responsible for the recovery in knee flexion and extension range of motion (ROM) **(16)**.

According to Potier et al. **(18)**, there has been a significant improvement in the range of motion in the knee joint. They looked at how 20 subjects' hamstring

strength and knee extension range of motion changed after 8 weeks of ECC strengthening exercises. They discovered that the ECC exercise program altered the biceps femoris muscle's muscle architecture, which in turn affected knee range of motion. Saeed et al **(16)**.'s comparison of the effects of 8 weeks of ECC strengthening exercises and CON strengthening activities on pain and knee joint ROM in 40 individuals with knee OA produced comparable results. Both exercise regimens, according to their findings, increased knee joint range of motion, functional capability, and discomfort, but ECC exercises were more successful.

The current study has some limitations. The authors were unable to get radiographic pictures of changes in tibiofemoral contact points and changes in joint space, which would have provided information on the mechanisms underlying the effects of exercise. Furthermore, eccentric and concentric activities may have possible that eccentric and concentric activities have distinct effects on strength in men and women. The reaction to exercise modality should therefore take gender into account in future investigations.

Conclusion

Knee flexion and extension ranges of motion as well as VAS, WOMAC, and TUG scores were measured before and after receiving concentric and eccentric strengthening treatments for 6 and 12 weeks. The current study's findings showed that eccentric strengthening exercises were superior to concentric strengthening exercises for reducing the severity of pain and increasing the functional capacity in individuals with knee OA.

Disclosure statement

No financial support or any financial benefit from this study has been gained.

Conflict of interest

No conflict of interest has been declared by the authors.

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