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Low repetition high resistance training versus high repetition low resistance training for strengthening calf muscles in patients with Knee osteoarthritis

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Abstract

Background: muscular strength training improves range of motion, muscle strength, and functional capacity in patients with knee osteoarthritis (OA) **OBJECTIVE:** The aim of this study was to compare the effects of low-repetition high resistance and high repetition low resistance strengthening training of calf muscle in patients with mild and moderate knee osteoarthritis**. METHODS:** Forty-eight patients of both genders with mild to moderate bilateral knee osteoarthritis, their age ranged from 50-60 years. The patients were randomly assigned into three groups, group (A): 16 patients received conventional physical therapy treatment only. Group (B) consisted of 16 patients received conventional physical therapy and low repetition high resistance training of calf muscle. Group (C) consisted of 16 patients received conventional physical therapy and high repetition low resistance training of calf muscle**. RESULTS:** The study found a significant decrease in VAS and WOMAC in group B and group C compared to group A, but no significant difference in VAS between the two groups. However, group B showed significant increases in the strength of their right and left calf muscles compared to group A and C. **CONCLUSION:** Resistance training exercises for calf muscles are recommended as in adjunct to the treatment's protocols for patients with knee osteoarthritis. Both high and low resistance training is effective in improving pain and function in patients with knee osteoarthritis. Also, high resistance training exercises are more effective than low resistance exercises**.**

Key words: calf muscles**;** knee osteoarthritis**;** strengthening exercises**.**

1. Introduction

Knee osteoarthritis (OA) is a leading cause of disability causing pain, limited range of motion, making daily activities difficult and resulting in a low quality of life (1). Factors such as gender, family history, joint overuse, obesity, and obesity are also associated with OA (2). The prevalence of OA has increased to 28% in rural areas and 25% in urban areas due to increased life expectancy (3).

Functional performance of these patients deteriorates due to a lack of voluntary activation, and pathophysiological effects cause biomechanical changes in the articular cartilage and surrounding ligaments, leading to increased joint compression and strain (4).

Knee osteoarthritis patients experience changes in calf muscles due to delayed or altered neuromuscular activation, resulting in decreased medial gastrocnemius activation and increased lateral gastrocnemius activation. This affects gastrocnemius function and composition, leading to decreased muscle mass, endurance, and strength (5,6).

Resistance training concepts can help achieve desired outcomes by varying repetitions, sets, load/intensity, and rest periods. Resistance training regimens should follow specificity, overload, and progression principles to challenge muscles to become stronger, faster, or more fatigue-resistant (7).

High resistance training is recommended for elderly patients to maximize strength and functional benefits. While low resistance training is used to reduce injury risk and increase local muscular endurance (8).

Therefore, this study was done to compare the effects of low-repetition high resistance and high repetition low resistance strengthening training of calf muscle in patients with mild and moderate knee osteoarthritis

2. Patients and Methods

2.1. Study patients and ethics

The study's sample size was calculated using G*Power program 3.1.9, resulting in 48 patients, with a required 16 subjects per group. Forty-eight patients from both genders with mild to moderate bilateral knee osteoarthritis participated in this study after signing the consent form. This study extended from September 2021 and ended to October 2022. It was conducted at the department of physical therapy in the general hospital in Kafr El-sheikh, Egypt. The study was approved by the Ethical Committee for Human Research at the Faculty of Physical Therapy, Cairo University, Egypt (NO: P.T.REC/012/004019).

2.2. Study design

This study was a Randomized controlled trial. Patients were randomly distributed into three groups using random generator (www.randomization.com). Group A (Control group): involved 16 patients and received conventional physical therapy treatment only. Group B (experimental group 1): involved 16 patients and received conventional physical therapy and low repetition high resistance training of calf muscle. Group C (Experimental group 2): involved 16 patients and received conventional physical therapy and high repetition low resistance training of calf muscle. All patients in group A were diagnosed and referred by an orthopedic surgeon (9). It was conducted at the department of physical therapy in the general hospital in Kafr Sheikh, Egypt.

2.3. Inclusion and exclusion criteria

To be included in the study, subjects were evaluated using the following criteria: Age ranges between 50-60 years from both genders, Patient with mild to moderate bilateral OA grade II-III, Patients who can walk with a painful knee OA without assistive devices and Body mass index 25-29.9 kg/m2. This study excluded patients with psychiatric disorders, total knee joint replacement surgery, BMI over 30 kg/m2, musculoskeletal system diseases, neuromuscular

diseases, serious cardiopulmonary conditions, inflammatory arthritis, cognitive impairment, history of traumatic knee OA, or intra-articular injections within the past 6 months (9).

2.4. Outcome measures:

1. **Pain assessment by visual analogue scale (VAS):** It is a 100-mm horizontal line anchored by word descriptors at each end by ‘‘no pain’’ on the left and ‘‘worst imaginable pain’’ on the right**.** It is reliable and valid (10).
2. **Arabic version of Western Ontario and McMaster Universities osteoarthritis index (WOMAC):** it is a self-administered questionnaire measuring pain, joint stiffness, and daily activity difficulty, translated into Arabic using a forward and backward translation procedure (11).
3. **Hand-held dynamometer (HHD):** it is a widely used method for assessing muscle strength and power due to its convenience, portability, and ease of application (**12**).

2.5. Assessment procedures:

Patients were evaluated at baseline and after 12 physical therapy sessions on alternative days.

- **Visual analogue scale:** was used to assess pain severity. Patient was asked to marks on the line the point that he feels which represents his/her perception of current state (10).
- **WOMAC questionnaire Arabic version:** the patient completed a questionnaire explaining its items, which included 5 questions about pain, 2 about stiffness, and 17 about degree of difficulty in daily life activities. Subscale scores were calculated separately, and a total score was recorded, aggregating dimensions into a global index (11).
- **Hand-held dynamometer (HHD):** the calf muscle strength was measured, by placing a dynamometer over the metatarsal heads on the sole of the foot, while patients lie supine with ankle in plantarflexion (13).

2.6. Treatment procedures:

- **Conventional treatment:** it was given to all groups and consisted of:

a. Instructions: all patients were advised to maintain a healthy weight, an active lifestyle and to contact their doctor if they need supplements (14).

b. Continuous ultrasonic: with 1 MHz frequency and 1 W/cm2 intensity. With the patients in a supine position, and applied to the both medial and lateral knee parts (5 min on each side) (14).

c. Therapeutic exercises: involving self-stretch of hamstring and calf, inner range knee extension, knee extension from sitting, straight leg raising and hip abduction.

- **Low repetition high resistance training of calf muscles:** it was done in group B (Experimental group 1).
  - It consists of unilateral heel raise Exercise: patient was asked to do unilateral calf raise while holding the weight in his hand.
  - Before starting the training, 60% of 1 RM was designated as the initial intensity for high-resistance strength training. 1RM was measured as the maximal weight that can be lifted once with correct lifting technique.
  - The exercise was done for 3 sets × 8 repetitions for 12 sessions (3 sessions /week) with 1minute of rest between sets.
  - Every week, 1 RM was retested, and the training weight was progressively increased by 5% of the new 1 RM, as tolerated (15).

- **High repetition low resistance training of calf muscle:** it was done in group C (Experimental group 2).
    - It was done in the same way as in group B but with Low-resistance exercise (10% of 1 RM) consisted of 10 sets × 15 repetitions for 12 sessions (3 sessions /week) with 1 minute of rest between sets (16).

2.7. Statistical analysis

MANOVA test was conducted for comparison of subject characteristics between groups. Fisher's exact test was used for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test for all variables. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Mixed MANOVA was performed to compare within and between groups effects on VAS, WOMAC and calf muscle strength. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparison. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

3. Results

***- Subject characteristics*:**

Table (1) showed the subject characteristics of group I, II and III. There was no significant difference between groups in age, weight, height and BMI distribution ($p > 0.05$). There was no significant difference between groups sex distribution ($p= 1$).

Table 1. Basic characteristics of patients.

Variable	Group I	Group II	Group III	p-value
	mean ± SD	mean ± SD	mean ± SD	
Age (years)	54.94 ± 4.34	55.44 ± 3.67	54.25 ± 3.34	0.67
Weight (kg)	77.81 ± 5.68	75.94 ± 6.61	74.56 ± 6.52	0.34
Height (cm)	163.81 ± 4.82	162.94 ± 7.83	160.06 ± 6.68	0.25
BMI (kg/m²)	29.38 ± 0.52	28.81 ± 1.11	29.01 ± 0.82	0.17
Sex, n (%)				
Females	13 (81%)	13 (81%)	14 (87.5%)	1
Males	3 (19%)	3 (19%)	2 (12.5%)	

SD, standard deviation; p-value, level of significance

Effect of treatment (both group B and C) on VAS, WOMAC and calf muscle strength:

Mixed MANOVA revealed that there was a significant interaction of treatment and time ($F = 31.91$, $p = 0.001$, Partial Eta Squared = 0.75). There was a significant main effect of time ($F = 966.71$, $p = 0.001$, Partial Eta Squared = 0.98). There was a significant main effect of treatment ($F = 12.56$, $p = 0.001$, Partial Eta Squared = 0.54).

Within group comparison

There was a significant decrease in VAS and WOMAC in the three groups post treatment compared with that pretreatment ($p < 0.001$). The percent of decrease of VAS and WOMAC in group I was 61.56 and 42.48% respectively and that in group II was 67.99 and 66.39% respectively while that in group III was 65.39 and 52.49% respectively.

There was a significant increase in strength of right and left calf muscles in group II and group III post treatment compared with that pretreatment ($p < 0.001$), while there was no significant change in calf muscle strength of group I ($p > 0.05$). (Table 2).

Between group comparison

There was no significant difference between groups pretreatment ($p > 0.05$). Post treatment there was a significant decrease in VAS and WOMAC of group II and group III compared with that of group I ($p < 0.01$); and a significant decrease in WOMAC of group II compared with that of group III ($p < 0.001$). There was no significant difference in VAS between group II and III ($p > 0.05$).

There was a significant increase in strength of right and left calf muscles of group II compared with that of group I and group III ($p < 0.001$). There was a significant increase in strength of right and left calf muscles of group III compared with that of group I ($p < 0.001$). (Table 2).

Table 2. ***Mean VAS, WOMAC and calf muscle strength pre and post treatment of group I, II and III:***

Variable	Group I	Group II	Group III	p-value		
	mean ± SD	mean ± SD	mean ± SD	I vs II	I vs III	II vs III
VAS						
Pre treatment	8.46 ± 0.64	8.06 ± 0.81	8.12 ± 0.61	0.32	0.51	1
Post treatment	4.09 ± 0.68	2.58 ± 0.62	2.81 ± 0.89	0.001	0.001	1
MD (% of change)	4.37 (61.56%)	5.48 (67.99%)	5.31 (65.39%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
WOMAC						
Pre treatment	43.69 ± 4.75	42.75 ± 4.93	45.13 ± 6.32	1	1	0.65
Post treatment	25.13 ± 3.91	14.37 ± 3.73	21.44 ± 3.09	0.001	0.01	0.001
MD (% of change)	18.56 (42.48%)	28.38 (66.39%)	23.69 (52.49%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
Right calf muscle strength (lb)						
Pre treatment	20.07 ± 1.61	19.72 ± 1.52	20.8 ± 1.94	1	0.71	0.24
Post treatment	20.1 ± 1.62	30.43 ± 1.93	26.48 ± 2.05	0.001	0.001	0.001
MD (% of change)	-0.03 (0.15%)	-10.71 (54.31%)	-5.68 (27.31%)			
	p = 0.94	***p = 0.001***	***p = 0.001***			
Left calf muscle strength (lb)						
Pre treatment	19.93 ± 1.56	19.65 ± 1.27	20.23 ± 1.77	1	1	0.88
Post treatment	20.06 ± 1.61	30.21 ± 2.39	26.41 ± 1.89	0.001	0.001	0.001
MD (% of change)	-0.13 (0.65%)	-10.5 (53.74%)	-6.18 (30.55%)			
	p = 0.71	***p = 0.001***	***p = 0.001***			

SD, Standard deviation; p-value, Level of significance

4. Discussion:

This study analyzed the effects of low repetition high resistance training and high repetition low resistance training on pain and functional performance in patients with knee osteoarthritis. There was a significant decrease in VAS and WOMAC in group B (low repetition high resistance training) and group C (high repetition low resistance training) compared to group A (control group). However, no significant difference was found in VAS between the two groups. However, group B (low repetition high resistance training) showed a significant increase in strength of right and left calf muscles compared to group A and group C, while group C showed a significant increase in strength.

This research examined both right and left knees, revealing strength deficits in subjects with asymmetrical involvement and bilateral symptoms. Contralateral knees in patients with unilateral or bilateral radiographic osteoarthritis show impairments (16).

Results showed a significant decrease in VAS and WOMAC between pre and post treatment, with no significant difference in VAS between group II and III compared to group I.

Resistance training has been shown to reduce pain and improve physical function in patients with knee osteoarthritis. High resistance exercises can reduce walking time on level surfaces for 60 meters by 8%-10% and improve 6-minute walking distance by an average of 28%-45%. Improving walking ability is clinically significant because it is linked to functional independence, reduced risk of mortality, and nursing home admission (17,18).

A. Effect of high vs low resistance training on pain and functional performance

High-intensity resistance training has been shown to boost energy expenditure in adults, enhance physical function and muscle strength, and lessen pain in people with knee osteoarthritis of the knee. About 56% of studies found a significant reduction in knee pain after high-intensity training, while 79% of studies showed a small effect size (15).

However, the findings contradict those of a study by **Mikesky et al. (2006),** which found no differences in pain ratings between resistance training and control groups after a 12-month program. The resistive exercise group showed preserved strength and decreased progression of joint space narrowing over a 30-month period when compared to the control group (19).

B. Effect of high vs low resistance training on calf muscle strength:

Research has shown that resistance training is the most effective intervention for increasing muscle strength, and it is suggested in knee osteoarthritis management recommendations. Previous studies have shown that subjects with knee OA who participated in moderate- to high-intensity resistance exercise regimens increased their quadriceps and hamstring strength by 6%-46% (15,20).

High-resistance exercise has been found to improve muscle strength, size, and range of motion in older men. Therapeutic exercise, such as open and closed kinetic chain exercises and progressive resistance training, can also improve muscle strength in people with knee OA (18).

In untrained elderly men, a low-repetition/high resistance group improved considerably more than a high-repetition/low resistance group. Both groups increased muscle strength in the knee flexors and extensors, as well as the hip flexors and abductors, with greater changes occurring in the resistance exercise group. Isokinetic knee torque can rise more with higher resistance exercise intensity (21).

Research has shown that high-intensity resistance training can significantly improve isokinetic strength in older women with knee osteoarthritis and total knee arthroplasty. This is due to the reduction in total workout time and improved patient adherence. Studies have also found that knee extensor and flexor torque increase during the initial 3- to 6-month phase and gradually decrease after the transition (22).

Resistance exercises have been found to be effective in improving muscle strength in older women with total knee arthroplasty and knee osteoarthritis. Studies have also found that resistance exercise groups tend to gain more power in all exercises than self-management exercises (23).

Research has also shown that both resistance exercises and aerobic exercises can decrease knee pain and disability, increase walking speed, and reduce self-reported disability (24). Low-resistance exercise may boost muscle strength via neuromuscular processes, and it is assumed that neural adaptation and neuromuscular learning are responsible for the increases in muscle strength in the minimal resistance group (25).

Despite the recommendation of low resistance exercise training to prevent injury from

overstretching, recent research has found that explosive resistance training and progressive resistance training programs are feasible and tolerable in preoperative patients with knee osteoarthritis, with an adherence rate of over 90% (22,26).

Future studies are recommended to assess the effects of resistance exercises of different group of muscles as hip muscles as in treatment program for knee OA. Also, to compare between different type of resistance exercises for calf muscles such as weight bearing and non-weight bearing exercises not just doses of exercises.

Our study had some limitations. Firstly, the lack of long term follow-up. In addition, other relevant measures, such as joint stability, pain during daily activities, and quality of life, were not considered.

5. Conclusion

Resistance training exercises are recommended for knee osteoarthritis patients, improving pain and function, with high resistance exercises being more effective than low resistance exercises.

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Patient consent statement:

Prior to the start of data collection, all patients provided their written, informed consent.

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