Effect of Three Different Physical Therapy Approaches on Function and Disability of the Knee Joint in Patients with Knee Osteoarthritis. Randomized Study.

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ABSTRACT

BACKGROUND: Knee osteoarthritis (OA) commonly causes increase in the patients' disability and reduce their function because it causes pain, limitation in knee range of motion and decrease in muscle power.

AIM: This study investigated the effect of three different physical therapy programs on knee range of motion , pain level, muscle strength and functional condition in patients with knee OA.

DESIGN: Randomized comparative study.

SETTING: Outpatient Rehabilitation clinic of Tongji Hospital (Wuhan, China).

POPULATION: Seventy-two patients of Knee OA (aged 40-70) enrolled and randomly allocated into three groups. Group A (n=24) received physical agents and isometric quadriceps exercises, group B (n=24) received same physical agents as group A in addition to open kinetic chain exercises and group C (n=24) received physical agents as group A in addition to closed kinetic chain exercises.

METHODS: knee range of motion (by electro goniometer), knee pain level (by VAS), quadriceps muscle strength (by isokinetic dynamometer) and functional condition (by WOMAC) were assessed before and after 5 weeks of treatment.

RESULTS: In between group analysis, there were significant differences ($P<0.05$) between the three groups for all outcome measure. In within-group analysis, group C was the only group that showed significant differences ($P<0.05$) in all the outcomes. Group A and B showed significant differences ($P<0.05$) in quadriceps muscle strength and knee pain and no significant differences ($P>0.05$) in knee ROM and functional condition.

CONCLUSIONS: After the study, our solid conclusion is that in physical therapy programs or protocols, closed kinematic chain exercise is very effective, it improves knee ROM, and help in reducing knee pain, muscle strength, function and disability for patients with knee osteoarthritis.

CLINICAL REHABILITATION IMPACT: Comparison between different physical therapy programs provides the rehabilitation team with the best treatment intervention that is more effective in treating the problems associated with knee osteoarthritis.

Key words: Disability, function, knee osteoarthritis, physical therapy.

Introduction

Knee osteoarthritis (OA) is considered one of the most predominant disorders that leads to chronic disability (1). This disability increases the need to relieve the accompanied pain and improve the function of these patients quickly to decrease these accompanying cardiovascular problems (2). About 100 million persons in China complain of knee OA with prevalence of symptomatic knee OA 8.1% (3,4) Arthritic disorders are considered a challenge to anyone worried by expenses of the healthcare, and their neglection causes an increase in the demands for more money to be spent on arthritis research. Patients with knee OA significantly develop an abnormal change in the knee articular cartilage (5), a reduction in the quadriceps muscles torque and strength (6) and a decrease in the knee ROM, however their precise mechanisms are still not unclear (7).

The limitation in the knee ROM is showed in several studies, however it is not well understood yet (8). It might be due to several causes. The first is due to the unequal distribution of the applied loads by the body weight during walking Thus, a greater load will be applied to the medial compartment of the knee joint than lateral compartment, which narrows the joint space at the medial compartment of the knee joint, hence causing an incongruity of the articular surface during motion and a decrease in ROM occurs (9). The second is due to the formation of osteophytes (10), which resulting into abnormal changes in the articular surface causing a limitation in its ROM (11). The third is due to an increase in capsule thickness with in the knee OA progresses, which restricts the ROM (8).

The limitation of the knee ROM is the most parameter that previous studies have not investigated. Other studies that looked at the difference between the effects of the closed kinematic chain (CKC) and opened kinematic chain (OKC) exercise on the knee joint and patient function in patients with knee OA didn't discuss its effect on the knee ROM, hence, these studies don’t give a complete picture of the effect of these exercises on the function and disability of the knee joint. Lim 2002 (12) conducted a study to compare the effect of OKC and CKC on the function and disability of patients with OA. However, his study didn't evaluate either the knee ROM or the pain level of the knee joint. Verma 2012 (13) compared the effect of OKC and CKC exercise on the quadriceps strength and functional condition of women only with knee OA. His study shows that the CKC exercise was more effective in improving the quadriceps strength and functional condition of women with knee OA.

Shah 2014 (14) compared the effect of the CKC and OKC on the knee pain and patient function. His study demonstrated that no significant difference between CKC and OKC exercises along with conventional therapy in reducing pain and improving patient function. They evaluated neither the muscle strength nor knee ROM. Recently, Olagbegi et al., 2016 (15) conducted a study to investigate the effect of combined chain exercises (CCEs) on pain and function in patients with knee OA. Their study found that CCEs are more effective than CKC or OKC in alleviating the knee pain and patient function. However, their study didn't investigate the effect of this exercise on muscle strength and knee ROM.

Patients with knee OA usually complain of a decrease in their function and disability due to significant adverse effects of the disease on pain, knee ROM and muscle strength. The effect of the exercise on the knee ROM considers the most outcome effect which has not been studied, hence, the search for the most effective exercise that gives optimum results in a short period is considered an urgent need. To the best of our knowledge, there is no comparative study that has investigated the effect of isometric, CKC and OKC exercises on the overall function and disability on patients with knee OA including knee ROM, knee pain, muscle strength, disability and function, which was the aim of our study to compare the effects of three different treatment approaches on the overall function and disability in patients with knee OA.

Material and Methods

Patients

This study was a randomized trial (Trial registration number is ChiCTR-INR-17014012) designed to comply with the recommendations of the Consolidated Standards of Reporting Trials (CONSORT) statement. The study was planned and conducted in accordance with the guidelines contained within the Declaration of Helsinki, and it was approved by Ethical Committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China. (No. TJ-IRB20160703). All patients, together with their caregivers, gave their written informed consent.

Eighty-six patients were diagnosed with a unilateral knee OA by one orthopedic surgeon who utilized clinical findings and imaging, such as X-ray (16). The inclusion criteria included unilateral knee osteoarthritis based on the radiological and clinical criteria for osteoarthritis diagnosis Mild and modearte OA according to EULAR evidence-based recommendations for the diagnosis of knee osteoarthritis (16), the patients can walk for 100 m or more on a surface that is uneven, they have knee pain lasting over 6 months and they have a limitation in knee flexion ROM more than 15 degrees (13,17). The exclusion criteria included any surgical history in the last 6 months on lower extremities, injection of steroids or hyaluronic acid in the articular cartilage, diabetes mellitus, communicative or cognitive impairments, congenital abnormalities, heart problems, neurological disease, unstable angina, total or partial hip or knee replacement, uncontrolled hypertension, traumatic conditions, respiratory diseases, musculoskeletal diseases, chronic kidney or liver diseases and stroke patients (18).

Fourteen patients were excluded after the initial examination, they included eight patients (10 %) did not meet the inclusion criteria and six patients (7.5%) assessed only at the baseline and did not continue the study. The patients that didn’t meet the inclusion criteria were having a total hip replacement (2) uncontrolled hypertension (3) and unstable angina.

Seventy-two patients who fulfilled all criteria, were aged 40 to 70 years. They were randomized to three groups by using randomized permuted blocks to accomplish the balance of the sample sizes among the three groups. The randomization was done by a college’s staff

who wasn't involved in this study and performed the outcome assessments. he was also blinded to group's types.

The three groups included group A (n=24) (physical agents and isometric quadriceps muscle exercises) and group B (n=24) (physical agents and OKC) and group C (n=24) (physical agents and CKC). The patients were examined both at the baseline and after 5 weeks of treatment. The physical therapy program for three groups was equal in time, 3seesions/week for 5 weeks as shown in Figure 1.

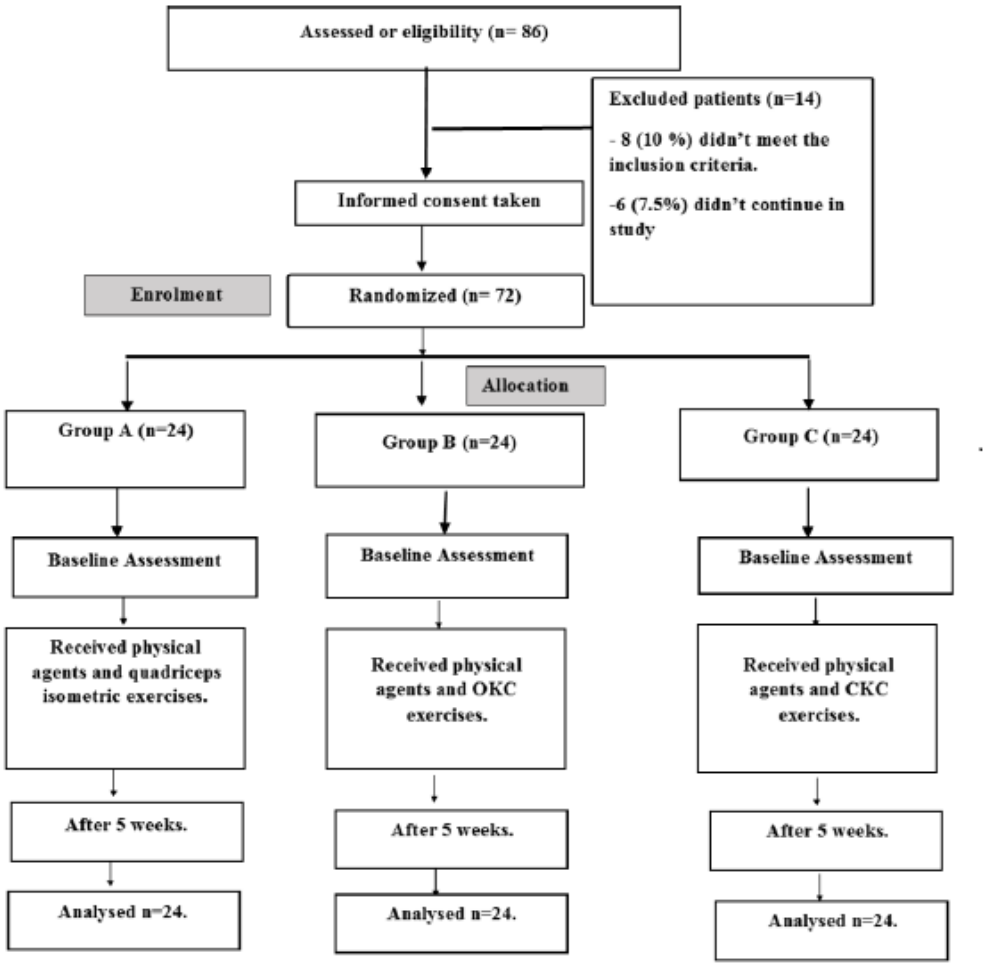

Figure 1: CONSORT chart for patient's flow in this study

Evaluative procedures

1-Knee ROM measurement

An electric-goniometer was used to measure the changes in the knee ROM of flexion in this study. Goniometers are considered a validated and reliable measure for assessing the knee ROM in patients with knee OA(19). The electro-goniometer was calibrated in three different angles (180º, 90º and zero). This method of calibration is repeated each time the device was

used to allow the accuracy of the measurement. The measurement of the knee ROM was performed according to Reese and Bandy (20).

2- *Knee pain measurement*

Knee pain severity was measured using visual analog scale (VAS) scale. VAS is a reliable and validated method of measuring pain severity (21).

3- Quadriceps strength

Muscle strength of knee extensors was tested using a Con-Trex isokinetic dynamometer (Con-Trex MJ; CMV AG, Dubendorf, Switzerland). The dynamometer is a reliable and validated method of measuring quadriceps muscle strength (22). The strength testing was performed in an order of 120°/s, 180°/s, and then 60°/s to control the effects of fatigue. Participants sat leaning against a backrest inclined 15° backward from vertical and were secured to the machine at the upper chest, pelvis, and distal femur on the tested side. The participants were instructed to extend the knee as far as possible, among the records of the 3 trials at each speed, the highest values were recorded as the peak torque. All data were corrected for the gravity (22).

4-*Knee functional condition*

Functional condition of the knee was measured based on the WOMAC scale. This WOMAC index is known to be a responsive, validated and reliable measure of knee osteoarthritis effects like functional condition (23). The WOMAC scale includes 17 items to evaluate the physical function of patient with OA. The patient response ranges from 1 = none to 5 = extreme. Total scores are created by summing up the scores for each item.

Treatment procedures

Group A

It included 24 patients who were given physical agents and isometric quadriceps exercises. The physical agents were performed according to the protocol of Fransen et al (18) because it is the most used protocol for the treatment of knee OA. It included transcutaneous electrical neuromuscular stimulation (T.E.N.S), hot pack, and ultrasound (U.S). A physiodyn-Basic electro therapy device (Physiomed elektromedizin, Schnaittach, Germany) was applied to the painful areas of the knee for 30 minutes. The TENS unit was adjusted to

apply a conventional TENS with a frequency of 100 Hz, a pulse duration of 60 µsn and an intensity as a tingling sensation felt by the patients. The hot pack was applied at the knee for 15 minutes. A Physioson-basic ultrasound device (Physiomed elektromedizin, Schnaittach, Germany) was used with a continuous mode three times a week for 5 weeks (15 treatment sessions) with the frequency of 1 MHz for deep penetration and with an intensity of 1.5 W/cm^2 with gel applied. All isometric quadriceps exercises were described in table 1 (24).

Table 1. Three training program exercises.

Exercise	Description
Isometric quadriceps exercises	It is performed by using a standard variable resistance leg extension machine (Cybex VR2) and using a strain gauge which placed in tension strap to give a resistance against isometric quadriceps contraction, with signal displayed on computer screen in front of patients to give them visual feedback for each contraction. Patients were asked to perform an isometric quadriceps strength from three different angles of knee flexion (50°, 70° and 90°). The patients completed three sets of 10 repetitions, with one set being completed at each of three angles of knee flexion (50°, 70°, 90°). There was 2 second rest between contractions and 2 min rest between each set. In each session, the sets of all angles were completed in a different random order
OKC exercises	
First OKC exercise	First OKC exercise performed with the knee joint in 30° flexion from full extension. The resistance was provided by a 10 cm-wide brace clasped around the ankle joint proximal to the malleolus. Patients were instructed to resist the motion as possible by applying force upward into the ankle brace in response to an auditory signal, the patients were asked to make a moderate and approximately equal effort for each repetition. They were given visual feedback of the force on a data screen. Three sets of 10 repetitions were performed for each task. With a 5–15 seconds rest between repetitions and 2–3 minutes rest between sets
Second OKC exercise	It was performed with knee in 90° flexion from full extension with the same consideration in position and performance during using isokinetic device as first exercise in OKC
Third OKC exercise	It was performed by position the patient in a side-lying position. The patient was asked to adduct the affected leg. The leg that is not affected was in the upward position with flexion of the knee while affected leg placed against the bed. The leg was then lifted up to adduction for about 10 seconds before being lowered gently back
CKC exercises	
First CKC exercise	It was performed from sitting position with the knee in 30° flexion from full extension. The resistance was provided by a plate placed under the whole foot. The dynamometer maintained the joint configuration in the CKC task like to the OKC task. Patients were instructed to respond as possible by pushing down against the resistance exerting pressure with the whole foot in response to an auditory signal, the patients were asked to make moderate and approximately equal effort for each repetition and were given visual feedback of the force on a data screen. Three sets of 10 repetitions were performed for each task. A 5–15 seconds rest between repetitions and 2–3 minutes rest between sets were used.
Second CKC exercise	It was performed from in sitting position with the knee in 90° flexion from full extension. The same OKC exercise consideration in position and performance during using isokinetic device were used as in first exercise in CKC
Third CKC exercise	It was performed from standing then the patient was asked to perform a step-up and down. The patient performed forward, backward and lateral step-ups and step-downs using a 5cm – high sturdy wooden box. The patient's trunk was kept upright and he/she ensured that his/her heel was the last to leave the floor and the last to return in order to emphasize the activities of the quadriceps muscle.

Group B

It included 24 patients. They received the same physical agents as group A in addition to OKC exercises. An isokinetic dynamometer (Con-Trex MJ; CMV AG, Dubendorf, Switzerland) was used. The patients seated with the hip joint was fixed in 90° flexion and ankle joint position was maintained at 90°. The pelvis was firmly strapped to the seat and arms were in resting position. All OKC exercises were described in table 1(13,25).

Group C

It included 24 patients and were subjected to the same physical agents as group A. In addition, they performed CKC exercises. An isokinetic dynamometer (Con-Trex MJ; CMV AG, Dubendorf, Switzerland) was used. The same OKC exercises considerations of position and performance for the isokinetic device were applied as well. All CKC exercises were described in table 1 (13,25).

Sample size calculation

A priori power test was used to calculate the sample size of this study. The G-POWER software (ver.3.1.9.2, Heinrich-Heine-University, Düsseldorf, Germany) was used to calculate the adequate sample size for this study. The power analysis for a one-way ANOVA with 3 groups was conducted in G*Power to determine a sufficient sample size using an alpha of 0.05, a power of 0.80, and a large effect size (f = 0.40) Based on the aforementioned assumptions, the desired sample size is 72 (27). A power of 80% is acceptable in most studies (28). Cohen (29) showed that a medium effect of .5 can be observed by the naked eye of a careful observer.

Data analysis

Descriptive statistics including mean and standard deviation were conducted to show the distribution of age, BMI, gender, pain history, level of activity, knee ROM, VAS, quadriceps muscle strength and functional condition among the study patients of three groups. ANOVA test was used to test within-group analysis and between group analysis. Shapiro-Wilk's test (P> .05) (26) was used to detect the normal distribution of the data. This supports our used parametric statistical method. Post-hoc analysis based on Tukey HSD was performed to compare the results after the treatment. The significance level was established at less than 0.05. The SPSS (ver. 24, IBM Inc., Armonk, NY, USA) was used for statistical analysis in this study.

Results

The demographic and general characteristics of the participants at the baseline were shown in Table 2. There are no significant differences in the baseline measurement between the three groups for their age, BMI, Sex, pain history and level of activity.

Table 2. Physical characteristics of patients in three groups.

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Items	Group A (n=24) M ±SD	Group B (n=24) M ±SD	Group C (n=24) M ±SD	P value
Age (yrs.)	47.5 ±5.87	48.5±6	48±6.16	0.270
BMI(kg/m^2)	37.5±3.24	37.3±3.24	37.1±3.24	0.320
Sex (%)				
Male	10(40 %)	11(45 %)	9(36 %)	0.460
Female	14(60 %)	13(55 %)	15(64 %)	
Pain history (%)				
Present	16 (68 %)	17 (73 %)	18 (77 %)	0.690
Absent	8 (32 %)	7 (27 %)	6 (23 %)	
Level of Activity (%)				
Active	9 (36 %)	8(32 %)	7 (27 %)	0.530
Sedentary	15 (64 %)	16 (68 %)	17 (73 %)	

M: Mean, SD: Standard deviation and P: Probability at .05

Compliance

The exercise sessions were successfully performed by a licenced physical therapist. Most patients showed that three sessions/week were good. All the patients accomplished the period of the study. The total number of the sessions for all the patients in each group was 15 sessions. The compliance in this study was defined as the patient's attendance of 13 sessions out of 15 sessions (93%). All the patients accomplished the compliance requirements in this study. In group A 23/24 patients attended full sessions and 1/24 patients missed one session. In group C 23/24 patients attended full sessions, 1/24 patient missed one session. Major causes for missed exercise sessions were sickness (91%), a disease in their family (6%) or climate conditions (3%).

Between groups

After 5 weeks, there were significant differences between the three groups for knee flexion ROM, knee pain, quadriceps strength and functional condition. P and F values for knee flexion ROM were (F = 9.483, p =0 .001), for VAS were (F = 9.483, p = 0.001), for muscle strength were (F = 30.536; p = 0.001), and for functional condition were (F = 17.424; p = 0.001).

Post-hoc analysis based on Tukey HSD after treatment revealed that the WOMAC mean of group C increased significantly than those in group A (MD = 15.8; p = 0.001) and group B (MD = 18.1; p = 0.001)., while non-significant difference was found between group A and Group B (MD = -2.3; p = 0.497). The muscle strength mean in group C was increased significantly than those in group A (MD = -15.7; p = 0.001) and group B (MD = -18.2, p = 0.001), while non-significant difference was found between group A and group B (MD = 2.5; p = 0 .331). The flexion ROM mean in group C was increased significantly than in group A (MD = -15.6; p = 0.001) and group B (MD = -11.3; p = 0.005), while non-significant difference was found between group A and group B (MD = 4.3; p = 0.255). VAS mean decreased significantly in group A than group B (MD = -2.8; p = 0.001), while group C significantly decreased than group A (MD = 1.7; p = 0.030) and group B (MD = 4.5, p = 0.001) as shown in Table 3.

Table 3. Between the three groups analysis between before and after treatment.

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	Before treatment								After treatment							
	ANOVA		Post hoc tests A vs B		A vs C		B vs C		ANOVA		Post hoc tests A vs B		A vs C		B vs C	
	F	P	MD	P	MD	P	MD	P	F	P	MD	P	MD	P	MD	P
FC(scores)	0.099	0.906	-1.8	0.660	-1	0.807	.8	0.845	17.424	0.001*	-2.3	0.497	15.8	0.001*	18.1	0.001*
QMS(N)	0.710	0.500	2.5	0.302	.1	0.967	-2.4	0.321	30.536	0.001*	2.5	0.331	-15.7	0.001*	-18.2	0.001*
Knee flex. ROM (degrees)	0.979	0.389	-5.8	0.178	-3.7	0.386	2.1	0.621	9.483	0.001*	-4.3	0.255	-15.6	0.001*	-11.3	0.005*
Knee pain(scores)	0.133	0.876	-.2	0.659	-.2	0.659	.000*	1.000	18.788	0.001*	-2.8	0.001*	1.7	0.030*	4.5	0.001*

FC: Functional condition, QMS: Quadriceps muscle strength, A: group A, B: group B, C: group C, Vs: Versus, M: Mean, SD: standard deviation, P: probability at 0.05, and *: Significant

Within group analysis

1. *Knee ROM*

There was a significant difference in group C only and non-significant differences for group A and B for the knee flexion ROM between the pre and post tests. P and F values for group

A and B were (F = 0.114; p = 0.740, F =0 .000; p = 1.000) respectively and for group C were (F = 12.745; p = 0.002). Mean and standard deviation for each group are shown in Figure 2 and in Table 4.

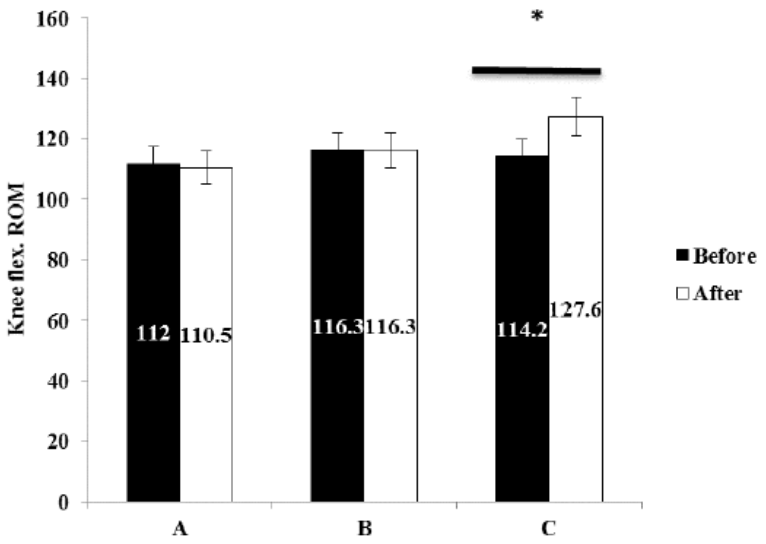

Figure 2. ANOVA results for knee ROM showed that there were no significant differences (P> .05) in group A and group B between pre-test and post-test. While, there was a significant difference for knee ROM (P< .05) between pre-test and post-test results for group C.

Table 4.Within the three groups analysis between pre-test and post-test.

Table 4: Within the three groups analysis between pre-test and post-test

		Pre-test		Post-test		ANOVA	
		M	SD	M	SD	F	P-value
FC(scores)	Group A	42.2	6.61312	48.3	9.74166	2.684	0.099
	Group B	44.5	8.00347	50.1	8.21178	2.385	0.140
	Group C	49.3	9.16576	26.4	7.70570	36.573	0.001 *
QMS(N)	Group A	32.9	6.47130	42	5.37484	11.702	0.003 *
	Group B	33	6.32456	39.5	5.98609	5.571	0.030 *
	Group C	41.9	5.55878	57.7	4.45845	49.163	0.001 *
Knee flex. ROM (degrees)	Group A	112	10.05540	110.5	9.84604	0.114	0.740
	Group B	116.3	8.08359	116.3	8.08359	0.000	1.000
	Group C	114.2	10.09730	127.6	6.23966	12.745	0.002 *
Pain level (scores)	Group A	8.1	.99443	3.5	1.08012	98.165	0.001 *
	Group B	8.3	.94868	6.3	1.94651	8.531	0.009*
	Group C	8.3	.451	1.8	1.05935	95.781	0.001 *

FC: Functional condition, QMS: Quadriceps muscle strength M: Mean, SD: standard deviation, P: probability at 0.05, and *: Significant

2. *Knee pain*

There were significant differences for all knee pain measurements between the pre and post-tests. P and F values for group A, B and C were (F = 98.165; p = 0.001, F = 8.531; p =0 .009, F = 95.781; p = 0.001) respectively. Mean and standard deviation for each group are shown in Figure 3 and Table 4.

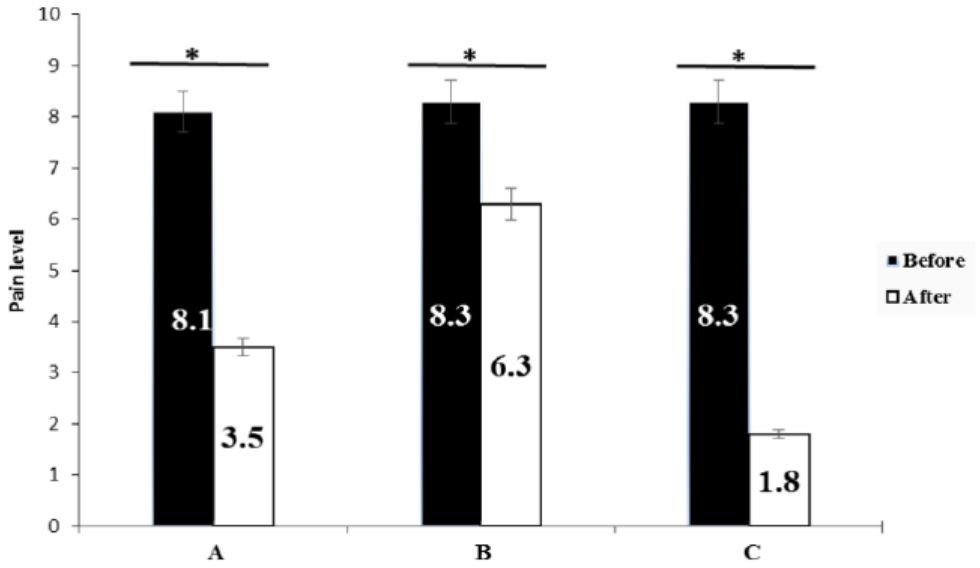

Figure 3. ANOVA results of knee pain showed that there were significant differences (P< .05) for the VAS scale between the pre-test and post-test within the three groups.

3. *Quadriceps strength*

There were significant differences for all groups' quadriceps strength between the pre and post-tests. P and F values for group A, B and C were (F = 11.702; p = 0.003, F = 5.571; p = 0.030, F = 49.163; p = 0.001) respectively, Mean and standard deviation for each group are shown in Figure 4 and Table 4.

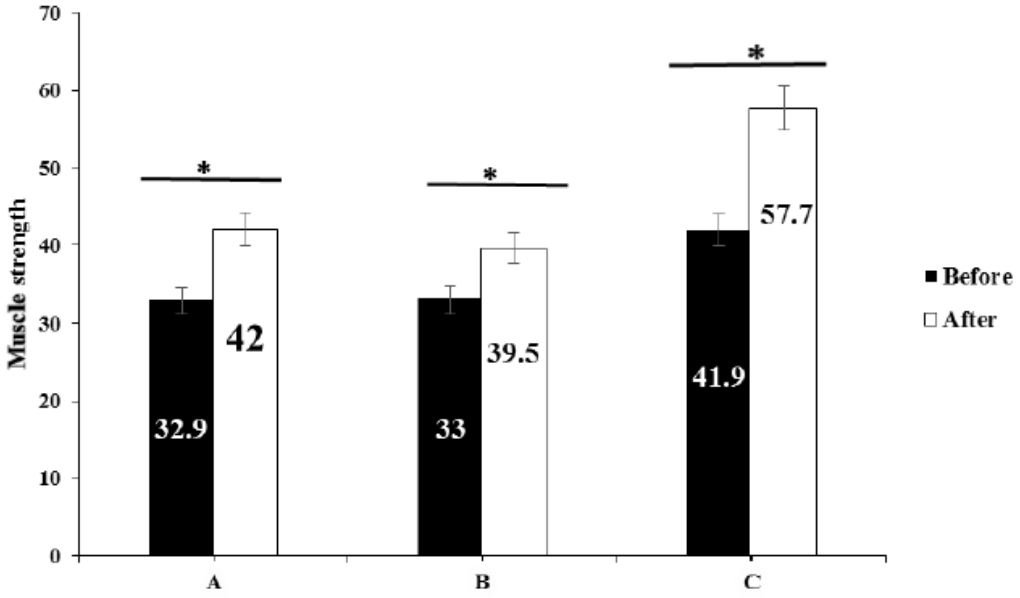

Figure 4 .ANOVA results of quadriceps strength showed that there were significant differences (P< .05) in the three groups for the quadriceps strength between the pre-test and post-test.

4. Functional condition

There was a significant difference in group C only and non-significant differences for group A and B for Functional condition between the pre and post-tests. P and F values for group A and B were (F = 0.099; p = 0.119, F = 2.385; p = 0.140) respectively and for group C were (F = 36.573; p = 0.001). Mean and standard deviation for each group are shown in Figure 5 and Table 4.

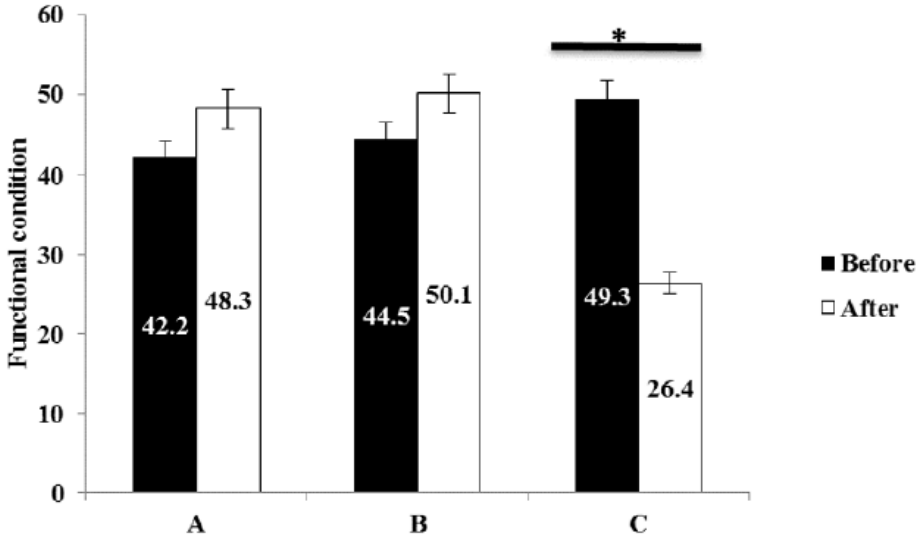

Figure 5. ANOVA results of WOMAC scale results showed that there were no significant differences (P> .05) in group A and B between pre-test and post-test. While, there was a significant difference (P< .05) of WOMAC scale results in group C between pre-test and post-test.

Discussion

Our study is considered unique because it gives a full picture of the function and disability that accompanied knee OA. This study investigated the effect of three different protocols usually used to treat the patients with knee OA for the purpose of establishing their impact on ROM, VAS, muscle strength and functional condition among the patients having knee OA.

For the knee flexion ROM, study findings showed that Group C (CKC exercises + physical agents) improved significantly in ROM than group A (physical agents+ isometric quadriceps exercises) and group B (OKC exercises + physical agents). These results were as the results of Perry et al., 2005 (30) who showed that both the CKC and the OKC can significantly improve knee stability and function. The increase in the ROM might be because CKC exercises leads to the minimisation of compression and shear force per unit area or because of neural inhibition (31,32). The second cause might be due to that , it showed the strong relationship between decreasing pain and improvement of ROM (33).

For pain results, our findings showed that pain level significantly lower in all groups. Previous studies showed that strengthening of the quadriceps reduces the knee pain (34–36) because the strengthening of the quadriceps improves the physical functions of patients having knee OA, which could decrease pain and lead to significant improvements in gait, stability, ROM and muscle strength in a wide variation across and within session.

For the quadriceps strength, the group C (CKC exercises + physical agents) also, was improved significantly in muscle strength than group A (physical agents+ isometric quadriceps exercises) and group B (OKC exercises + physical agents). However, It is was demonstrated that the CKC and OKC exercises are effective in enhancement the quadriceps strength, but there are also disagreements existing relating to the onset of the OKC exercises (37). According to the study conducted by Bakhtiary 2008 (38) the activity of the quadriceps muscle was established to be greatest in CKC exercises in the situation where the knee was close to full flexion and in the OKC exercises, when the knee was close to full flexion. The compressive forces of the patella femoral were established to be greatest when the CKC exercises neared full flexion as well as when the OKC exercises in the extension phase were at the knee midrange. This supports the result of the current study that the improvement of the strength of the quadriceps was higher in the CKC group in comparison with the OKC group.

In terms of which of the three groups had higher outcomes on functional condition, it was found that group C (CKC exercises) were improved significantly than group A (isometric quadriceps exercises) and group B (OKC exercises). According to the study carried out by Augustsson *et al.*, 1998 (39) CKC exercises are preferred than the OKC due to the co-activation of gastrocnemius and quadriceps muscles in a spontaneous manner. This co-activation is essential for the stability of the knee joint. This co-activation is shown to be greater in the CKC.

The OKC and the CKC exercises are performed in the rehabilitation of the knee in the majority of patients having knee OA. Lim 2002 (12) showed that OKC and CKC are associated with an improvement of function and a decrease in knee pain following the treatment of individuals that reported knee OA pain. Till now, the effect of such interventions on the reflexive time of response of the vastus lateralis and the vastus medialis

oblique muscles was not documented (40). In this regard, CKC exercises have a greater effectiveness in comparison with the OKC exercises in functional recoveries of persons having knee osteoarthritis (13).

The major limitation of this study was the short duration of treatment (35 days). We didn't investigate the long effect because we focused on the acute effects to gain as much improve as much in our dependent variables. Also, the age of our study didn't include elderly who usually have more severe knee OA.

Future studies require comparability of the participants' demographics with the outcomes of an intervention to increase the validity of the conclusions that are drawn from the findings. In addition, future research ought to have an increase in the duration of treatment should be conducted. Also, future studies that include elderly patients or patients with rheumatoid arthritis should be conducted due to more cartilage destruction will be in these people.

Conclusions

After the study, our solid conclusion is that in physical therapy programs or protocols, closed kinematic chain exercise is very effective, it improves knee ROM, and help in reducing knee pain, muscle strength, function and disability for patients with knee osteoarthritis. Thus, the CKC exercise should be included in the treatment of knee OA to get best improvement in a short period of time.

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TITLES OF TABLES

Table 1. Three training program exercises**.**

Table 2. Physical characteristics of patients in three groups.

Table 3. Between the three groups analysis between before and after treatment.

Table 4.Within the three groups analysis between pre-test and post-test.

TITLES OF FIGURES

Figure 1. CONSORT chart for patient's flow in this study.

Figure 2. ANOVA results for knee ROM showed that there were no significant differences (P> .05) in group A and group B between pre-test and post-test. While, there was a significant difference for knee ROM (P< .05) between pre-test and post-test results for group C.

Figure 3. ANOVA results of knee pain showed that there were significant differences (P< .05) for the VAS scale between the pre-test and post-test within the three groups.

Figure 4.ANOVA results of quadriceps strength showed that there were significant differences (P< .05) in the three groups for the quadriceps strength between the pre-test and post-test.

Figure 5. ANOVA results of WOMAC scale results showed that there were no significant differences (P> .05) in group A and B between pre-test and post-test. While, there was a significant difference (P< .05) of WOMAC scale results in group C between pre-test and post-test.