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The effectiveness of open versus closed kinetic chain exercises on pain, function and range of motion in patients with knee osteoarthritis

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: The comparative efficacy of open and closed kinetic chain exercises (OKCE and CKCE) on the symptoms of osteoarthritis (OA) has not been exhaustively studied. To evaluate and compare the effectiveness of eight-week open OKCE and CKCE on pain, function and range of motion of patients with knee OA.

Material and methods: A quasi-experimental study involved twenty-nine consecutive patients with knee OA allocated to either OKCE or CKCE groups. Participants' pain intensity (PI), functional score (FS), active range of motion AROM) and knee passive range of motion (PROM) were assessed using the visual analogue scale, the functional index questionnaire and a half-circle universal goniometer respectively at baseline and at the end of weeks 4 and 8.

Results: The groups were not significantly different ($p > 0.05$) on any of the four outcomes at any time point of the study (PI: 0.825; FS: 0.480; AROM: 0.363; PROM: 0.662). There was a significant time effect for all measures as pain intensity ($p < 0.001$) significantly decreased while FS, AROM and PROM significantly increased ($p \leq 0.001$, 0.002, 0.007, respectively) overtime from baseline to the 8th week ($p < 0.05$). Group by time interaction was not significant ($p > 0.05$) for all four measures.

Conclusions: Both exercise regimens have comparable effects on pain, function and knee range of motion.

Key words: exercise therapy, function, pain, knee osteoarthritis, range of motion.

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INTRODUCTION

Osteoarthritis (OA) is a major health challenge of global concern that is associated with chronic joint pain, reduced functional capacity and poor quality of life [1]. It is reportedly linked with increased ageing population and worldwide prevalence of obesity [2]. The disease imposes a crucial healthcare burden and accounts for high annual hospital visits in the developed nations [1,3]. Chronic OA of the lower limb joints may lead to reduced physical fitness with a resultant increased risk of cardio metabolic co-morbidity [4, 5] and early mortality [6].

The disease is a degenerative disorder of synovial joints characterized by focal loss of articular cartilage with reactive changes in the subchondral and marginal bone, synovium, and para-articular structures [7]. Osteoarthritis has been described as a clinical syndrome of joint pain accompanied by different levels of functional limitation and a reduced quality of life [8]. It is the most common form of degenerative joint disease, affecting 15% to 40% of people aged 40 and above [9]. It is a leading cause of activity limitation and has a slow, progressive course that ends with joint failure and subsequent disability [10, 11].

The knee is the most commonly involved joint in OA [12]. Clinically, knee OA is characterized by pain during weight bearing, tenderness, limitation of joint motion, crepitus, occasional effusion, and variable degrees of local inflammation [13]. Pain is the most frequent reason why patients with knee OA seek medical attention and rehabilitation [13]. If left untreated or not properly managed, pain and stiffness may result in a loss of functional independence [14].

Muscle strength and functional capacity have been shown to be significantly reduced in patients with OA [15, 16] and the functional consequences of knee OA are associated with lower extremity mobility limitations [17, 18]. The functional deficit in the quadriceps muscle may cause impaired balance and gait, thus reducing mobility and function in patients with knee OA [19]. There is no known cure for knee OA but international guidelines [1] have recommended exercise therapy as an invaluable non-pharmacological intervention for the disease. Evidence from systematic reviews and meta-analyses of RCTs has also indicated that muscle strengthening and aerobic exercises are effective in reducing pain and disability, and improving quality of life in patients with mild to moderate OA of the knee [1, 20, 21]. In the systematic review by Lange et al. [20], resistance training was specifically found to be effective for improving muscle strength and self-reported measures of pain and physical function in the majority of the reviewed studies.

Exercises employed in the rehabilitation of knee complaints are performed either in an open or a closed kinetic chain [22]. Open and closed kinetic chain exercises (OKCE and CKCE) have been shown to be individually effective for the improvement of quadriceps muscle strength in knee OA [23–25], but there is no consensus regarding the comparative effectiveness of the two modes of exercise even though extensive literature in the area has been published in the last two decades. For example, investigators like Lim [26], Jan et al. [24] and Olagbegi et al. [25] did not report any difference between OKCE and CKCE, whereas other researchers [24, 26–30] found differences between them. Besides, the studies indicating differences between OKCE and CKCE seem to have limitations that vary from non-equivalence of exercise intensities [24, 27–29] to the use of single exercise type [30]. Therefore, it is relevant to further explore the scientific discourse; hence this study was designed to compare the effects of OKCE and CKCE on pain, function and range of knee flexion in patients with knee OA.

patients with knee OA. It was hypothesized that there will be no difference between the effects of OKCE and CKCE on the selected clinical variables.

MATERIAL AND METHODS

A quasi-experimental study involving twenty-nine patients with knee OA was undertaken. The Health Research Ethics Committee of the University of Ibadan and University College Hospital approved the study (UI/UCH: 03/07/2001).

Participants were patients with knee OA receiving treatment at the University College Hospital (UCH), Ibadan, Nigeria. They all gave their informed consent before being included in the study. They were males and females with knee OA of one or both knees with grade II Kellgren and Lawrence classification system based on plain x-rays [31]. They also met the American College of Rheumatology Criteria for clinical diagnosis of knee OA which were pain in the knee for most days of the prior month, crepitation on active joint motion, morning stiffness less than 30 minutes in duration, patient’s age 38 years and above, and bony enlargement of the knee on examination [13]. The participants were also placed on 100mg Voltaren daily. Potential participants who had co-morbid neurological and severe systemic diseases as well as those with inability to walk were excluded from the study.

Participants were assigned to either the Open Kinetic Chain (OKC) or the Closed Kinetic Chain (CKC) group in order of their availability. There were 15 and 14 participants in OKC and CKC groups respectively and all 29 participants completed the study.

ASSESSMENT OF PAIN, FUNCTION AND RANGE OF MOTION

Pain Intensity (PI)

The Visual Analogue Scale (VAS) was used for pain assessment. Participants were asked to identify the activity of daily living that gave them most pain. Pain intensity was then assessed by asking the participants to mark the point on the VAS that corresponded to the intensity of the pain they felt while performing the identified activity [32]. The validated Yoruba version was administered on to participants who only understood the local language [33].

Functional Score

Participants’ functional ability was assessed with the Functional Index Questionnaire (FIQ) and recorded as a Functional Score (FS). The FIQ is a knee function questionnaire that has been used previously used as an outcome measure in patients with patellofemoral syndrome and chrondromalacia patallae [34]. It was considered appropriate as an outcome measure in this study because it assesses functions that are of primary importance to a Nigerian with an osteoarthritic knee. The questions in the FIQ were, however, restructured to ensure easy understanding by an average Nigerian while retaining the original meaning. Thus, “do you” or “would you” were rephrased to “do you” and “city block” changed to “distance between two electric poles". An expert from the Department of Linguistics and African Studies, University Of Ibadan translated the questionnaire into the Yoruba language to ensure its uniform administration to the largely illiterate cohort. FIQ assesses participant's difficulty with activities of daily livings. It has eight items and uses a scale of 0–2 to grade the difficulty the patient encounters while performing the function. The maximum score possible on FIQ is 16 while the minimum is 0 [34].

Range of Motion
Participants' active range of motion (AROM) for knee flexion was measured with a half-circle, universal goniometer. They assumed a prone position with the hip in anatomical zero degree position on the testing table, with feet together and both lower limbs relaxed. The fulcrum of the goniometer was placed on the joint line of the affected knee joint while the imaginary straight line between the greater tronchanter and the lateral malleolus was used as reference. They were instructed to flex their knees while maintaining the neutral position of the hip, and the AROM of the knee was measured and recorded in degrees to the nearest whole number [35]. Participants' passive range of motion (PROM) was measured with the participant and goniometer positioned as described for AROM, except that the knee was passively moved through the available range of motion by the researcher [35].

Pain intensity, functional score and range of motion (active and passive) were assessed at baseline and at the end of the 4th and 8th weeks of study.

Intervention
Participants were instructed not to change their normal routine of daily activities or take part in any additional form of physical activity or physiotherapy while the study lasted.

Open Kinetic Chain Exercise (OKCE) Group

Participants in this group were treated individually and performed the following exercises:

Quadriceps Setting
Participants assumed a supine position on a plinth and were instructed to perform isometric contraction of the quadriceps muscle of the affected lower extremity by drawing up his patella while maintaining the knee in extension. The contraction was held for a count of 10, then the participant relaxed and repeated the exercise 10 times [25, 36]. This exercise was carried out by the participants throughout the duration of the study.

Straight leg raising (SLR)
Participants in the supine position isometrically contracted their quadriceps (quadriceps setting) and lifted the lower extremity up to achieve about 45° of hip flexion while maintaining the knee in extension. They held the position to a count of 10, and then lowered the limb; repeating the exercise 10 times. The contralateral knee and hip were flexed to about 900 and 450 respectively to avoid undue stress on the low back [25]. From the third week SLR with weight was commenced by strapping an ankle weight equivalent to participant's 10RM to the ankle region [25,36].

Full-arc extension
Participants in a high sitting position had a weight corresponding to their 10RM strapped to the leg of the affected lower limb just above the ankle. A towel roll was used for protection of the popliteal space. They were asked to lift the load slowly through the range of 90° knee flexion to 0° of knee extension. The position was held for a count of 5 then the participant lowered the load [25, 36]. Participants performed three bouts of ten repetitions of this exercise per session; however, the foot was rested on a stool between the bouts [25]. This exercise was carried out from the fourth week to the end of the study.

Closed Kinetic Chain Exercise (CKCE) Group

Participants in the CKCE group individually underwent the following exercises:

Quadriceps Setting Exercise
Participants sat on a chair with their back supported, knee extended and heel on the floor. They pressed their heels against the floor and thighs against the seat of the chair. The position was held for a count of 10 after which the participant relaxed [25]. This exercise was performed throughout the duration of the study.

Mini-squats
Participants assumed the standing position and bent both knees to about 30-60 degrees while maintaining the trunk in the upright position. The position was held for a count of 10; participants then relaxed and repeated the exercise 10 times [25]. This exercise was carried out in the second week of the study only as it was discontinued once the patient started mini-squats with the weight. From the third week, participants now had a bar bell with plastic weights placed across their shoulders for mini-squats with weight [36].

Step-up and step-down
Participants performed forward, backward and lateral step-ups and step-downs using a 5cm – high sturdy wooden box [25]. They were instructed to keep their trunk upright and to ensure that their heel was the last to leave the floor and the last to return in order to emphasize the activities of the quadriceps muscle [25, 36]. Participants performed 10 repetitions of each component of the exercise. This exercise was carried out during the fourth week only. From week 5, ankle weight was strapped to participants' ankle region for step-ups and step-downs with weight [25, 36].

The summary of exercise intervention and progression is presented in Table 1.

Table 1. Summary of exercise training and progression for participants in the OKCE and CKCE groups

	OKCE	CKCE
Week 1	(a) Quadriceps setting (10 reps)	(a) Quadriceps setting (10 reps)
Week 2	(a) Quadriceps setting (10 reps)	(a) Quadriceps setting (10 reps)
	(b) Straight leg raising (10 reps)	(b) Mini-squats (10 reps)
Week 3	(a) Quadriceps setting (10 reps)	(a) Quadriceps setting (10 reps)
	(b) Straight leg raising with weight (new 10 RM)	(b) Mini-squats with weight (new 10 RM)
Week 4	(a) Quadriceps setting (10 reps)	(a) Quadriceps setting (10 reps)
	(b) Straight leg raising with weight (new 10 RM)	(b) Mini-squats with weight (new 10 RM)
	(c) Full arc extension (with new 10 RM as weight)	(c) Step-up and step-down
Week 5-8	(a) Quadriceps setting (10 reps)	(a) Quadriceps setting (10 reps)
	(b) Straight leg raising with weight (new 10 RM)	(b) Wall slides with weight (new 10 RM)
	(c) Full arc extension (with new 10 RM as weight)	(c) Step-up and step-down with weight

Note: 10 repetitions of each exercise were carried out per session (except for full-arc extension and air cycling).

Participants (OKCE) performed 3 bouts of 10 repetitions of full-arc extension.

Participants started with a weight equivalent to their 10RM and progressed by determining a new 10RM at the beginning of each week.

Participants had barbells placed across their shoulders for mini-squats with weight.

DATA ANALYSIS

The data were analyzed using Statistica software package, version 13 (Statistica Statsoft, Inc, Tulsa, USA). The Shapiro Wilk test performed on the data showed that all the measures follow normal distribution. Mean and standard deviation as well as confidence intervals were computed to summarize the data. The groups' demographic and baseline clinical variables were compared using the independent t-test. Analysis of Covariance (ANCOVA) was used for between-group comparison at the end of the 4th and the 8th week of intervention controlling for baseline values of the dependent variables. The overall time and group by interaction effects was analyzed using two-way repeated measures Analysis of Variance (ANOVA). The dependent variables analyzed were: pain intensity, functional score, and range of motion (active and passive). When significant time effects were detected by the ANOVA, Bonferroni post-hoc was used to assess differences across the baseline, the 4th and the 8th weeks. The level of significance was set at $p \leq 0.05$.

RESULTS

Twenty-nine individuals with knee OA (15 OKCE and 14 CKCE group) participated in the study. Twenty-four (82.8%) of the subjects were females and only four (17.2%) were males. The flowchart of participants' recruitment and participation in the protocol is presented in Figure 1.

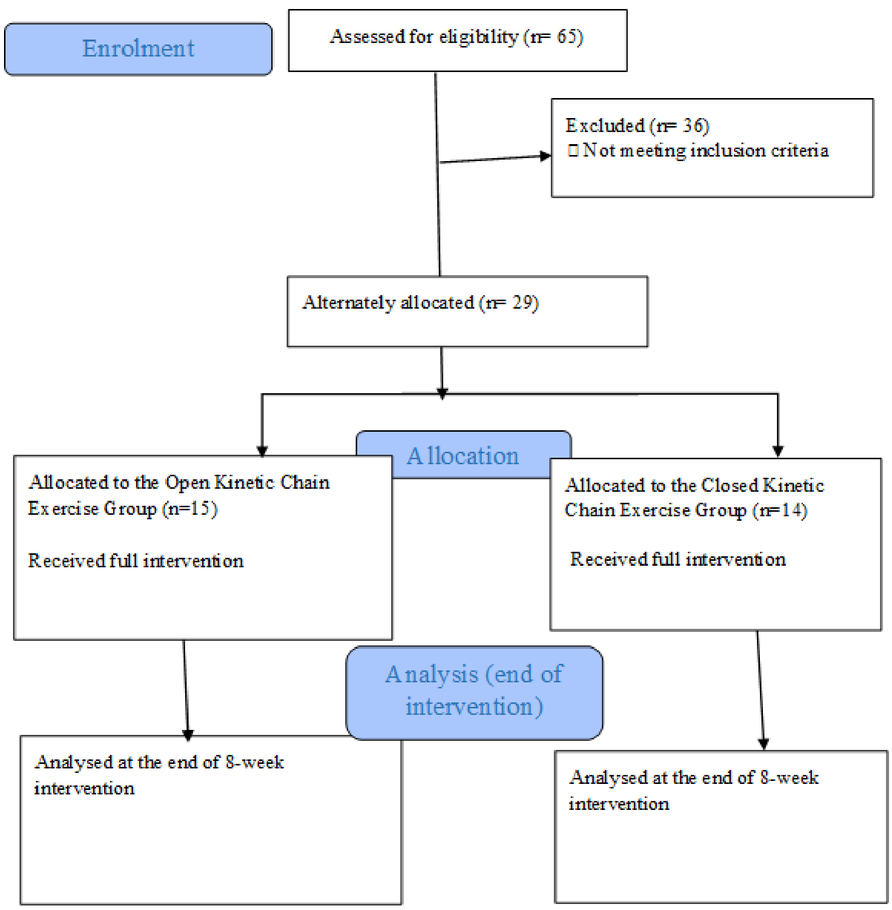

Fig. 1. Flow chart of the subjects' participation and follow-up

The demographic characteristics and baseline clinical variables of participants in OKCE and CKCE groups is presented in Table 2; the groups were not significantly different regarding their demographic characteristics and baseline clinical variables. The results of between-group comparisons for the groups are presented in Table 3. There was no significant difference between the two groups on any of the measures at any of the time points of the study [PI: (p = 0.825); FS: (p = 0.480); AROM: (p = 0.363); PROM: (p = 0.662)].

Table 2. Comparison of participants' demographic and baseline clinical variables

Variable	Treatment groups		t-value	p-value
	OKCE (n = 15) Mean ± SD	CKCE (n = 14) Mean ± SD		
Age (years)	60.00 ±8.81	57.57 ±8.72	0.746	0.462
Height (m)	1.61 ±0.08	1.63 ±0.11	0.783	0.441
Weight (kg)	80.03 ±20.68	80.63 ±16.98	0.085	0.933
BMI (kg/m^2)	30.87 ±6.91	30.31 ±5.92	0.230	0.820
PI	7.63 ±1.60	6.41 ±1.87	1.886	0.070
FS	6.73 ±1.94	7.43 ±1.95	0.961	0.345
AROM	100.27 ±18.80	104.43 ±16.30	0.635	0.531
PROM	108.73 ±18.17	114.71 ±13.50	1.000	0.326

$p \leq 0.05$

OKCE – Open kinetic chain exercise; CKCE – Closed kinetic chain exercise

BMI – Body mass index, PI- Pain intensity, FS – Functional score, AROM – Active range of motion, PROM – Passive range of motion.

Table 3. Between-group comparison of pain intensity, functional score, active and passive range of motion at the end of the 4th and the 8th weeks of study

Variable	Mean square	F	p-value	Partial Eta Square
PI	0.141	0.050	0.825	0.002
FS	1.861	0.513	0.480	0.019
AROM	79.056	0.858	0.363	0.032
PROM	18.174	0.196	0.662	0.007

$p \leq 0.05$

PI – Pain intensity, FS – Functional score, AROM – Active range of motion, PROM – Passive range of motion.

Analysis of time and group by time interaction effects on the variables is presented in Tables 4 and 5. There was a significant time effect on all four measures [p-value; effect size: PI: (< 0.001; 0.658); FS: (< 0.001; 0.625); AROM: (0.002; 0.200); PROM: (0.007; 0.169)] as in both groups pain intensity significantly decreased (Mean ±SD: OKCE: 7.63 ±1.60; 3.84 ±1.84; CKCE: 6.41 ±1.87; 3.40 ±1.85), while the functional score (OKCE: 6.73 ±1.94; 10.13 ±2.70; CKCE: 7.43 ±1.95; 11.21 ±2.15) and AROM (OKCE: 100.27 ±18.80; 106.80 ± 14.31; CKCE: 104.43 ±16.30; 112.21 ±11.22) significantly increased from baseline to the end of the 8th week. The passive range of motion for the CKCE group significantly increased from baseline to the end of the 8th week (114.71 ±13.50; 120.64 ± 11.32). However, the increase in PROM for OKCE group (108.73 ±18.17; 109.73 ±18.38) within the same time interval was not significant.

Table 4. Analysis of time and group by time interaction effects on pain, function and range of motion

Variable/Effect	Mean square	F	p-value	Partial Eta Square
PI				
Time	84.087	51.905	< 0.001*	0.658
Group by time	1.189	0.734	0.485	0.027
FS				
Time	93.711	44.914	< 0.001*	0.625
Group by time	2.470	1.184	0.314	0.042
AROM				
Time	417.100	6.767	0.002*	0.200
Group by time	1.200	0.506	0.606	0.018
PROM				
Time	298.000	5.503	0.007*	0.169
Group by time	12.000	0.229	0.796	0.008

*denotes significance at p ≤ 0.05

OKCE – Open kinetic chain exercise; CKCE – Closed kinetic chain exercise

PI- Pain intensity, FS – Functional score, AROM – Active range of motion, PROM – Passive range of motion

For a particular variable, mean values with different superscript are significantly different (p ≤ 0.05). Mean values with same superscripts are not significantly different (p > 0.05).

Table 5. Bonferroni post-hoc analysis

Variable	Baseline Mean ±SD (95% CI)	4th Week Mean ±SD (95% CI)	8th Week Mean ±SD (95% CI)
OKCE Group			
PI	7.63 ±1.60 [a] (6.75-8.52)	5.50 ±1.61 [b] (4.61-6.39)	3.84 ±1.84 [c] (2.82-4.86)
FS	6.73 ±1.94 [a] (5.66 - 7.81)	7.80 ±2.54 [a] (6.39-9.21)	10.13 ± 2.70 [c] (8.64 - 11.63)
AROM	100.27 ±18.80 [a] (89.86-110.68)	104.00 ±17.54 [a] (94.29-113.71)	106.80 ±14.31 [b] (98.87-114.73)
PROM	108.73 ±18.17 [a] (98.67-118.79)	109.73 ±18.38 [a] (99.55-119.91)	109.73 ±18.38 [a] (99.55-119.91)
CKCE Group			
PI	6.41 ±1.87 [a] (5.33-7.50)	4.86 ±2.04 [b] (3.69-6.04)	3.40 ±1.85 [b] (2.33-4.47)
FS	7.43 ±1.95 [a] (6.30-8.55)	9.64 ±3.18 [b] (7.81-11.48)	11.21 ±2.15 [b] (9.97-12.46)
AROM	104.43 ±16.30 [a] (95.02-113.84)	112.21 ±13.77 [a] (104.26-120.17)	112.21 ±11.22 [b] (105.74-118.69)
PROM	114.71 ±13.50 [a] (106.92-122.54)	117.57 ±14.94 [a] (108.94-126.20)	120.64 ±11.32 [b] (114.12-127.18)

*denotes significance at p ≤ 0.05

OKCE – Open kinetic chain exercise; CKCE – Closed kinetic chain exercise

PI- Pain intensity, FS – Functional score, AROM – Active range of motion, PROM – Passive range of motion

For a particular variable, mean values with different superscript are significantly different (p ≤ 0.05). Mean values with same superscripts are not significantly different (p > 0.05).

The changes in PI for the CKCE group were not significant at the week 4–8 interval of the study, while changes in FS were also not significant for the OKCE and CKCE groups at baseline, week 4 and week 4–8 intervals respectively. There were no significant changes in AROM for both groups at baseline-week 4 interval of the study. Changes in PROM for the CKCE group were not significant at baseline-week 4 time interval but there were no significant changes in the outcome for the OKCE group across all-time points of the study. There were no significant group by time interaction effects for all four measures [PI (p = 0.485); FS (p = 0.314); AROM (p = 0.606) PROM (p = 0.796)].

Group by time interaction effects and the trends of PI, FS, AROM and PROM are illustrated in Figures 2–5.

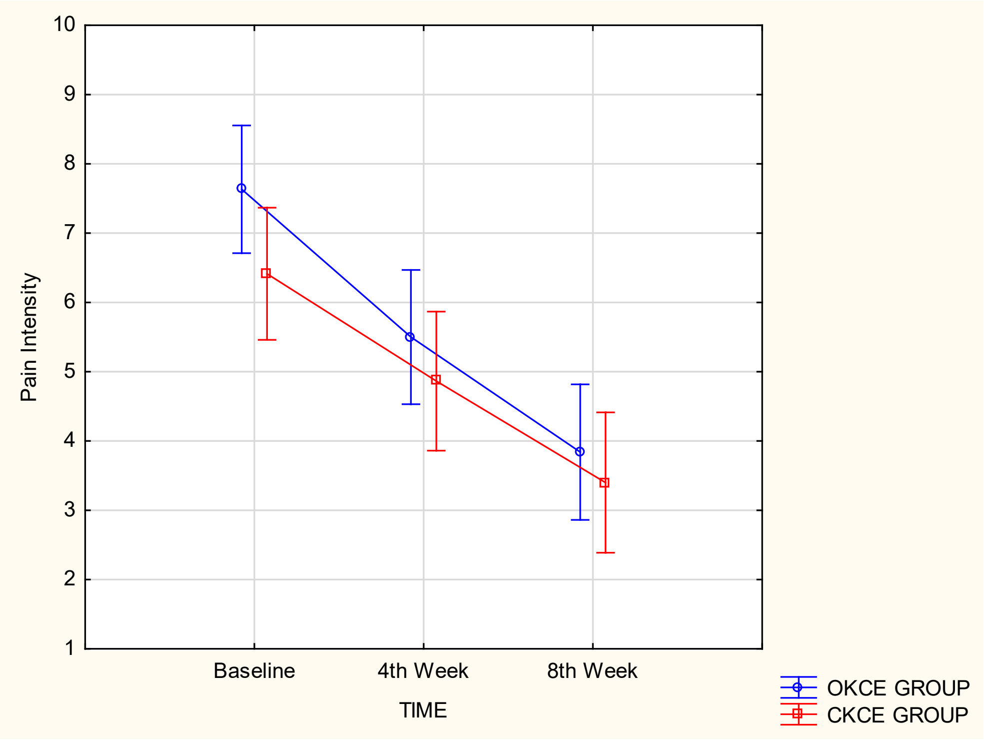

Fig. 2. The trend of pain intensity across the three time-points of intervention

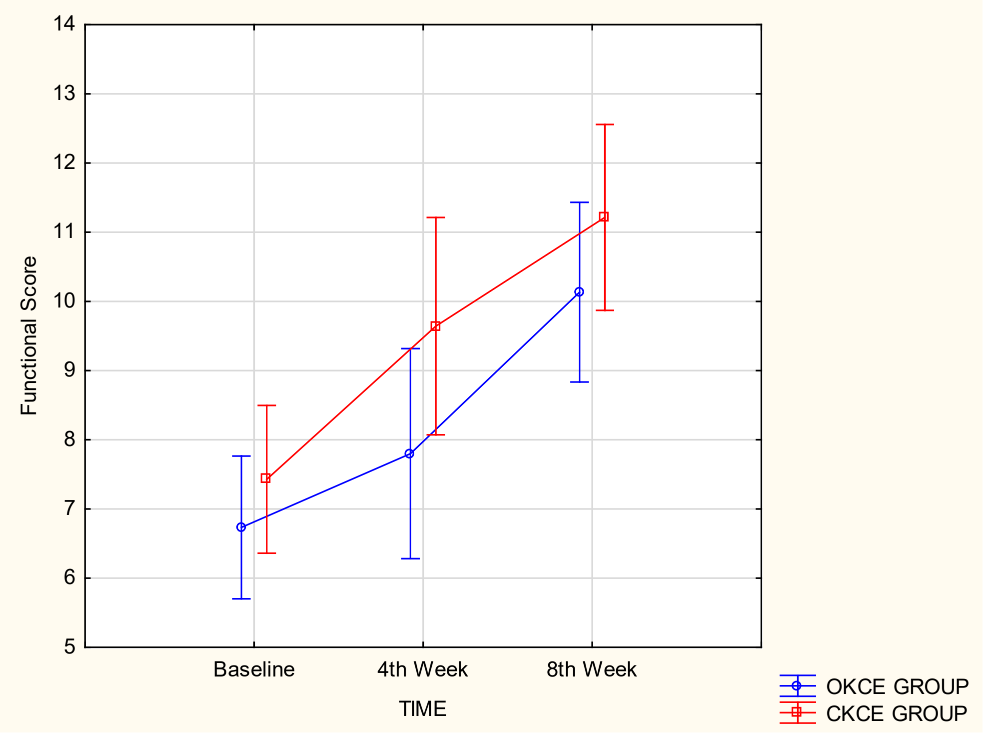

Fig. 3. The trend of functional score across the three time-points of intervention

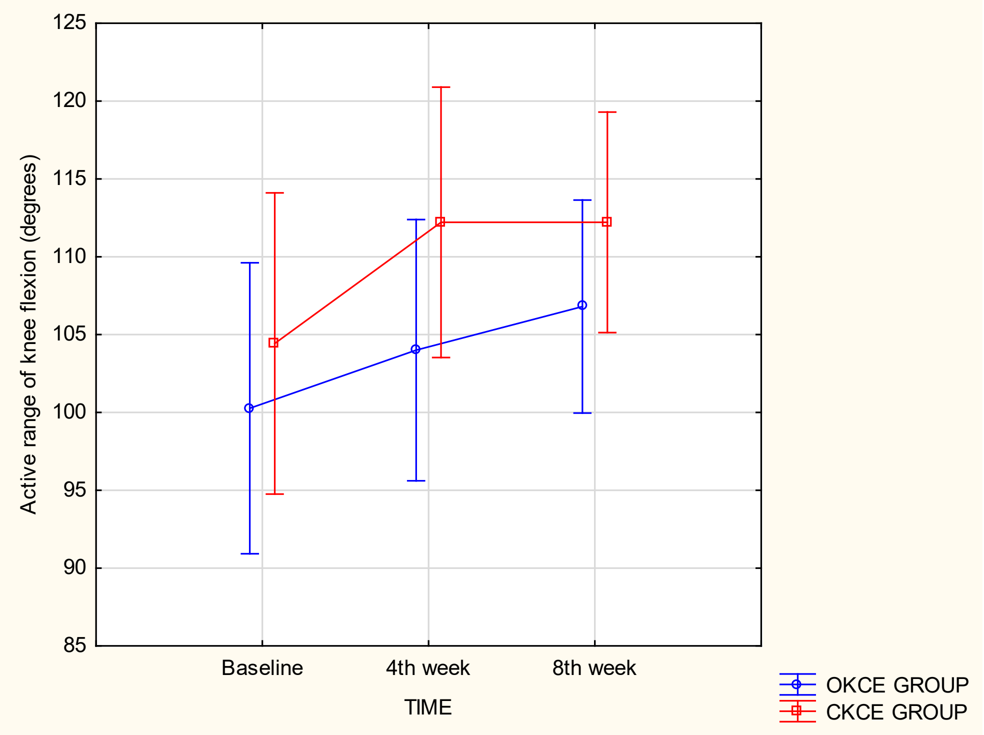

Fig. 4. The trend of active range of knee flexion across the three time-points of intervention

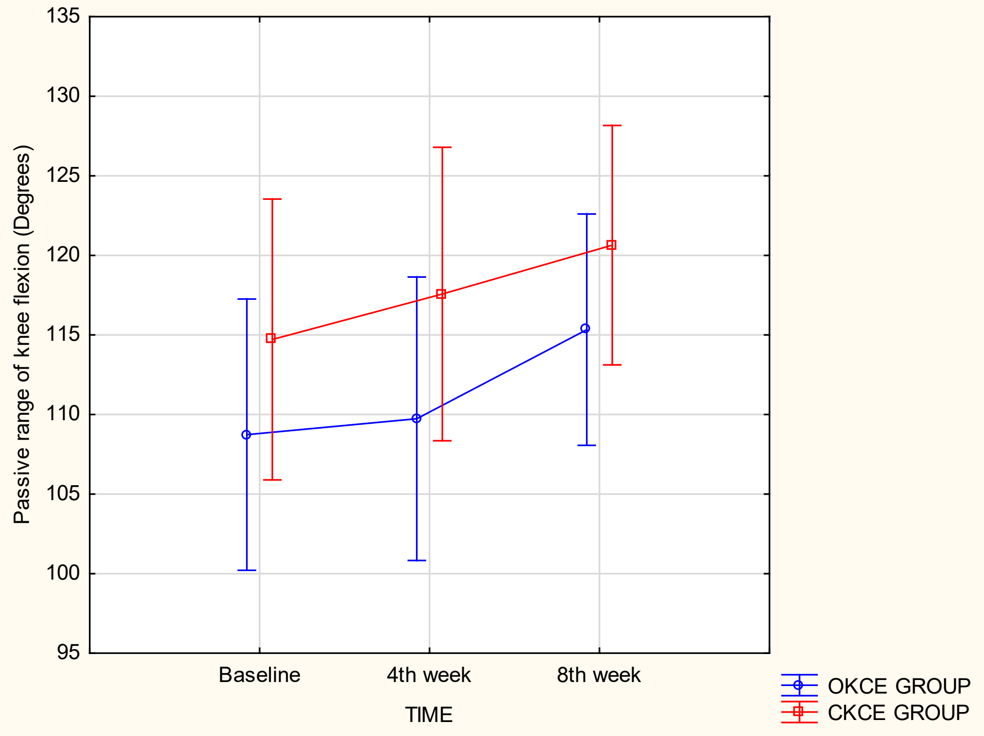

Fig. 5. The trend of passive range of knee flexion across the three time-points of intervention

DISCUSSION

The major aim of this study was to compare the effects of OKCE and CKCE on pain, physical function and range of motion in patients with OA of the knee. The two groups were comparable regarding their clinical variables at the three time points of this study. This suggests that either OKCE or CKCE can be used to points of this study. This suggests that either OKCE or CKCE can be used to improve treatment outcomes for pain, function and range of motion in patients with knee OA. The observed finding may be explained in the light of the fact that OKCE and CKCE groups had very similar strength training progression with overload of 10RM every week for each participant. It can thus be inferred that the two modes of exercises produced similar quadriceps muscles strengthening effects on the four measures evaluated in this study. The findings are similar to the reports of Olagbegi et al. [25] who also employed similar training progression and did not find differences between OKCE and CKCE in terms of pain and function. Lim [26] and Jan et al. [23], who utilized mechanical gadgets for OKCE and CKCE training, also reported similar findings. According to reports of previous studies, it appears OKCE and CKCE are generally comparable in their effects on pain [23–26, 28, 30]; however, some authors [24, 26–30] have reported differences between the two modes of exercises in terms of functional improvement. Apart from the already highlighted limitations in terms of non-equivalence of exercise intensities [24, 27–29] and the use of single exercise type (mini-squats versus straight leg raising) [30], Daskapan et al. [30] also evaluated functional outcomes using different outcome measures (WOMAC, TUG, Kujala Scale and walking time downstairs).

OKCE have been traditionally preferred to CKCE in the management of knee OA because of the concerns about the possibility that CKCE induces wear and tear of the joint cartilage, which might accelerate disease progression [37]. However, Alghamdi et al. [37] proved that the use of OKCE alone in managing knee OA compromises the specificity and selectivity principles of training. The principles allude that optimal gains in a motor activity are made when the exercise employed in rehabilitation most closely resembles the activity [36, 38]. Improvements in daily function well complimented by exercise resembling the daily activity [37] and functional activities (such as walking) have been shown to have more CKCE components than OKCE [36]. Furthermore, it has been reported that exercise interventions for OA should involve considerations of joint stability, joint motion, joint effusion, synovial fluid level, position sense, balance, and conduct of daily activities [38–40]. While improvement in functional activity is very important, the specificity of such exercise must also be mainly geared toward strengthening, a situation in which OKCE is more applicable. Therefore, it is not surprising that researchers have advocated for the use of combined OKCE and CKCE for optimal benefits in the management of knee OA [25, 37].

The significant time effect of both exercise programmes on pain and functional score suggests either OKCE or CKCE can be used for pain reduction and improvement of function in this cohort of individuals. The finding is consistent with reports from previous studies regarding the specific effects of OKCE and CKCE [25, 26, 30] and general effects of muscle strengthening exercise regimens on pain in patients with knee OA [20, 41]. Reduction in pain and the consequent improvement in function following quadriceps strengthening exercise have been linked to increased stability of the knee joint which is enhanced by improvement in the quadriceps muscle strength [42, 43]. Evidence from literature has also shown that using exercise improving quadriceps strength may activate the pain-suppressing β-endorphin system [44] and favorably influence the sensory input to the central nervous system and the gate control mechanism [45]. Simkin et al. [46] also submitted that quadriceps strengthening is associated with improved blood flow and cartilage nutrition.

The strength of the quadriceps muscle has been linked with both performance – based and self- reported physical function [47]. A significant inverse relationship between pain and physical function among patients with knee OA has also been reported in literature [48]. This suggests that reduction in pain among this category of individuals is accompanied by decreased disability. Olagbegi et al. [25] who also observed significant improvement in function for patients with knee OA treated separately with OKCE and CKCE attributed their findings to pain relief and joint stability occasioned by improved quadriceps muscle function.

Participants in the two groups also demonstrated significant improvements in active and passive range of knee flexion. It has been reported that muscle lengthening during eccentric dynamic resistance strength training enhances improvement of the joint range of motion [36,49]. The (OKCE) full-arc extension and (CKCE) mini-squats used for quadriceps strength training in this study involved both concentric and eccentric phases of quadriceps muscle contraction. It is plausible that the eccentric components of the two modes of exercises compared in this study probably accounted for the significant increases in both active and passive ranges of knee flexion observed in this study. Shakoor et al. [41] similarly observed that six weeks of combined isometric exercise and NSAIDs significantly improved range of knee flexion in patients with knee OA. Awotidebe et al. [50] also found significant improvement in the active knee range of motion for a group of patients with knee OA who had OKCE. The mean increase in range of motion reported by Awotidebe et al. and colleagues [50] was slightly higher than that obtained in the present study (8.6 versus 7.2 degressdegrees). Awotidebe et al. [50], however, employed stretching and range of motion exercises for warm-up which could have accounted for the difference in this measure from between both studies.

CLINICAL IMPLICATION OF FINDINGS FROM THE STUDY

The study’s outcome indicated that OKCE and CKCE are both effective for reducing pain and improving functional ability and range of knee flexion in patients with knee OA, thereby suggesting that both exercise protocols can be employed in isolation for pain reduction and improvement of in function and range of motion in this category of patients.

LIMITATIONS OF THE STUDY

The results of this study should be interpreted with caution because of the following limitations: the Ssample size of 29 appears small for power of 80% and it is plausible that the findings would have been different with a larger sample size. Secondly, the assessors were not blinded to participant’s interventional group assignment, although the researchers did their best to minimize assessment-related bias by ensuring that a neutral research assistant recorded all data into the data spreadsheet. It is probable that such a bias might have introduced some confounding factors that may threaten the internal validity of this study. Further, the effects of 100mg Voltaren and Abitren used by the participants along with the intervention were not evaluated; information on participants’ compliance with drug use could have been helpful in isolating the effects of the exercise intervention.

Lack of a control group with knee OA undergoing drug alone is another limitation of this study. This would have probably revealed the real treatment effects by eliminating possible placebo effects of the interventions.

CONCLUSIONS

The findings of this study have shown that OKCE and CKCE are both effective for improving treatment outcomes of pain, function and joint range of motion in patients with knee OA. Physiotherapists are encouraged by the findings from this study to use either open or closed kinetic chain exercises for pain relief and improvement of in function and knee flexion in patients with mild to moderate OA. Future studies should investigate and compare the effects of OKCE and CKCE on other clinical and psychosocial variables of knee OA and on OA of other joints of the body (e.g. hip) for wider use.

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