

NARRATIVE REVIEW

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The effects of closed kinetic chain exercise on pain and physical function in patients with knee osteoarthritis: a narrative review

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Abstract

Background Osteoarthritis (OA) has become a serious public health exposure because it leads to chronic pain and minimizes physical function and quality of life (QOL). This review aimed to find out the effectiveness of closed kinetic chain exercise (CKCE) on pain, range of motion (ROM), physical function, and QOL in subjects with knee OA.

Methods The design of this study was a narrative review. A computerized electronic search was performed using PEDro, PubMed, CINAHL, and EMBASE Register of controlled trials with keywords including osteoarthritis, knee OA, closed chain exercise, closed kinetic chain exercise, functional exercise, physiotherapy exercise, and therapeutic intervention. The inclusion criteria consisted of studies that were randomized controlled trials, published in English from 2016 to 2023. Here, allotted osteoarthritis was the primary concern, and we identified closed kinetic chain exercise as one of the treatment options.

Results The initial search of the database revealed a total of 91 studies. Of those studies, 11 were selected as potentially meeting the inclusion criteria. Ultimately, six studies were retained for the final review. The evaluations suggested that CKCE has better impacts on pain, capacity, and ROM in knee OA. After reviewing, it has been revealed that at least an 8-week program with 3 sessions per week in 30 min longer might have greater effects on the CKCE program.

Conclusion The results of this narrative review have shown that CKCEs are efficient for relieving pain, promoting function, increasing knee ROM, and enhancing QOL in subjects with knee OA.

Keywords Osteoarthritis, Knee OA, Close kinetic chain exercise, Close chain exercise

Introduction

Knee osteoarthritis (OA) is a profuse general musculoskeletal condition globally, affecting the cartilage and synovial joints and diminishing physical function [1]. It

is an extremely alarming public health vulnerability that leads to chronic pain and instability of the knee joint that decreases the range of motion (ROM), impairs physical function, and minimizes the quality of life [2]. It has been estimated that about 40 to 80% of people with radiographic features will have a symbolic illness [3]. Knee OA is usually developed among the elderly and results in an increased risk of illness and frequent falls and leads to death [4].

Osteoarthritis is the most commonly experienced illness in the musculoskeletal framework, and it is the fundamental cause of pain and incapacity in more aged persons [5]. OA is considered as a complex multifactorial

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joint pathology and is the most widely recognized type of joint issue on the earth [2]. Osteoarthritis affects 12% of the populace in the age range of 25 to 74 years [6]. Most of the senior citizens experience knee OA around the world [7]. The incidence of OA reveals that women, aged persons, obesity, and previous history of a knee injury have a moderate to high risk of developing knee complaints and radiographic features and symptomatic OA [8].

In Bangladesh, knee OA is one of the most frequently recognized illnesses impacting both growing older men and women [9]. In the USA, around 60 million people have knee OA and this figure will increase by 50% over the next decade. Around 10–30% of individuals with OA explain severe pain and functional limitations; thus, the disability rate is expanding gradually [10].

Physical exercise can alleviate pain, improve functional ability, and promote emotional and mental state in knee OA patients [11]. Open kinetic chain exercises (OKCEs) or closed kinetic chain exercises (CKCEs) are used for the treatment of knee complaints [12]. The close-chain parameters take part in kinaesthesia and balance exercises. CKCEs have been viewed as specifically fruitful for the progress of muscle energy and employ motions where the body moves on a distal part that is fixed or stabilized on a support surface [13]. In 2012, Verma revealed that CKCE may improve the neuromuscular arrangement of the knee joint, expand proprioception, and enhance the function of the knee joint [14]. Researchers found several comparing studies of CKCE and OKCE to manage the knee OA. However, current practice in the physiotherapeutic management of knee OA through CKCE is mostly needed for appropriate guidance. The goal of the study was to determine the effectiveness of CKCEs in relieving pain, increasing ROM, and improving physical function in patients with knee OA.

Methodology

Study design

The study design was a narrative review.

Search strategy

A computerized electronic search was performed using PEDro, PubMed, CINAHL, and EMBASE using the medical subject heading (MeSH) or keywords including “osteoarthritis,” “knee OA,” “knee osteoarthritis,” “closed kinetic chain,” “closed kinetic chain exercise,” “functional exercise,” “physical therapy exercise,” and “therapeutic intervention.” Here, we allotted “osteoarthritis” as the primary focus and identified “closed kinetic chain exercise” as one of the intervention options (Fig. 1).

Study selection

The initial analysis was performed based on the title and abstract. Titles and abstracts were displayed and identified the relevant studies. When there is doubt, discussion among the authors was done to resolve the issues. Then, the relevant full-text articles were read carefully according to the inclusion and exclusion criteria.

Eligibility criteria

The following criteria were used to include the study for the review: randomized control trial, osteoarthritis population, age 38 years and above, studies from 2016 to 2023, PEDro scale score of 5 or more, and only studies in the English language. The exclusion criteria are as follows: abstract published papers, conference papers, qualitative and observational studies, and articles that are non-English.

Quality appraisal

The critical appraisal and quality of the included studies were conducted independently using the PEDro scale.

Results

This review consists of six randomized control trials to assess the effectiveness of CKCE as a rehabilitation protocol for patients with knee OA. The studies have included 30–90 subjects in each study, which comprise a total of 347 participants combined. The overall quality of the trials was moderate, as mentioned below following the PEDro scale. It gives an analysis of the quality assessment through the PEDro score analysis (Table 1).

This study provided support for the efficacy of CKCE in relieving pain, improving muscle strength, and improving physical function in subjects with OA. We have evaluated the results of a few randomized control trials to find out the efficacy of CKCE for patients with knee OA. The summary of the included RCTs and the results are given below (Table 2).

Results showed that CKCEs are more fruitful than OKCEs for relieving pain during walking [2]. Both chain exercise regimens, CKCE and OKCE, have comparable impacts on pain, capacity, and ROM of the OA knee joint [16]. The study revealed that CKCE relieved pain, improved ADL, sports, and recreational activity, and increased 6-min walking distance in patients with knee OA [17].

Discussion

We examined the effects of CKCEs on patients with knee OA through a narrative review study. According to Dincer, Aribal, Saygin, Incedayi, and Rodop (2016),

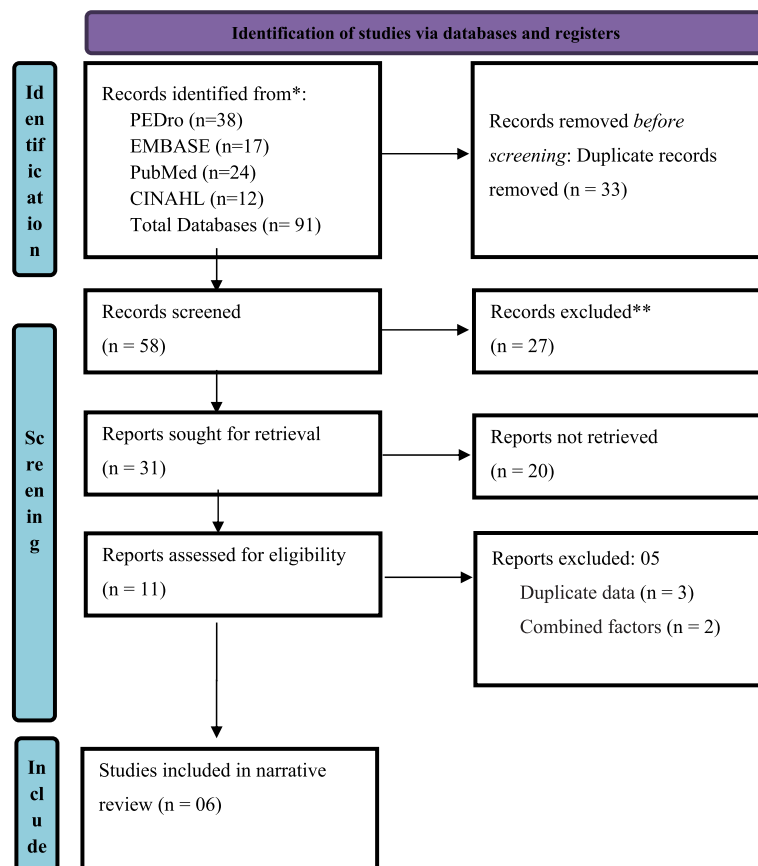


Fig. 1 Proposed reporting item for narrative review (PRISMA flowchart)

Table 1 Quality assessment through PEDro score

PEDro score items	1	2	3	4	5	6	7	8	9	10	11	Total score
Dincer et al. [15]	+	+	+	+	-	-	+	+	-	+	+	7
Adegoke et al. [16]	+	+	+	+	-	-	-	-	+	+	+	6
Olagbegi et al. [2]	+	+	-	+	-	-	-	+	-	+	+	5
Nahayatbin et al. [17]	-	+	-	+	-	-	-	+	-	+	+	5
Olagbegi et al. [12]	+	+	+	+	-	-	-	-	+	+	+	6
Özüdoğru et al. [18]	+	+	+	+	-	-	-	+	-	+	+	6

the study aimed to assess the effectiveness of CKCE on joint cartilage in subjects with Grade I–III knee OA. The exercise group (EG) performed CKCE, TENS, and hot packs monitored by physical therapists. The control group (CG) was treated with TENS and a hot pack. The total treatment duration was 12 weeks where 3 weeks in hospital and 9 weeks in home-based treatment. Then, measurements were done by VAS, Western Ontario McMaster University Osteoarthritis Index (WOMAC) tests, and magnetic resonance imaging (MRI) at baseline and at the end of the 12-week period. Results

displayed no meaningful outcome of CKCE on the cartilage volume or morphology of the OA knee [15]. Another study revealed that CKCE are functional, safe, and effective exercises for muscle strength and facilitating joint position sense [14, 19].

In the study done by Adegoke, Sanya, Ogunlade, and Olagbegi (2019), the effectiveness of CKCEs and OKCEs on pain, function, and joint ROM was compared. Experimental group OKCEs received intervention on quadriceps setting, SLR, and full-arc extension. Control group CKCEs received treatment on quadriceps-setting

Table 2 Outcome measurement, interventions, and results of the articles

Author	Objectives	Participant	Inclusion criteria	Study design	Intervention	Control	Duration	Tools	Impression	Journal name, country, & year
					Experimental					
Dincer, Aribal, Saygin, Incedayi & Rodop [15]	To assess the effectiveness of CKEs on the joint cartilage in subjects with grade I-III knee OA	Total 35 patients EG=19 CG=16	Subjects with grade I-III OA Age between 40 and 60 years ACRC criteria were enrolled	RCT	Experimental group (EG): CKCEs TENS Hot-pack	Control group (CG): TENS Hot-pack	30-min exercise regimen weekly 5 sessions for a 12-week duration	VAS WOMAC MRI	Results displayed no great outcome of CKCE on the cartilage volume or morphology of the OA knee	Turkey Journal of Physical Medicine and Rehabilitation Turkey (2016)
Adegoke, Sanya, Ogunlade, & Olagbegi [16]	To evaluate and compare the effectiveness of OKCE and CKCE on pain, function, and ROM of patients with knee OA	Total 29 subjects OKCE = 15 CKCE = 14	Both sexes of single or both OA knees Grade II based on the KLC system ACRC for classification of knee OA Age 38 years and above	RCT	OKCEs Quadriceps setting SLR Full-arc extension	CKCEs Quads setting Mini-squats Step-up & down Wall slides with a weight	10 repetitions in each session for 8-week duration	VAS FIQ Half-circle universal Goniometer	Both chain exercise regimens have comparable impacts on pain, capacity, and ROM of OA knee	Baltic Journal of Health and Physical Activity Nigeria (2019)
Olagbegi, Adegoke & Odole [2]	To compare the effects of OKCEs, CKCEs, and CCEs on pain and physical function in OA knee	Total 79 participants OKCE = 26 CKCE = 26 CCE = 27	Both sexes of single or both OA knees Grade II is based on the KLC system ACRC for classification of knee OA	RCT	OKCEs Quadriceps setting SLR, full-arc extension Cycling in the air	CCEs: OKCEs + CKCEs	3 times per week 12-week duration	VAS Scale IKHOAM scale	CKCEs are more fruitful than OKCEs for relieving pain during walking	Bangladesh Journal of Medical Science Bangladesh (2016)

Table 2 (continued)

Author	Objectives	Participant	Inclusion criteria	Study design	Intervention		Duration	Tools	Impression	Journal name, country, & year
					Experimental	Control				
Nahayatbin et al. [17]	This study aimed to investigate and compare the effectiveness of Tai Chi and CKCEs on patients with knee OA	Total 48 patients CKCE = 16, TCE = 16 No Rx = 16	Knee OA Age: 45–65 years Grades II–III based on the KLC system & grade III (Oxford scale)	RCT	CKCE: Standard physical therapy CKCE and Static stretching TCE: Standard physical therapy Tai Chi warm-up and cool-down and 6-form of the yang style of TCEs	No Rx: Standard physical therapy only	12 sessions of exercises in 4 weeks	6 MMT & KOOS Questionnaire	Both TCE and CKCE relieved pain, improved ADL, sports and recreational activity, and increased 6-min walking distance in patients with knee OA	IRCMJ Iran (2018)
Olagbegi, Adegoke & Odole [12]	To investigate the effects of OKCE, CKCE & CCE on quads muscle power and thigh girdle in patients with OA knee	Total 96 participants OKCE = 32 CKCE = 32 CCE = 32	Mild to moderate knee OA Both sexes of single or both OA knees Grade II based on the KLC system ACRC for classification of knee OA Crepitation & morning stiffness	RCT	OKCEs Quadriceps setting Cycling in the air SLR Full-arc extension CKCEs Quadriceps setting Wall slides with a weight Step up and down with the weight	CCEs: OKCEs + CKCEs	10 repetitions per session 12-week duration	Cable tensiometer Tape measure	Each of the three therapy regimens is fruitful and demonstrates equivalent impacts on quads muscle power in knee OA	Archives of physiotherapy South Africa (2017)
Özudođru & Gelecek [18]	To evaluate the effects of OKCE and CKCE on pain, physical function, muscular strength, and QOL in knee OA patients	Total 60 participants OKCE = 20 CKCE = 20 CG = 20	Age range of 45 to 75 years Unilateral knee OA grades I–II At least 3 months with pain	RCT	OKCEs Four-way straight leg rises Concentric quadriceps Maximal knee extension CKCEs Mini squat Sit to stand Anterior lunge and 3-side step-up exercise CG Home exercise regimen through phone call	Exercised thrice weekly for 12 weeks duration	VAS WOMAC Isokinetic test SF-36	Both groups are helpful in relieving knee pain and reducing stiffness and improving muscle power and CKCE is the safest for low-grade knee OA patients	Revista da Associação Médica Brasileira (2023)	

ACRC American College of Rheumatology Criteria, CCE combined chain exercise, CKCE close kinetic exercise, CKCE close kinetic chain exercise, FIQ Functional Index Questionnaire, IKHOAM Ibadan Knee/Hip Osteoarthritis Outcome Measure, KOOS Knee Injury & Osteoarthritis Outcome Score, MRI magnetic resonance imaging, OKCE open chain exercises, OKCE open kinetic chain exercise, RCT randomized clinical trial, ROM range of motion, SLR straight leg raise, TCE Tai Chi exercise, VAS visual analog scale, WOMAC Western Ontario McMaster University Osteoarthritis Index

exercises, mini-squats, step-ups and step-downs, and wall slides with weight. Both groups were given 10 repetitions in each session and an 8-week duration. Patients' pain intensity, functional score, and active and passive ROM were evaluated by using the visual analog scale (VAS), functional index questionnaire (FIQ), and a half-circle universal goniometer (HUG), respectively, at baseline and at the end of 4 and 8 weeks. The findings of this study have shown that OKCE and CKCE are both efficient for enhancing intervention outcomes of pain, function, and joint ROM in subjects with knee OA [16]. A similar study found significant improvement in pain, physical function, QOL, and joint ROM in both the CKCE and OKCE groups in subjects with knee OA [20].

Olagbegi, Adegoke, and Odole (2016) stated that this study was to investigate and compare the effectiveness of OKCEs, CKCEs, and combined chain exercises (CCEs) on pain and physical function in OA knee management. Subjects in the OKCE group provided the accompanying exercises: quads setting, SLR, full-arc extension, and cycling in the air. Subjects in the CKCE group provided the following exercises: quadriceps setting exercise, wall slides, and step-up and step-down. Subjects in the CCE group received treatment for both OKCEs and CKCEs. The intervention was given three times per week for 12 weeks. The results were measured by VAS and Ibadan Knee and Hip Osteoarthritis Outcome Measure (IKHOAM). The study revealed that OKCEs, CKCEs, and CCEs are all effective in enhancing treatment effects for subjects with knee OA. However, CCEs are more effective than CKCEs or OKCEs for pain relief. CKCEs are more effective than OKCEs for relieving pain during walking with an OA knee [2]. One recent study, conducted over 12 weeks of OKCEs, CKCEs, and their combination CCEs, found significant improvement in the static and dynamic quadriceps strength and thigh muscle bulk in 96 patients with knee osteoarthritis [12, 21].

According to Nahayatbin et al. (2018), the effectiveness of Tai Chi exercises (TCEs) and CKCEs was investigated and compared in individuals with OA knee. Subjects in the CKCE group underwent the following exercises: standard physiotherapy technique, CKCEs, and static stretching. Subjects in the TCE group underwent the following exercises: standard physiotherapy technique, Tai Chi warm-up and cool-down, and form 6 of the Yang style of TCEs. Subjects in the no-treatment group underwent the following exercises: standard physical therapy protocol only. Every group received treatment for 12 sessions over 4 weeks. Nevertheless, both TCEs and CKCEs enhanced QOL beyond that of the no-intervention group. Subjects in both the intervention groups showed alleviated pain compared to the control group. Both therapeutic approaches had the same impact on enhancing

QOL [17]. Wang et al. showed that TCEs produced more significant improvements in depression and the physical component of QOL in patients with knee OA compared to patients who received only routine physiotherapy [22]. CKCEs include squat and leg press exercises that improve pain scales, functional scores, and strength [17, 21].

Olagbegi, Adegoke, and Odole revealed the effects of OKCEs, CKCEs, and CCE on quadriceps muscle strength and thigh girth in patients with knee OA. Subjects in the OKCEs group provided the accompanying exercises: quads setting, cycling in the air, SLR with weight, and full-arc extension. Subjects in the CKCE group provided the accordant trials: quads setting, wall slides with weight, and step-up and step-down with weight. Subjects in the CCE group received treatment for both OKCEs and CKCEs. The intervention was given for 10 repetitions per session over a 12-week period. The measurements were done with a cable tensiometer and tape measure. Each of the three therapy regimens is effective and demonstrates equivalent impacts on quadriceps muscle power in subjects with osteoarthritis [12]. Several studies have suggested that CCE effectively shortens the existing hospitalization period, enables a smooth return to daily life, and improves the stability, muscle strength, physical function, and balance ability required for daily life after knee OA rehabilitation [23, 24].

In the study done by Özüdoğru and Gelecek, the effects of OKCE and CKCE on pain, physical function, muscular strength, and QOL were evaluated. Subjects in the OKCE group independently provided the accompanying exercises: four-way straight leg raises, concentric quadriceps, and maximal knee extension. Subjects in the CKCE group underwent the following exercises: mini-squat, sit-to-stand, anterior lunge, and 3-side step-up exercise. The control group was provided home-based exercise through phone calls. The intervention was given thrice weekly for 12 weeks. Exercised 6 weeks under supervision and next 6 weeks home-based progressive exercise. The results were measured by VAS, WOMAC, Isokinetic test, and SF-36. The study revealed that both groups are helpful in relieving knee pain and reducing stiffness, and improving muscle power and CKCEs are the safest for low-grade knee OA patients [18]. One study found that CKCEs improved muscle power, joint sense, and functional activities, and it was safe and effective for application for knee OA rehabilitation [25].

After reviewing, it has been revealed that at least an 8-week program with 3 sessions per week for 30 min longer might have a greater effect in the CKCE program along with conventional physiotherapy practice for patients with knee OA. The review was committed to assessing the modern evidence on the effects of CKCE as a rehabilitation protocol. The narrative review proposed

CKCE programs likely quadriceps settings, mini-squats, sit-to-stand, anterior lunge, wall slides, and step up and down with weight for rehabilitation of subjects with knee OA. All six articles reviewed the favorable outcomes of minimizing pain, ensuring joint ROM, and enhancing function and QOL in OA knee patients.

Conclusion

The results of this narrative review have shown that CKCEs are effective for physical function in patients with knee OA, but there is still a dispute over OA treatment. Further studies are also necessary to assess the general effectiveness of CKCEs in a wide range of populations for enhancing physical function and ADLs. The OKCEs and CKCEs have separate effects on various outcomes like pain and quality of life, but a combination of both formats showed significant effects in all the outcomes considered. Finally, it can be recommended that CKCEs are efficient for relieving pain and promoting function, increasing knee ROM, and also enhancing the QOL in subjects with knee OA.

Abbreviations

ACRC	American College of Rheumatology Criteria
ADL	Activity of daily life
BHPI	Bangladesh Health Professions Institute
BMRC	Bangladesh Medical Research Council
CCE	Combined chain exercise
CKE	Close kinetic exercise
CKCE	Close kinetic chain exercise
CRP	Centre for the Rehabilitation of the Paralyzed
FIQ	Functional Index Questionnaire
IKHOAM	Ibadan Knee/Hip Osteoarthritis Outcome Measure
IRB	Institutional review board
KOOS	Knee Injury & Osteoarthritis Outcome Score
MMT	Manual muscle testing
MRI	Magnetic resonance imaging
OA	Osteoarthritis
ORSI	Osteoarthritis Research Society International
OCE	Open chain exercises
OKCE	Open kinetic chain exercise
QOL	Quality of life
RCT	Randomized clinical trial
ROM	Range of motion
SPSS	Statistical Package of Social Science
TCE	Thai Chai Exercise
VAS	Visual analog scale
WOMAC	Western Ontario McMaster University Osteoarthritis Index
WOMET	Western Ontario Meniscal Evaluation Tool
WHO	World Health Organization

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Authors' contributions

Conceived and designed the article: FA and MOH; Critical and approved the final version: KMAH, MKU, ZBSN, and MSI; Wrote the first draft of the manuscript: ZBSN, MNH, MWI, and FA; Prepared the final manuscript: FA, MSI, and KMAH. All authors reviewed and approved the final manuscript. All authors have read and approved the final manuscript.

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Declarations

Ethics approval and consent to participate

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Consent for publication

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Competing interests

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