



Effectiveness of Open and Closed Kinetic Chain Exercises on Chronic Knee Osteoarthritis: Case Series

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Abstract

Introduction: Osteoarthritis (OA) is a form of progressive joint disease caused by inflammation and degradation of cartilage in the joints. The use of exercise for the management of knee OA are many, including aerobic, aquatic and/or resistance exercises. Additionally, combined chain exercises (CCEs) are recently given attention. These exercises have been found to be effective on improved pain and physical limitations in patients with knee OA. In this study, the effectiveness of a 4 week programme of CCEs on pain levels, knee range of motion (ROM) and functional abilities in patients with chronic knee osteoarthritis was examined. **Method:** This was a case study design and the participants were recruited using the convenience sampling technique. In this study, each patient received a four (4) week program of CCEs in form of quadriceps setting exercise, straight leg raising (SLR), full arc extension, cycling in the air, wall slide and step-up and step-down. Pre-test and Post-test scores were assessed using goniometry, VAS, GROC, and WOMAC. **Result:** The mean age and BMI of the participants were 53 ± 7.21 and 28.07 ± 2.77 respectively with five females. There were significant differences between pre and post treatment variables after four weeks of treatment (pain, $p=0.01$; functional disability, $p=0.01$; range of motion, $p=0.01$; muscle strength, $p=0.01$). **Conclusion:** The finding of this study concluded that a 4-week programme of combined open and close kinetic chain exercises is effective in the management of patients with knee OA.

Keywords: Kinetic, Closed, Open, Arthritis, Knee

Introduction

Osteoarthritis (OA) is one of the major musculoskeletal health problems that is associated with pain, reduction in functional ability and quality of life (Fransen *et al.*, 2015). The disease, characterised by complex multifactorial joint pathology, is the most common form of joint disorder globally and majorly affects the knee (Aeden Nevitt, 2006; Silver *et al.*, 2008; Diracoglu *et al.*, 2008). The prevalence of the knee OA has been on the increase both in high and low-income countries. It has been reported that 10% to

15% of individuals who are 60 years and above have a certain degree of OA and this prevalence is higher in females than males (WHO Department of Chronic Diseases and Health Promotion). Globally, over 100 million individuals have OA (Hinman, Hunt, Creaby, Wrigley, McManus, Bennell, *et al.*, 2010) and results in moderate (1.9%) and severe disability (8.1%) in high income countries in people in the age group of 0-59 and >60 years of age but higher in in the low-income (14.1%) and middle income countries (19.4%) (World

Report on Disability, 2011). In the Framingham study, the prevalence of radiographic knee OA in adults aged >45 was 19.2% (Lawrence, Felson, Helmick, *et al.*, 2008) and the lifetime risk of developing symptomatic knee OA to be about 40% in men and 47% in women (Murphy, Schwartz, Helmick, *et al.*, 2008). Huang, Chen, Chen, Weng, Wang and Wang (2000) reported that OA of the knee prevalence is associated with advancing age and occurs in >30% of participants with older than 65% of age and 40% of them were symptomatic. Akinpelu, Alonge, Adekanla, and Odole (2009) further reported that about 19.6% of adults in Nigeria have symptomatic OA of the knee with higher prevalence among the female gender in a community-based study. Globally, among adults of more than 45 years of age, OA of the knee is responsible for more than 80% of the disease's total burden (Vos, Flaxman, Naghavi, Lozano, Michaud, Ezzat *et al.*, 2012). Furthermore, Cross, Smith, How, Nolte, Ackerman, Fransen *et al.*, (2014) reported that the Global Burden of Disease Study revealed that OA of the knee and hip is now ranked as the 11th leading cause of years lived with disability and 38th highest in disability-adjusted life years among 291 health conditions analysed.

International guidelines and findings from systematic reviews provide strong evidence in support of exercise therapy as first-line non-pharmacological interventions for the amelioration of symptoms (Lang, 2008; Fransen *et al.*, 2015). Fransen *et al.*, (2015) in a recent systematic review concluded that land-based therapeutic exercises generally provide benefits in terms of reduced knee pain and improved physical function and quality of life among people with knee OA. This suggests that therapeutic exercises meticulously planned to strengthen the quadriceps muscle can relieve pain and lead to functional recovery of the muscle (Imoto *et al.*, 2012).

The exercises used for the treatment of knee joint dysfunctions are performed either in an

open or closed kinetic chain (Kisner & Kolby, 2007). Open kinetic chain exercises are exercises in which the hand or foot is free to move (Cho *et al.*, 2014). Whereas closed kinetic chain exercises are those exercises in which the hand or foot is not free to move, they are fixed/locked (Cho *et al.*, 2014). 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 (Verma, 2012; Daskapan, 2013; Gbiri *et al.*, 2013) but it appears there is no consensus regarding the comparative effectiveness of the two modes of exercise. A randomized controlled trial by Cho *et al.*, (2014) showed that CKCE improved electromyographic activities of all components of the quadriceps femoris muscle, whereas OKCE did not show a significant effect on vastus lateralis. However, the specific effects of CKCE on muscle strength in the rehabilitation of knee OA has only been recently reported by Olagbegi *et al.*, (2017), which focused on quadriceps muscle strength and thigh girth of patients with knee OA. However, the above study largely ignored the pain and functional ability assessment of the knee OA patients. In view of this, our study was a case series study of the effects of a 4-week combined open and closed kinetic chain exercises (OKCE and CKCE) on the pain level, knee range of motion, functional ability and general quality of life among in patients with chronic knee OA.

Case Reports/Presentations

Case 1

Miss A.M. is a 47 years old trader who presented to physiotherapy with worsening right knee pain over the past 9 weeks. She was a traditional Yoruba dancer who has excelled in many Yoruba dancing competitions over the years and is married and blessed with 4 children. She has had progressively worsening knee pain that is exacerbated by ceremonial dancing and prolonged standing for about 30 minutes. Her sleep is slightly disturbed and self-care is slowing in the morning due to morning stiffness, but otherwise unlimited. She is able to complete a full 20 minutes

dancing, but with pain. Pain is worst with free-styles and body shaking. Her dancing speed has been greatly affected by the injury.

On Examination - Knee joint assessment revealed limited passive ROM for flexion (125°) and extension (5°), all with pain (5 points on VAS). Bilateral quadriceps and hamstring muscle strength testing revealed decreased strength on the left (4/5) for all muscle groups. Ligament stress testing of the left knee were all negative but patella mobilization revealed point tenderness, crepitus, and pain. However, she reported that her pain is better with ibuprofen (400 mg 2x/day).

Case 2

Mrs. I.A. who is a 55 year old housewife presented to Physiotherapy with a complaint of knee pain in her left lower limb. The pain started six months ago and was gradual. Her pain was worse in the morning and at the end of the day. However, it ceased after some movement, but returned following prolonged standing and getting up from seated position or prolonged rest. She had no history of any trauma but occasionally trekked while carrying her grandson on her back from her house to her village located approximately two 2 kilometres away from the main town and had an average of five (5) hour standing during household activities.

On Examination - Patient I.A is 1.5m and has a weight of 80kg yielding a BMI of 26.67 kg/m² and had no co-morbidities. Her pain level was 8 points on the visual analogue scale (VAS) at the time of presentation. Valgus and Varus tests for medial and lateral collateral ligaments of the knee were performed and the results were negative. Furthermore, there was pain on the anterior drawer test at the left knee but that does not show any sign of anterior cruciate ligament laxity. The quadriceps angle, active and passive knee mobilizations were within normal ranges but, there was a crepitus sound on knee joint distraction. There was mild swelling and tenderness at the knee with mild patella restriction. A plain radiograph (AP and lateral) of the left knee revealed

decreased joint space with marginal osteophytes with intact joint alignment and bone density.

Case 3

Mr. U.L. is a 45 years old student who presented to physiotherapy with worsening right knee pain over the past 4 months. He lives with his wife, daughter, and son-in-law and their two children (2 and 5 years). He has had progressively worsening right knee pain that is exacerbated by prolonged standing for about 3 hours. His sleep is not disturbed and he has no difficulty with self-care. While climbing ladders, the knee feels unstable as if it might give out and this limits Mr. L's efficiency and confidence to embrace farming as a business.

On Examination - Knee joint assessment revealed limited passive ROM for flexion (130°) and extension (7°), all with pain (4 points on VAS). Bilateral quadriceps and hamstring muscle strength testing revealed decreased strength on the left (3/5) for all muscle groups. Ligament stress testing of the left knee neck were all negative but patella mobilization revealed point tenderness, crepitus, and pain. However, Mr. U.L reported that he does not take any medication for pain.

Case 4

Alhaji T.W is a 63 year old man who presented to physiotherapy with a referral letter from his orthopaedic surgeon, who wrote that Alhaji T.W was mainly having pain in the medial compartment of his right knee and that prior radiographs demonstrated significant degenerative changes in the patella-femoral articulation and the lateral tibiofemoral compartment. According to Alhaji T.W, the drug therapy he received in the past failed to relieve him of his suffering for the past 4 whole months.

On examination - there was reasonable quadriceps bulk and minimal right genu varum and the left knee has good alignment. The Lachman test was negative and the collateral stress tests and McMurray tests were negative. The left knee has full motion

range, but the right knee has limited range both in flexion (100°) and extension (5°). Bilateral quadriceps and hamstring muscle strength testing revealed decreased strength on the right (2/5) for all muscle groups.

Case 5

Mrs. A.E is a 55 year old woman met at the physiotherapy department with a complaint of left knee pain which started about 2 years ago. Her pain was worse on prolonged standing and was aggravated by jogging. The patient has managed 1 year ago without satisfactory improvement and she said that sometimes the pain resolved on its own but resurfaces after a while. The patient is not a known hypertensive or diabetic but known to have peptic ulcer disease. She has not had surgery and was on anti-ulcer drugs and the pain

significantly affected her activity of daily living. She is married with 5 children.

On Examination - BMI was 32.67 kg/m² suggesting stage 1 obesity. Her pain was 6 on a visual analogue scale (VAS) at the time of presentation. Her knee ROMs were 120° and 10° for both flexion and extension. Collateral ligaments stress tests were all negative. Furthermore, there was pain during anterior drawer test of the left knee with crepitation on active knee range of motion. The quadriceps angle, active and passive knee mobilizations were within normal ranges, but there was mild swelling and tenderness at the knee with mild patella restriction. A plain radiograph (AP and lateral) of the left knee revealed decreased joint space, marginal osteophytes with intact joint alignment and bone density.

Table 1: Treatment Procedure Summary

Weeks	CCEs
Week 1	(a) OKC Quadriceps setting (10 repetitions) (b) Straight leg raising (10 repetitions) (c) CKC Quadriceps setting (10 repetitions) (d) Cycling in the air (2 min for a bout)
Week 2	(a) OKC Quadriceps setting (10 repetitions) (b) Straight leg raising (10 repetitions) (c) CKC Quadriceps setting (10 repetitions) (d) Cycling in the air (2 min for a bout) (e) Wall slides without weight (10 repetitions) (f) Step-up and down without weight (10 repetitions)
Week 3	(a) OKC Quadriceps setting (10 repetitions) (b) Straight leg raising with weight (10 reps) (c) CKC Quadriceps setting (10 repetitions) (d) Cycling in the air (2 min for a bout) (e) Wall slides with weight (5kg) (f) Step-up and down with weight (5kg) (g) Full-arc extension (3 bouts of 10 reps)
Week 4	(a) OKC Quadriceps setting (10 repetitions) (b) Straight leg raising with weight (10 reps) (c) CKC Quadriceps setting (10 repetitions) (d) Cycling in the air (2 min for a bout) (e) Wall slides with weight (5kg) (f) Step-up and down with weight (new 5kg) (g) Full-arc extension (3 bouts of 10 repetitions)

CCEs= Combined Chain Exercises, OKC= Open Kinetic Chain, CKC= Closed Kinetic Chain

Results

Five individuals with knee OA participated in this study of which 60% of them were females. The mean age and BMI of the participants were 53 ± 7.21 and 28.07 ± 2.78 respectively as shown in Table 2. There were significant differences in the levels of pain ($p=0.01$),

functional disability ($p=0.01$), range of motion ($p=0.05$), muscle strength and improvement in the global rating of care scale (GROC) ($p=0.01$) after four weeks of treatment interventions as shown in Table 3 below.

Table 2: Demographic Characteristics

SN	Age	Sex	Occupation	BMI	Education
1.	47yrs	F	Trading	27.2kg/m ²	Diploma
2.	55yrs	F	Housewife	26.67kg/m ²	Secondary
3.	45yrs	M	Student	25.45kg/m ²	Degree
4.	63yrs	M	Retired	28.37kg/m ²	Degree
5.	55yrs	F	Paid job	32.67kg/m ²	Degree

SN = Serial Number, yrs= years, F= Female, M= Male, BMI=Body Mass Index

Table 3: Outcome Measures at Baseline and after 4 Weeks of Treatment

	n	Df	m±sd	T	P
Pain	5	4	2.60±1.14	5.10	0.01
Functional Disability	5	4	30.40±5.32	12.78	0.01
GROC	5	4	-8.00±0.71	-25.30	0.01
ROM	5	4	-12.00±10.10	-2.66	0.05
Muscle Strength	5	4	-1.20±0.20	-6.00	0.01

Discussion

This study was carried out to determine the combined effects of open and closed kinetic chain exercises on the levels of pain, knee range of motion, functional disability and quality of life among individuals with osteoarthritis of the knee joint. Majority of the participants were females and there were a reduction in pain, knee range of motion, functional disability and improvement in the quality of life after four weeks of combined open and closed kinetic chain exercises. Regular exercise has great importance in maintaining good health.

The benefits of regular and moderate exercise include reduced risks for some musculoskeletal disorders such as OA (Pichler *et al.*, 2013; Musumeci, *et al.*, 2013; Musumeci, *et al.*, 2014). Physical exercise can play a crucial role in the treatment of OA in optimizing both physical and mental health,

enhancing energy, decreasing fatigue and improving sleep (Musumeci, 2015). Biomechanical stimulus generated by dynamic compression during moderate exercise can reduce the synthesis of proteolytic enzymes, regulating the metabolic balance and preventing the progression of the disease (Leeuwenburgh & Heinecke, 2001).

Recently, studies have shown that physical activity is effective in reducing pain and movement limitations in knee diseases, such as OA (Fransen *et al.*, 2016; Castrogiovanni & Musumeci, 2016; Page *et al.*, 2011), and in knee instability (Abulhasan *et al.*, 2016). Today, physical activity is considered as a complementary and optional treatment. It is up to health professionals to encourage the use of physical activity as a primary treatment, especially in patients with mild OA that are likely to be more motivated. This is because

they are not yet afflicted with the most severe OA symptoms characterized by a higher degree of pain and disability. Moreover, the non-pharmacological intervention is recommended in national and international guidelines, including EULAR and OARSI (Zhang *et al.*, 2010; Fernandes *et al.*, 2013).

The modalities of exercise recommended for the management of knee OA were aerobic, aquatic, and/or resistance exercises associated with weight loss for overweight patients (Yusuf *et al.*, 2011). Other non-pharmacologic therapies conditionally recommended for knee OA include knee Kinesio taping, medial wedge insoles for valgus knee OA, subtalar strapped lateral insoles for varus knee OA, manual therapy, hydrokinesis therapies, tai chi, walking aids, thermal agents and psychosocial interventions (Hochberg *et al.*, 2012; Musumeci *et al.*, 2014). Treatment of OA is based on a combination of treatment protocols, including physical therapy, medical therapy, exercise-based therapy and even psychological counselling (Knoop *et al.*, 2013; Musumeci *et al.*, 2015).

The outcome of this study suggested that four weeks of CCEs combined with home programs are effective in patients with chronic knee OA. However, like other forms of exercises, the effectiveness of CCEs in the management of chronic knee OA has been well documented (Akinpelu *et al.*, 2007; Akinpelu *et al.*, 2009; Akinpelu *et al.*, 2011; Lange *et al.*, 2008). Additionally, some of the authors (Akinpelu *et al.*, 2007; Akinpelu *et al.*, 2009; Akinpelu *et al.*, 2011) found CKCE to have produced significantly higher quadriceps muscle strength than OKCE while the two modes of exercises were reported to be equal in their effects on quadriceps muscle

strength in some other studies (Lange *et al.*, 2008). Moreover, according to some studies (Hasan & Shuckett, 2010; Odole *et al.*, 2006), OKCEs are better for isolated quadriceps muscle strengthening while CKCE encourages co-contraction of other muscle groups with the bodyweight providing additional resistance. Furthermore, the specific effects of CCE on quadriceps muscle strength and thigh girth (Verma, 2012; Olagbegi *et al.*, 2017), pain and physical functions (Olagbegi *et al.*, 2016) in patients with knee OA have also been independently reported. However, the aforementioned studies largely ignored the assessment of knee joint range of motion and patients' general perception of recovery which the present study was able to examine. The outcome of this study suggested that four weeks of CCEs combined with home programs are effective in pain reduction, increased functional ability, knee joint range of motion, and general perception of recovery in patients with knee OA.

Conclusion

Based on the findings of this study, it is concluded that a 4-week programme of CCEs is effective in the management of OA of the knee. We thus recommend that similar researches may be conducted using a larger sample size as well as conducting randomised controlled trials using OKCE and CKCE.

Acknowledgement

We acknowledge the participants as well as the Head and members of the Physiotherapy Department, Aminu Kano Teaching Hospital, Zaria Road, Kano.

Conflict of interest

We declare no conflict of interest.

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