

ORIGINAL ARTICLE

Effects of Open and Closed Chain Exercises on Dynamic Balance and Range of Motion in Patients with Knee Osteoarthritis: RCT

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ABSTRACT

Background: Osteoarthritis is a combination of mechanical problems characterized by degradation of articular cartilage, articulating joints and subchondral space.

Aim: To compare the effects of open chain kinetic exercises and closed kinetic chain exercises in improving dynamic balance and range of motion in patients with knee osteoarthritis.

Study Design: Randomized controlled trial.

Methodology: Study was conducted at Chughtai Medical center Lahore and sample of 46 patients were recruited and were randomly allocated in two groups. One group performed OKC exercises and the other group was asked to perform CKC exercises, while both of the groups received a common baseline treatment prior to corresponding intervention. Two session a week were given for a period of one month. Goniometry and Y-balance scale were used to assess ROM and dynamic balance pre and post treatment, respectively. Data was evaluated by using SPSS version 23.

Results: In this study, the intra-group analysis illustrated that the increase in range of motion and improvement in dynamic balance was statistically significant in both groups with $p\text{-value} < 0.05$. Whereas, the inter-group analysis showed that both interventions were clinically effective in treating knee osteoarthritis with $p\text{-value} > 0.05$ during the treatment session of four weeks.

Practical Implication: This study highlighted that physical training that includes open kinetic chain (OKC) and closed kinetic chain (CKC) exercises were found to be effective in improving balance and in increasing range of motion by reducing pain among osteoarthritis patients. **Conclusion:** It was concluded that patients with OKC exercises have shown equal improvement in ROM and dynamic balance compared to those who have been treated with CKC exercises.

Keywords: Osteoarthritis, Exercises and Dynamic Balance.

INTRODUCTION

Osteoarthritis (OA) is the commonly found degenerative joint disease with chronic presentation, affecting weight-bearing joints. It gradually leads to a disability restricting the individual from various daily functional activities. It is a combination of mechanical problems characterized by degradation of articular cartilage, articulating joints, and subchondral space. This damage results in fibrillation, fissures and gross ulcerations^{1,2}.

As a result of disarrangement in the usual process of wear and tear, deterioration of articulating surfaces of the joint occurs. This degeneration causes frequent knee pain which limits the mobility and compromises quality of life. Among major part of population with knee osteoarthritis, knee pain is usually the main culprit for knee replacements³.

The decrease in movement is secondary to pain, regional muscles may atrophy, and ligaments may become weaker^{4,5}. Most common sites for osteoarthritis are hip (19%), spine, hand, and foot (30%) while majorly affecting knee joint (41%). According to evidence from several studies, people with age group 45-70yrs having osteoarthritis of knee suffer limitations in climbing stairs, ascending on inclined surfaces, standing from a sitting position on a chair even more while standing from the floor⁶.

According to the area of involvement and related factors, OA can be classified as Primary OA or idiopathic OA which develops over progressive time due to aging or family history. More common in elders when there is no previous pathology. It involves one joint or smaller joints as in hand joints, hip, and knee. While Secondary OA occurs due to predisposing factors such as injury to the joint, rheumatoid arthritis, developmental dysplasia of the hip, joint deformity, obesity, and hyperthyroidism^{7,8}. During the development of osteoarthritic changes at the knee joint, evidence has reported a definite impairment of balance and proprioception in those candidates thus leading them at great risk of falls. As osteoarthritis is one of the major culprits of falls in the elderly along with

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osteoporosis^{9,10}.

Physical therapy including physical exercise and balance training is important in this old group of population as it is beneficial in reducing pain, improving balance and proprioception, muscle strength, postural stability and better performance in activities of daily living¹¹. In this view, open kinetic chain (OKC) and closed kinetic chain (CKC) exercises are found to be effective in improving balance and in increasing range of motion by reducing pain.

The objective of the study was to compare the effects of open chain kinetic exercises and closed kinetic chain exercises in improving dynamic balance and range of motion in patients with knee osteoarthritis.

METHODOLOGY

After IRB permission, both male and female aged 45-65 years suffering from knee pain for more than 3 months were asked to take part present study. This was a randomized controlled trial (RCT) and 46 patients were randomly selected and divided into two groups equally. Patients having unilateral knee osteoarthritis grade II (according to Killegren and Lawrence classification of knee OA) were the enrolled population and was confirmed by radiographic imaging. Study was conducted at Chughtai Medical center Lahore. Participants were randomly allocated in two groups. One group performed OKC exercises and the other group was asked to perform CKC exercises, while both of the groups received a common baseline treatment prior to corresponding intervention. Two session a week were given for a period of one month. Goniometry and Y-balance scale were used to assess ROM and dynamic balance pre and post treatment, respectively^{12,13}.

Exercise intervention:

Open chain exercises: Patients were asked to perform the open-chain exercise using cuff weights of (0.5-2.5Kg) tied on the ankle or dorsum of the foot in a progressive resistance training according to the strength of the patient by finding his/her 1 repetition

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maximum (RM). 1 RM was calculated in the first session only, as RM varied for each patient. Two sessions per week of this exercise protocol (1 set of 10RM) were given for the duration of one month in non-weight bearing/sitting position¹⁴.

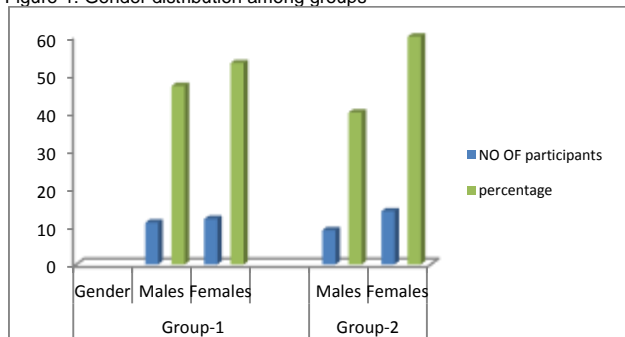
Closed chain exercises: Patients were asked to perform step up, step down and terminal extension in standing using a therapeutic resistance band of different resistances; light, medium, and medium to heavy in standing position according to their submaximal strength in the first session. For terminal extension, patients were asked to extend the knee against the resistance band. Other parameters and progression of closed-chain exercises included; changing the base of support from wide to narrow, support surface from rigid to soft, changing balance from external support to no external support and eyes open to eyes closed. Two sessions per week of this exercise protocol (1 set of 10reps) for a period of one month was incorporated in weight-bearing/standing position¹⁵.

Statistical analysis: All collected data was analyzed through SPSS version 23. All qualitative data was presented in frequency form and quantitative data was in the form of mean ± SD. Unpaired t-test was used for parameters in between groups and paired sample t-test for parameters within the group.

RESULTS

The study sample (n = 46) comprised of 47% male patients and 53% female patients in OKC group whereas, in CKC group 40% were males while 60% were females as demonstrated by figure-1.

Figure-1: Gender distribution among groups



Distribution of participants among both groups according to age were shown in table-1 and figure-2.

Figure-2: Participants distribution among groups as per age (yrs)

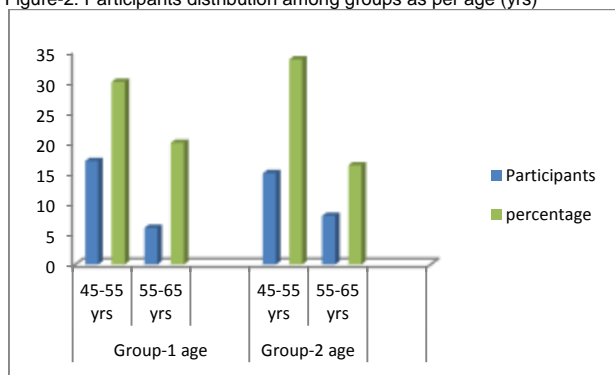


Table 1: Socio-Demographic Variables

Study group	N	%
Group 1		
45-55	17	30%
56-65	6	20%
Group 2		

45-55	15	33.7%
56-65	8	16.3%

Mean differences between pre and post-treatment results for all subjects in OKC group was -5.6 ± 1.076 , 1.27 ± 0.00 , -0.7746 ± 0.08795 for Flexion ROM, extension ROM and dynamic balance assessment respectively. While mean differences between pre and post-treatment results for all subjects in CKC group was -6.73 ± 1.375 , 1.4 ± 0.462 , -1.4626 ± 0.24026 for flexion ROM, extension ROM and dynamic balance assessment respectively. Independent samples test for equality of means was used to find the comparison of flexion, extension and dynamic balance assessment score after treatment in affected knee among both intervention groups as shown in table-2.

Paired t-test was performed to compare the results of dynamic balance pre and post-treatment in both groups. The results from the pre-test ($M = 69.0187$, $SD = 8.56238$) and post-test ($M = 69.7933$, $SD = 8.65033$) dynamic balance assessment scores indicated that the balance significantly improved in the affected knee after the intervention was given to the OKC group ($t(14) = -12.045$, $p = 0.000$). Likewise, the CKC group also showed statistically significant result ($t(14) = -9.958$, $p = 0.000$).

Table-2: Group Comparison of Dynamic Balance, Knee Flexion & Extension

Mean ±SD	Group-1	Group-2
Dynamic Balance		
Pre-treatment	69.0187±8.56	69.4827±8.669
Post-treatment	69.7933±8.65	70.9453±8.90
Knee Flexion		
Pre-treatment	110±9.198	111.47±9.862
Post-treatment	116±8.122	118.20±8.487
Knee Extension		
Pre-treatment	3.20±1.521	3.07±1.438
Post-treatment	1.93±1.280	1.67±0.976

P value: <0.05*

DISCUSSION

This strengthening program was designed in such a manner that it improved anterior reach more effectively, by performing exercises in sagittal plan in both groups. Usually, it is observed that the endurance of muscle reduces, if there are contusions on muscular tissue or if the muscle is atrophied. Since patients with OA tends to stay immobile for longer period due to pain and difficulty in functional movements, as a consequence, there is remarkable reduction in muscle strength and endurance. It is noteworthy, that the strength of quadriceps is essential in maintaining the alignment and joint tracking of knee and other associated joints like hip and ankle^{16,17}. The data in this study has shown; as the strength of the quadriceps improves so does the balance, intensity of pain and ROM improve. Various systems of the human bodywork as a syncytium to maintain balance and accurate base of support such as the somato-sensory, vestibular, visual and synchronization of the musculoskeletal system¹⁸. Several studies have shown that OKC, CKC, Tai chi and aerobic exercises improve balance system in pathologies like OA^{19,20}.

We also found that, CKC exercises in the initial phase, were excruciating contrasted with OKC exercises because of the weight-bearing position. Later on, patients dependably needed a change in their actions like hunching down, strolling or stair climbing and CKC exercises helped them in their utilitarian rehabilitation. So, in the long term recovery program of osteoarthritis, it is beneficial to incorporate both OKC activities and CKC workouts. CKC exercises are close to natural movement patterns like in standing or weight-bearing position therefore, it has provided relatively better effects^{21,22,23}.

In this randomized controlled trial, muscle range of motion, strength, and pain significantly improved with substantial improvement in composite score of anterior, posterolateral, and posteromedial reach after assessing patients by Y-balance test. Normally, Y-balance test demands co-contraction of stance leg muscles to increase the excursion distances¹⁰ whereas, in knee

OA co-contractions of antagonist knee muscles predominantly occurs. However, the relationship between dynamic balance and co-contraction of muscles has not been investigated yet. OKC and CKC also enhances muscular co-ordination thereby activating in time of need, that is how the balance was improved.²⁴ Therefore, more investigations are needed to assure the mechanism of dynamic balance impairments. Our study for the first time has shown that the dynamic balance in patients with grade II OA improves with both OKC and CKC exercises. However, the data suggests that CKC exercises are more effective in improving the dynamic balance as compared to OKC. It was deduced that open kinetic chain exercises and closed kinetic chain exercises are equally effective in improving dynamic balance, pain and consequently ROM in patients with knee osteoarthritis.

CONCLUSION

It was concluded that patients with OKC exercises have shown equal improvement in ROM and dynamic balance compared to those who have been treated with CKC exercises.

Limitations: Sample size was very small and financial limitations followed by low man power for follow-ups.

Author's contribution: MEHR&ZH: Overall supervision, write up and literature review, **WE&SF:** Statistics application, analysis literature review, help in write up, **FS&MH:** Literature review help in write-up.

Conflict of interest: None

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REFERENCES

- Felson DT. Challenges of identifying and treating patellofemoral osteoarthritis. *BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine*; 2016.
- Bhatia D, Bejarano T, Novo M. Current interventions in the management of knee osteoarthritis. *Journal of pharmacy & bioallied sciences*. 2013;5(1):30.
- Nguyen U-SD, Zhang Y, Zhu Y, Niu J, Zhang B, Felson DT. Increasing prevalence of knee pain and symptomatic knee osteoarthritis: survey and cohort data. *Annals of internal medicine*. 2011;155(11):725-32.
- Jasper J, Metsaars W, Jansen J. Ochronosis of the knee with secondary osteoarthritis requiring total knee replacement in a patient with cryptogenic organising pneumonia. *BMJ case reports*. 2016;2016:bcr2016215412.
- Cliborne AV, Wainner RS, Rhon DI, Judd CD, Fee TT, Matekel RL, et al. Clinical hip tests and a functional squat test in patients with knee osteoarthritis: reliability, prevalence of positive test findings, and short-term response to hip mobilization. *Journal of Orthopaedic & Sports Physical Therapy*. 2004;34(11):676-85.
- Duffell LD, Southgate DF, Gulati V, McGregor AH. Balance and gait adaptations in patients with early knee osteoarthritis. *Gait & posture*. 2014;39(4):1057-61.
- Goldring MB, Goldring SR. Articular cartilage and subchondral bone in the pathogenesis of osteoarthritis. *Annals of the New York Academy of Sciences*. 2010;1192(1):230-7.
- McGonagle D, Tan AL, Carey J, Benjamin M. The anatomical basis for a novel classification of osteoarthritis and allied disorders. *Journal of anatomy*. 2010;216(3):279-91.
- Arden NK, Nevitt MC, Lane NE, Gore LR, Hochberg MC, Scott JC, et al. Osteoarthritis and risk of falls, rates of bone loss, and osteoporotic fractures. *Arthritis & Rheumatism*. 1999;42(7):1378-85.
- Hinman R, Bennell K, Metcalf B, Crossley K. Balance impairments in individuals with symptomatic knee osteoarthritis: a comparison with matched controls using clinical tests. *Rheumatology*. 2002;41(12):1388-94.
- Beckwee D, Vaes P, Cnudde M, Swinnen E, Bautmans I. Osteoarthritis of the knee: why does exercise work? A qualitative study of the literature. *Ageing research reviews*. 2013;12(1):226-36.
- Takacs J, Krowchuk NM, Garland SJ, Carpenter MG, Hunt MA. Dynamic Balance Training Improves Physical Function in Individuals With Knee Osteoarthritis: A Pilot Randomized Controlled Trial. *Archives of Physical Medicine and Rehabilitation*. 2017.
- Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. *International journal of sports physical therapy*. 2012;7(2):139.
- Coughlan GF, Fullam K, Delahunt E, Gissane C, Caulfield BM. A comparison between performance on selected directions of the star excursion balance test and the Y balance test. *Journal of athletic training*. 2012;47(4):366-71.
- Muir SW, Berg K, Chesworth B, Speechley M. Use of the Berg Balance Scale for predicting multiple falls in community-dwelling elderly people: a prospective study. *Physical therapy*. 2008;88(4):449-59.
- Goniometry of knee joint (Flexion & extension) [Available from: <http://at.uwa.edu/gon/knee.htm>].
- Cooper C. *Fundamentals of Hand Therapy: Clinical reasoning and treatment guidelines for common diagnosis of the upper extremity*. 2nd Edition ed2013. 596 p.
- Stoppani DJ. Calculate Your ONE-REP MAX (1RM) *Bodybuilding.com*®; January 10, 2018 [Available from: <https://www.bodybuilding.com/func/other7.htm>].
- Takacs J, Krowchuk NM, Garland SJ, Carpenter MG, Hunt MA. Dynamic balance training improves physical function in individuals with knee osteoarthritis: a pilot randomized controlled trial. *Archives of physical medicine and rehabilitation*. 2017;98(8):1586-93.
- Wegener L, Kisner C, Nichols D. Static and dynamic balance responses in persons with bilateral knee osteoarthritis. *Journal of Orthopaedic & Sports Physical Therapy*. 1997;25(1):13-8.
- Kwon YJ, Park SJ, Jefferson J, Kim K. The effect of open and closed kinetic chain exercises on dynamic balance ability of normal healthy adults. *Journal of physical therapy science*. 2013;25(6):671-4.
- Iwasaki T, Shiba N, Matsuse H, Nago T, Umezū Y, Tagawa Y, et al. Improvement in knee extension strength through training by means of combined electrical stimulation and voluntary muscle contraction. *The Tohoku journal of experimental medicine*. 2006;209(1):33-40.
- Hassan B, Mockett S, Doherty M. Static postural sway, proprioception, and maximal voluntary quadriceps contraction in patients with knee osteoarthritis and normal control subjects. *Annals of the rheumatic diseases*. 2001;60(6):612-8.
- Bennell KL, Hinman RS, Metcalf BR, Crossley KM, Buchbinder R, Smith M, et al. Relationship of knee joint proprioception to pain and disability in individuals with knee osteoarthritis. *Journal of orthopaedic research*. 2003;21(5):792-7.