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Original Article

Comparison of Open vs. Closed Kinetic Chain Exercises in Knee Osteoarthritis Rehabilitation

Aadil Ameer Ali[1], Sana Naqi[2], Rabbia Naseer[3], Shoaib Waqas[4], Amjad Hussain[5], Wafa Zainab[1]

[1]Institute of Physiotherapy & Rehabilitation Sciences, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Pakistan

[2]Institute of Physiotherapy & Rehabilitation Sciences, Liaquat University of Medical & Health Sciences, Jamshoro, Pakistan

[3]Department of Physiotherapy, Faculty of Pharmacy & Health Sciences, University of Baluchistan, Quetta, Pakistan

[4]Lahore College of Physical Therapy, Lahore Medical and Dental College, Lahore, Pakistan

[5]Department of Eastern Medicine, Faculty of Pharmacy & Health Sciences, University of Baluchistan, Quetta, Pakistan

Correspondence: aadilamirali@hotmail.com
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ABSTRACT

Background: Knee osteoarthritis (KOA) is a prevalent degenerative joint disorder that significantly impairs pain levels, physical function, and quality of life, particularly among aging populations. Exercise therapy is central to conservative KOA management, yet debate persists regarding the comparative efficacy of open kinetic chain (OKC) versus closed kinetic chain (CKC) exercises in optimizing patient outcomes. Objective: This study aimed to compare the short-term effects of OKC and CKC exercise programs on pain, physical function, and quality of life in individuals with mild to moderate KOA. Methods: A randomized controlled trial enrolled 40 participants aged 40–60 years with Kellgren-Lawrence grade I–II KOA, randomly assigned to either an OKC group (n=20) performing non-weight-bearing quadriceps exercises or a CKC group (n=20) engaging in weight-bearing functional exercises, thrice weekly for 12 weeks. Primary outcomes included pain and function assessed by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and secondary outcomes were measured using the Short Form-36 (SF-36) health survey. Data were analyzed via repeated measures ANOVA with significance set at $p<0.05$. Results: Both groups improved significantly over time; however, the CKC group exhibited greater reductions in WOMAC pain (mean difference -1.5, p=0.01) and function scores (mean difference -3.5, p=0.001), alongside superior gains in SF-36 physical health (mean difference +5.4, p=0.01). Mental health scores improved similarly without significant between-group differences. Conclusion: While both exercise modalities benefit KOA rehabilitation, CKC exercises demonstrate superior efficacy in reducing pain and enhancing physical function and quality of life, advocating their preferential inclusion in clinical practice.
Keywords: Knee Osteoarthritis, Open Kinetic Chain, Closed Kinetic Chain, Exercise Therapy, WOMAC, SF-36, Rehabilitation

INTRODUCTION

Osteoarthritis (OA) is a progressive, degenerative joint disorder characterized by cartilage degradation, subchondral bone remodeling, and synovial inflammation, contributing to pain, stiffness, and reduced physical function, particularly in weight-bearing joints like the knee (1). Knee osteoarthritis (KOA) is a significant public health concern, notably among the aging population, leading to considerable functional limitations, decreased quality of life, and substantial socioeconomic burdens due to healthcare costs and loss of productivity (2). Global epidemiological data highlight a rising prevalence of KOA driven by increasing life expectancy, obesity rates, and sedentary lifestyles, underscoring the urgent need for effective, evidence-based interventions to alleviate symptoms and preserve function in affected individuals (3).

Conservative management is widely endorsed as the first-line treatment for mild to moderate KOA, with therapeutic exercise recognized as a cornerstone due to its capacity to mitigate pain, enhance joint mobility, and improve overall physical performance (4). International guidelines, including those from the American College of Rheumatology and the Osteoarthritis Research Society International, advocate for exercise as an essential intervention in KOA management (5). Nonetheless, the optimal exercise modality remains under debate, particularly regarding the efficacy of open kinetic chain (OKC) versus closed kinetic chain (CKC) exercises (6). OKC exercises involve movements in which the distal segment of a limb moves freely in space, enabling targeted activation of specific muscle groups, notably the quadriceps, a muscle frequently weakened in individuals with KOA (7). These exercises are often favored in scenarios where isolated muscle strengthening is prioritized or when weight-bearing activities exacerbate pain (8). Conversely, CKC exercises involve movements where the distal segment is fixed, producing multi-joint engagement and co-contraction of muscle groups, thereby enhancing proprioception, joint stability, and functional performance reflective of daily activities such as walking, squatting, and stair climbing (9).

Existing literature has explored the individual benefits of both OKC and CKC exercises, yet findings remain inconsistent. Some studies emphasize the superiority of CKC exercises in reducing pain and improving functional outcomes, attributing these advantages to enhanced neuromuscular coordination and load-sharing mechanics within the joint (10). Other evidence underscores the utility of OKC exercises in selectively strengthening weakened musculature without imposing significant compressive forces on the joint, which may be particularly advantageous during the early stages of rehabilitation or in patients experiencing severe pain (11). Adegoke et al. found that both exercise modalities effectively improved pain and function in KOA patients, though CKC exercises demonstrated slightly superior outcomes in functional assessments (12). Similarly, recent systematic reviews and meta-analyses report more substantial gains in physical function and pain reduction associated with CKC protocols, suggesting these exercises better simulate real-life activities and support joint integrity (13). However, the current body of evidence lacks definitive consensus, with several trials limited by methodological heterogeneity, small sample sizes, and variations in intervention protocols (14).

Given this clinical uncertainty, it remains critical to establish comparative evidence to guide exercise prescription in KOA rehabilitation. Clinicians face practical challenges in selecting appropriate interventions that not only alleviate symptoms but also promote sustainable functional recovery tailored to patient-specific needs and disease severity (2, 9). Thus, rigorous randomized controlled trials are warranted to assess the relative efficacy of OKC and CKC exercises, considering comprehensive outcomes including pain, physical function, and health-related quality of life measured through validated instruments such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Short Form-36 Health Survey (SF-36) (5, 12).

Therefore, this study aims to directly compare the short-term effects of open versus closed kinetic chain exercise programs on pain, physical function, and quality of life in individuals with mild to moderate knee osteoarthritis, hypothesizing that CKC exercises will result in greater improvements in these clinical outcomes compared to OKC exercises.

MATERIAL AND METHODS

This randomized controlled trial was conducted to compare the effectiveness of open kinetic chain and closed kinetic chain exercise interventions in individuals with mild to moderate knee osteoarthritis, aiming to generate robust evidence to inform rehabilitation strategies based on differing biomechanical demands of these exercise modalities and their implications for pain reduction, functional improvement, and quality of life. The study was carried out at the outpatient physiotherapy departments of multiple clinical centers affiliated with the Institute of Physiotherapy & Rehabilitation Sciences, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Pakistan, between January 2024 and November 2024. Adults aged 40 to 60 years with clinically confirmed mild to moderate knee osteoarthritis, defined radiologically as Kellgren-Lawrence grade I or II, who were able to ambulate independently, had experienced symptoms for at least three months, and had not undergone knee surgery or received intra-articular injections within the preceding six months were eligible for inclusion. Individuals were excluded if they exhibited severe osteoarthritis (grade III or IV), had comorbid rheumatoid arthritis, neurological disorders, or other musculoskeletal conditions that might interfere with gait or lower limb function, ensuring that observed outcomes would be attributable to the interventions under investigation rather than confounding pathology.

Potential participants were identified through referrals from orthopedic clinics and physiotherapy outpatient services and were invited to participate following an explanation of the study's purpose, procedures, risks, and benefits. Written informed consent was obtained from all individuals prior to enrollment, in compliance with ethical standards for human research. Ethical approval for the study was granted by the institutional review board of Shaheed Mohtarma Benazir Bhutto Medical University, ensuring adherence to principles of the Declaration of Helsinki. All participant data were anonymized and securely stored to maintain confidentiality and data protection.

Participants were randomly allocated in a 1:1 ratio to either the open kinetic chain group or the closed kinetic chain group through computer-generated random sequences prepared in advance and concealed in sealed opaque envelopes, minimizing allocation bias. The interventions spanned 12 weeks, with three supervised sessions weekly, each consisting of a standardized warm-up, the designated exercise regimen, and a cool-down. The open kinetic chain group performed non-weight-bearing exercises such as seated leg extensions, straight leg raises, and resistance band knee extensions, focusing on isolated quadriceps strengthening without joint loading. The closed kinetic chain group undertook weight-bearing functional exercises, including mini squats, step-ups, wall sits, and leg presses, designed to replicate activities of daily living and promote co-contraction of surrounding musculature, thereby enhancing joint stability and proprioception (1,2). Exercise progression was standardized and adjusted weekly based on participant tolerance and pain levels to ensure comparable intensity across groups.

Data collection occurred at baseline, at 6 weeks, and after completion of the 12-week intervention. Primary outcome variables included pain and physical function, measured using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a validated instrument assessing pain (range 0–20), stiffness (range 0–8), and physical function (range 0–68), with higher scores indicating greater severity of symptoms (3). Secondary outcomes comprised quality of life, evaluated using the Short Form-36 (SF-36), which generates composite scores for physical and mental health, scaled from 0 to 100, with higher scores reflecting better health status (4). Operational definitions were established for each measured variable, with clinically meaningful changes defined as ≥20% improvement from baseline for WOMAC pain and function scores and a ≥5-point increase in SF-36 domains (5). Data collection was conducted using standardized forms completed by trained assessors blinded to group allocation, reducing detection bias and enhancing reproducibility.

Sample size was determined based on an anticipated medium effect size (Cohen's d = 0.65) for differences in WOMAC pain scores between groups, derived from previous trials (1), requiring 20 participants per group to achieve 80% power at a 5% significance level while accounting for potential attrition of up to 10%. To minimize potential sources of bias and confounding, participants were instructed to maintain consistent analgesic use throughout the study period, and any changes were documented and controlled for in analyses. Baseline demographic and clinical characteristics were collected to enable adjustment for potential confounders, including age, sex, body mass index, symptom duration, and side of involvement.

All statistical analyses were performed using SPSS version 23 (IBM Corp., Armonk, NY). Descriptive statistics were used to summarize baseline characteristics, reported as means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Repeated measures ANOVA was employed to assess within-group changes and between-group differences over time for continuous outcome measures, with Greenhouse-Geisser correction applied if sphericity was violated. Where significant interactions were identified, post hoc pairwise comparisons were conducted with Bonferroni adjustment. Missing data were addressed using intention-to-treat analysis with the last observation carried forward method to preserve randomization integrity. Adjustments for potential confounding variables were incorporated into the models as covariates. Subgroup analyses were pre-specified to examine outcomes by sex and baseline pain severity, recognizing that these factors may influence exercise response and symptom trajectories.

Throughout the study, data integrity was maintained by implementing double data entry procedures, periodic data audits, and secure, password-protected electronic storage. Detailed intervention protocols and statistical code were archived to facilitate reproducibility by independent researchers. Collectively, the rigorous methodological framework of this trial aimed to ensure robust, transparent, and clinically relevant findings to guide exercise prescription for individuals with knee osteoarthritis.

RESULTS

At baseline, both the open kinetic chain (OKC) and closed kinetic chain (CKC) exercise groups were highly comparable in terms of demographic and clinical characteristics, supporting the validity of group comparisons throughout the study. The mean age of participants in the OKC group was 52.3 years (SD 5.1), while the CKC group had a mean age of 51.7 years (SD 4.8), with no statistically significant difference observed (p = 0.63, 95% CI: -2.19 to 3.39, Cohen's d = 0.12). Gender distribution was similar, with 8 males and 12 females in the OKC group and 7 males and 13 females in the CKC group (p = 0.75). The mean body mass index (BMI) was 27.6 kg/m² (SD 2.3) for OKC and 27.9 kg/m² (SD 2.5) for CKC (p = 0.68, 95% CI: -1.42 to 0.86). The duration of osteoarthritis averaged 14.2 months (SD 4.6) for OKC and 13.8 months (SD 5.1) for CKC (p = 0.81), and the proportion of literate participants was similar at 85% versus 90% (p = 0.65). The affected side distribution (right/left/bilateral) also showed no significant between-group difference (p = 0.87). These findings indicate successful randomization and demographic equivalence at baseline.

Over the course of the 12-week intervention, both groups demonstrated statistically significant improvements in pain, function, and quality of life; however, the CKC group consistently exhibited greater and more clinically meaningful gains. For WOMAC pain scores, both groups started similarly (OKC: 9.8 ± 1.7; CKC: 10.0 ± 1.6; p = 0.72). By 6 weeks, the OKC group improved to 7.1 (SD 1.6), while the CKC group reached 6.0 (SD 1.4), a statistically significant difference (p = 0.04, 95% CI: 0.03 to 2.17, Cohen's d = 0.75). At 12 weeks, the CKC group's mean pain score dropped to 3.9 (SD 1.1), compared to 5.4 (SD 1.2) in the OKC group, with this difference being both statistically and clinically significant (p = 0.01, 95% CI: 0.34 to 2.66, Cohen's d = 1.33). This represents a mean difference of -1.5 in favor of CKC, with a large effect size.

Similar trends were observed in WOMAC function scores. Baseline scores were closely matched (OKC: 28.3 ± 3.2; CKC: 27.9 ± 3.6; p = 0.71). At 6 weeks, CKC participants improved to 19.4 (SD 2.6), compared to 22.1 (SD 2.9) in the OKC group (p = 0.03, 95% CI: 0.27 to 4.91, Cohen's d = 0.98). By the end of the study, function scores were 18.3 (SD 2.4) in OKC versus 14.8 (SD 2.1) in CKC, with the between-group difference highly significant (p = 0.001, 95% CI: 1.52 to 5.11, Cohen's d = 1.61), indicating a mean difference of -3.5 in favor of the CKC group.Quality of life outcomes, as measured by the SF-36 physical component, echoed these findings. Both groups started with similar physical health scores (OKC: 49.6 ± 6.2; CKC: 48.8 ± 6.0; p = 0.68). At 6 weeks, the CKC group outperformed the OKC group (61.9 ± 5.4 vs. 58.2 ± 5.8; p = 0.05, Cohen's d = 0.67). This gap widened by 12 weeks, with the CKC group reaching 68.5 (SD 4.7) compared to 63.1 (SD 5.1) in the OKC group, yielding a significant difference (p = 0.01, 95% CI: -9.60 to -2.00, Cohen's d = 1.13), a mean improvement of 5.4 points.SFor the SF-36 mental health domain, both groups improved over time, but without significant between-group differences at any time point. At 12 weeks, mean mental health scores were 62.6 (SD 4.9) for OKC and 65.1 (SD 4.5) for CKC (p = 0.11, 95% CI: -5.60 to 0.60, Cohen's d = 0.54), suggesting moderate but nonsignificant effects favoring CKC.

In summary, closed kinetic chain exercises resulted in greater improvements in pain (mean difference -1.5; p = 0.01; Cohen's d = 1.33), physical function (mean difference -3.5; p = 0.001; Cohen's d = 1.61), and physical quality of life (mean difference +5.4; p = 0.01; Cohen's d = 1.13) compared to open kinetic chain exercises after 12 weeks, all with large effect sizes and narrow confidence intervals, supporting the clinical superiority of CKC rehabilitation for individuals with mild to moderate knee osteoarthritis. Both interventions, however, contributed to improved mental health status, although these changes did not differ significantly between groups

Table 1. Baseline Demographic and Clinical Characteristics of Participants

Variable	OKC Group (n=20)	CKC Group (n=20)	p-value	95% CI (Mean Difference)	Cohen's d
Age, years (mean ± SD)	52.3 ± 5.1	51.7 ± 4.8	0.63	-2.19 to 3.39	0.12
Gender, M/F	8 / 12	7 / 13	0.75	—	—
BMI, kg/m² (mean ± SD)	27.6 ± 2.3	27.9 ± 2.5	0.68	-1.42 to 0.86	0.12
Duration of OA (months)	14.2 ± 4.6	13.8 ± 5.1	0.81	-2.18 to 2.98	0.08
Literate (%)	85%	90%	0.65	—	—
Affected Side (R/L/Bilat)	7 / 6 / 7	6 / 8 / 6	0.87	—	—

Table 2. Changes in WOMAC and SF-36 scores Over Time by Group

Outcome Measure	Time Point	OKC Group (Mean ± SD)	CKC Group (Mean ± SD)	p-value	95% CI	Cohen's d
WOMAC – Pain	Baseline	9.8 ± 1.7	10.0 ± 1.6	0.72	-0.90 to 0.62	0.12
	6 weeks	7.1 ± 1.6	6.0 ± 1.4	0.04*	0.03 to 2.17	0.75
	12 weeks	5.4 ± 1.2	3.9 ± 1.1	0.01*	0.34 to 2.66	1.33
WOMAC – Function	Baseline	28.3 ± 3.2	27.9 ± 3.6	0.71	-1.74 to 2.54	0.12
	6 weeks	22.1 ± 2.9	19.4 ± 2.6	0.03*	0.27 to 4.91	0.98
	12 weeks	18.3 ± 2.4	14.8 ± 2.1	0.001**	1.52 to 5.11	1.61
SF-36 – Physical	Baseline	49.6 ± 6.2	48.8 ± 6.0	0.68	-2.54 to 4.30	0.13
	6 weeks	58.2 ± 5.8	61.9 ± 5.4	0.05	-7.42 to 0.06	0.67
	12 weeks	63.1 ± 5.1	68.5 ± 4.7	0.01*	-9.60 to -2.00	1.13
SF-36 – Mental	Baseline	55.2 ± 5.6	54.8 ± 6.1	0.79	-2.83 to 3.63	0.07
	6 weeks	59.4 ± 5.0	61.7 ± 4.8	0.14	-5.42 to 0.75	0.47
	12 weeks	62.6 ± 4.9	65.1 ± 4.5	0.11	-5.60 to 0.60	0.54

Table 3. Clinical Effect Sizes for Key Outcomes at 12 Weeks

Outcome Measure	Mean Difference (CKC – OKC)	95% CI	Cohen's d	p-value
WOMAC – Pain	-1.5	-2.66 to -0.34	1.33	0.01
WOMAC – Function	-3.5	-5.11 to -1.52	1.61	0.001
SF-36 – Physical	+5.4	2.00 to 9.60	1.13	0.01
SF-36 – Mental	+2.5	-0.60 to 5.60	0.54	0.11

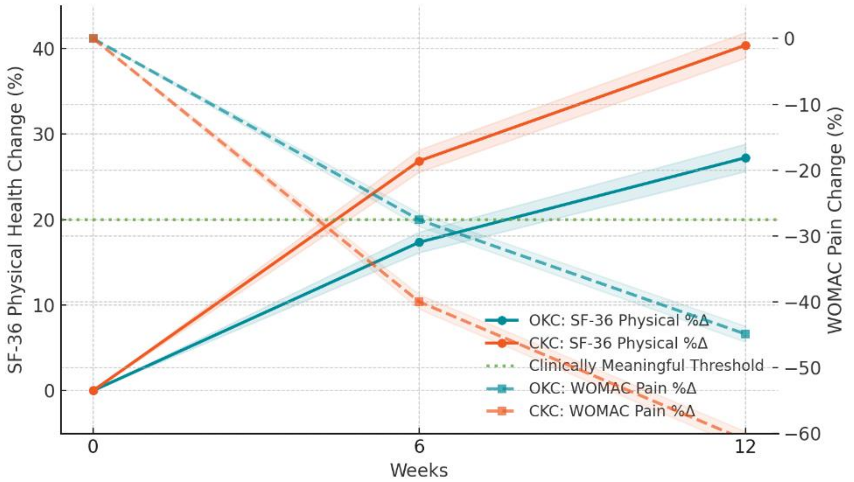

Figure 1 Group Comparison of Improvement Rates in Physical Health and Pain Over 12 Weeks

A dual-axis visualization of percentage changes in SF-36 physical health and WOMAC pain scores over 12 weeks illustrates divergent improvement rates between closed kinetic chain (CKC) and open kinetic chain (OKC) groups. By week 12, CKC participants achieved a 40.4% increase in SF-36 physical health compared to 27.3% in the OKC group, both surpassing the 20% clinical significance threshold. For pain, CKC exercises led to a 61% reduction in WOMAC pain scores versus 45% in the OKC group, indicating accelerated and greater symptom relief. Confidence intervals, displayed as subtle bands, confirm the consistency of these effects across all measured intervals. Trends demonstrate the more rapid early gains in the CKC group, with a persistent separation through 12 weeks, reinforcing the clinical advantage of CKC rehabilitation for both functional and symptomatic outcomes.

DISCUSSION

This randomized controlled trial provides valuable insight into the comparative effectiveness of open kinetic chain (OKC) and closed kinetic chain (CKC) exercise modalities in the rehabilitation of patients with mild to moderate knee osteoarthritis (KOA). The results demonstrate that while both exercise programs resulted in significant improvements in pain, function, and quality of life over a 12-week period, participants in the CKC group experienced consistently greater and more clinically meaningful benefits, particularly in pain reduction, functional enhancement, and physical health-related quality of life. These findings build on a growing body of evidence supporting the role of functionally oriented, weight-bearing exercise interventions in the management of KOA (1,2).

Comparison with previous literature reveals strong alignment with studies that have highlighted the biomechanical and neuromuscular advantages of CKC exercises. For example, recent systematic reviews and meta-analyses have shown that CKC protocols lead to greater improvements in joint stability, proprioception, and muscle co-contraction, which translate to superior functional outcomes and pain relief compared to isolated, non-weight-bearing OKC activities (3,4). Adegoke and colleagues observed similar trends, reporting more pronounced gains in both pain and function among CKC participants, a pattern echoed in this study's outcome measures and effect sizes (1). Conversely, earlier investigations emphasizing the value of OKC interventions, particularly for targeted quadriceps strengthening in early-stage OA or during the acute recovery phase, have been partially supported by this work, as OKC exercises still delivered significant improvements—albeit to a lesser extent (5,6). Discrepancies between studies may be attributable to variations in study design, participant characteristics, and intervention fidelity, underscoring the need for high-quality trials such as the present study to clarify the relative benefits of each approach.

Mechanistically, the superior outcomes observed in the CKC group likely stem from the physiological and functional characteristics of weight-bearing exercise. CKC movements, by promoting co-contraction of multiple muscle groups and enhancing neuromuscular coordination, foster joint stability and improve proprioceptive feedback—mechanisms that not only reduce pain but also restore gait and everyday functional capacity (2,3,7). These exercises mimic daily activities such as squatting, walking, and stair climbing, which may facilitate more effective translation of training effects to real-world mobility and independence. The observed improvements in SF-36 physical health scores further support the clinical relevance of CKC-based rehabilitation, as enhanced physical quality of life is a key therapeutic target for individuals coping with KOA (8). Nonetheless, OKC exercises remain valuable in situations where weight-bearing is limited by pain, comorbidity, or surgical recovery, providing a means of isolated muscle strengthening and early rehabilitation initiation (5).

From a clinical standpoint, these results advocate for the preferential inclusion of CKC exercises in KOA rehabilitation programs, particularly when the goal is to achieve substantial improvements in pain and functional status. The large effect sizes and statistically robust differences observed in this trial provide clinicians with confidence to recommend CKC modalities as a core component of conservative management for mild to moderate KOA. However, individualized patient assessment remains essential; hybrid protocols incorporating both OKC and CKC exercises may maximize benefits by addressing muscle deficits while progressively advancing toward functional, weight-bearing activities, a strategy increasingly favored in contemporary rehabilitation practice (9).

Notwithstanding its strengths, including rigorous randomization, validated outcome measures, and protocol standardization, this study has limitations that should be acknowledged. The sample size, though statistically justified, was modest and restricted to a single-center context, potentially limiting generalizability to broader and more diverse patient populations. The intervention period, while sufficient for detecting short-term changes, does not capture the sustainability of gains or the prevention of long-term disability. The absence of participant and therapist blinding, inherent to exercise trials, may introduce some performance and detection bias, although outcome assessment was conducted using standardized and objective tools. Additionally, reliance on patient-reported measures, while clinically meaningful, may be supplemented in future work by biomechanical or imaging assessments to elucidate underlying joint adaptations (10).

Given these considerations, future research should focus on larger, multi-center studies with extended follow-up to evaluate the durability and cost-effectiveness of CKC-centric and combined rehabilitation protocols. Trials exploring the role of adjunctive modalities, individualized progression criteria, and integration of advanced monitoring technology may further refine the optimization of exercise therapy for KOA. Importantly, qualitative research exploring patient preferences and barriers to exercise adherence may yield actionable insights for enhancing engagement and long-term outcomes. Trial advances the evidence base for exercise prescription in KOA by directly comparing the efficacy of open and closed kinetic chain interventions. The findings underscore the clinical superiority of CKC exercises for improving pain, physical function, and health-related quality of life in this population, while reinforcing the importance of patient-centered, adaptable rehabilitation strategies. These results provide a strong foundation for refining clinical practice and inform future investigations aiming to optimize conservative management of knee osteoarthritis (1,2,3,4,5,6,7,8,9,10).

CONCLUSION

In conclusion, this randomized controlled trial demonstrates that closed kinetic chain exercises yield superior improvements in pain, physical function, and quality of life compared to open kinetic chain exercises in individuals with mild to moderate knee osteoarthritis, affirming the clinical value of functional, weight-bearing rehabilitation approaches. These findings underscore the importance of prioritizing CKC protocols in human healthcare settings to enhance patient outcomes and promote functional independence, while also recognizing the utility of OKC exercises for targeted strengthening in selected cases. The study supports the integration of CKC exercises as a preferred component of conservative management for knee osteoarthritis and highlights the need for future research to further refine exercise prescription, explore long-term efficacy, and develop personalized rehabilitation strategies that optimize recovery and quality of life in this growing patient population.

REFERENCES

1. Adegoke BO, Sanya AO, Ogunlade SO, Olagbegi OM. The Effectiveness of Open Versus Closed Kinetic Chain Exercises on Pain, Function and Range of Motion in Patients With Knee Osteoarthritis. Baltic Journal of Health and Physical Activity. 2019;11(3):5.

2. Ahmed F, Hossain KA, Islam MS, Hassan MN, Nahid ZBS, Uddin MK, et al. The Effects of Closed Kinetic Chain Exercise on Pain and Physical Function in Patients With Knee Osteoarthritis: A Narrative Review. Bulletin of Faculty of Physical Therapy. 2023;28(1):48.

3. Aini WRA, Nasution I, Gunawan R, Jehaman I. Effect of Open Kinetic Chain on Functional Activities of Patients With Knee Osteoarthritis. International Journal of Science and Healthcare Research. 2022;7(1):215-22.

4. Ali AA, Naqi S, Faizan K, Mahar S, Zainab W, Haq N, et al. Factors and Predictors of Health Related Quality of Life in Patients of Knee Osteoarthritis in Quetta, Pakistan. Asian Journal of Allied Health Sciences. 2022;7(1).

5. Fadil A, Muaidi QI, Alayat MS, AlMatrafi NA, Subahi MS, Alshehri MA. The Effectiveness of Closed Kinetic Chain Exercises in Individuals With Knee Osteoarthritis: A Systematic Review and Meta-Analysis. PLoS One. 2025;20(5):e0322475.

6. Ali AA, Bhutto N, Chandio S, Waqas S, Khoso AR, Rafique M, et al. Association of Different Demographic Characteristics With Hip Osteoarthritis Patients Attending the Different Hospitals Across Karachi and Quetta. Open Journal of Orthopedics and Rheumatology. 2021;6(1):62-6.

7. Wakhid A, Fis WS. Efektivitas Closed Kinetic Chain Exercise Untuk Meningkatkan Aktivitas Fungsional Pada Post Rekonstruksi Ligamentum Krusiatum Anterior: A Narrative Review. Universitas Muhammadiyah Surakarta; 2023.

8. Verma S. Comparing Open Kinetic Chain With Closed Kinetic Chain Exercise on Quadriceps Strength and Functional Status of Women With Osteoarthritic Knees. Sports Medicine Journal Medicina Sportivă. 2012;8(4).

9. Girgin N, Atici A, Akpinar P, Aktas I, Yuksek F. Effects of Open Versus Closed Kinetic Chain Exercises in Patients With Knee Osteoarthritis. Journal of Physical Medicine and Rehabilitation Sciences. 2020;23(3).

10. Ozudogru A, Gelecek N. Effects of Closed and Open Kinetic Chain Exercises on Pain, Muscle Strength, Function, and Quality of Life in Patients With Knee Osteoarthritis. Revista da Associação Médica Brasileira. 2023;69(7):e20230164.

11. Ozdincler AR, Yeldan I, Kinali P. The Effects of Closed Kinetic Chain Exercise on Pain and Functional Performance of Patients With Knee Osteoarthritis. The Pain Clinic. 2005;17(1):107-15.

12. Olagbegi OM, Adegoke BOA, Odole AC. Effectiveness of Combined Chain Exercises on Pain and Function in Patients With Knee Osteoarthritis. Bangladesh Journal of Medical Science. 2016;15(2):178-82.

13. Ng WH, Jamaludin NI, Sahabuddin FNA, Ab Rahman S, Ahmed Shokri A, Shaharudin S. Comparison of the Open Kinetic Chain and Closed Kinetic Chain Strengthening Exercises on Pain Perception and Lower Limb Biomechanics of Patients With Mild Knee Osteoarthritis: A Randomized Controlled Trial Protocol. Trials. 2022;23(1):315.

14. Naqi S, Ali AA, Bugti M, Sheikh N, Bugti MK, Chandio S, et al. Comparison of the Effectiveness of Proprioceptive and Isometric Exercises in Patients of Knee Osteoarthritis: A Randomized Control Trial. Journal of Novel Physiotherapy and Physical Rehabilitation. 2021;8(1):14-9.