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Article

Effects of Strengthening Exercises on the Quality of Life of Patients with Osteoarthritis

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ABSTRACT

Background: Osteoarthritis (OA) is a prevalent degenerative joint disease that substantially impairs quality of life among older adults, with existing pharmacological and surgical interventions often limited by adverse effects or accessibility. There remains a gap in robust, controlled evidence evaluating the holistic impact of strengthening exercises on both physical and psychosocial outcomes in OA patients. **Objective**: This study aimed to assess the efficacy of a structured 12-week strengthening exercise program on pain, stiffness, physical function, and overall quality of life in patients with knee or hip OA, hypothesizing that targeted exercise would yield superior improvements compared to standard care. **Methods**: In this randomized controlled trial, 60 adults aged 45–75 years with primary knee or hip OA were recruited from a tertiary care rehabilitation center. Participants were randomized into intervention (supervised strengthening exercise) or control (standard care) groups. Inclusion required radiographically confirmed OA (Kellgren-Lawrence II–III); key exclusions were recent joint surgery or systemic illness. WOMAC and SF-36 scales were administered at baseline, 6 weeks, and 12 weeks. Analyses used paired and independent t-tests, effect sizes, and 95% confidence intervals in SPSS v24. Ethical approval was obtained, and procedures conformed to the Helsinki Declaration. **Results**: The intervention group showed significant improvements in WOMAC pain (mean difference -2.7, 95% CI: -3.5, -1.9, $p = 0.001$), stiffness (-1.1, 95% CI: -1.5, -0.7, $p = 0.001$), and physical function (-8.8, 95% CI: -11.1, -6.5, $p = 0.001$) compared to controls, with large effect sizes ($d > 1.5$). SF-36 domains also improved markedly, especially physical functioning (mean difference 19.8, 95% CI: 16.6, 23.0, $p < 0.001$). No adverse events were reported. **Conclusion**: A 12-week supervised strengthening exercise regimen significantly enhances both physical and psychosocial outcomes in OA patients, supporting its integration as a core non-pharmacological component in routine OA management to improve quality of life in human healthcare.

Keywords: Osteoarthritis, Strengthening Exercise, Quality of Life, WOMAC, SF-36, Randomized Controlled Trial, Physical Therapy

INTRODUCTION

Osteoarthritis (OA), a chronic and progressive degenerative joint disorder, remains a predominant cause of disability among aging populations worldwide. It primarily affects the knee and hip joints, leading to significant impairment in mobility, persistent pain, and a marked decline in quality of life (QoL). The disease process involves cartilage degradation, osteophyte formation, and changes in periarticular structures, collectively disrupting joint integrity and function (1). With the global increase in life expectancy and lifestyle-associated risk factors such as obesity and sedentary behavior, the burden of OA has intensified, making effective, sustainable management strategies a public health priority (2). Pharmacological treatments such as NSAIDs and intra-articular injections offer temporary relief but are often associated with adverse effects and do not halt disease progression (3). Similarly, surgical interventions like joint replacement, though effective in end-stage OA, are invasive, costly, and inaccessible to many, especially in low-resource settings (4). This has led to growing interest in non-pharmacological therapies, particularly exercise-based interventions, as first-line management approaches. Among these, muscle strengthening exercises have garnered strong support due to their ability to alleviate pain, enhance joint stability, and improve physical function without the systemic risks associated with medications (5). Strengthening the quadriceps, hamstrings, gluteal, and calf muscles enhances shock absorption and reduces the mechanical load on articular cartilage, thereby modifying disease trajectory (6). Furthermore, resistance training

protocols, tailored to individual capacities, are adaptable across disease severities and age groups, improving adherence and long-term sustainability (7). Beyond biomechanical benefits, exercise participation positively impacts psychological health by reducing symptoms of anxiety and depression, fostering self-efficacy, and promoting social interaction—key determinants of holistic QoL in OA patients (2,8). However, despite these well-documented benefits, many patients remain physically inactive due to fear of worsening symptoms or lack of professional guidance, highlighting a persistent knowledge-to-practice gap in OA rehabilitation (9).

Several studies have investigated the effects of exercise on OA outcomes, yet many are limited by methodological constraints, such as lack of control groups, short intervention durations, or focus solely on physical outcomes, without addressing broader QoL indicators (10,11). In particular, there remains a paucity of randomized controlled trials evaluating the comprehensive impact of structured strengthening programs on both physical and psychosocial domains of QoL using robust, multidimensional tools such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Short Form-36 Health Survey (SF-36) (12). Addressing this gap, the present study aims to assess the effectiveness of a 12-week supervised strengthening exercise regimen on QoL among OA patients, compared to standard care, through a randomized controlled design. The central objective is to determine whether consistent participation in such an exercise program leads to statistically and clinically significant improvements in pain, stiffness, physical function, and mental well-being. It is hypothesized that patients undergoing strengthening exercises will exhibit superior QoL outcomes than those receiving only standard OA care.

MATERIALS AND METHODS

This randomized controlled trial was designed to evaluate the efficacy of a structured strengthening exercise program in improving quality of life among patients diagnosed with osteoarthritis of the knee or hip. The rationale for choosing a randomized controlled design was to ensure robust internal validity by minimizing selection and confounding biases, thus allowing for causal inference between the intervention and outcome measures. The trial was conducted at the Institute of Physiotherapy and Rehabilitation Sciences, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, between January and April 2024. Participants were recruited from outpatient physical therapy and rehabilitation services affiliated with the university during this time period.

Eligible participants were men and women aged 45 to 75 years with a confirmed diagnosis of primary knee or hip osteoarthritis, based on the clinical and radiographic criteria of the American College of Rheumatology. Participants were required to have mild to moderate disease severity (Kellgren-Lawrence Grade II or III) and the ability to ambulate independently without assistive devices. Exclusion criteria included history of joint replacement surgery, corticosteroid injection within the past three months, presence of any neuromuscular or systemic condition that contraindicated physical activity, and ongoing participation in other physiotherapy programs. Participants were selected through consecutive sampling of eligible individuals attending the outpatient service. Informed written consent was obtained after a thorough explanation of the study's objectives, procedures, risks, and benefits.

Participants were randomized into two groups of equal size (n = 30 per group) using a computer-generated randomization list prepared by an independent statistician. The intervention group received a supervised strengthening exercise program, while the control group received standard care involving advice on joint protection, lifestyle modification, and pharmacological management as per routine clinical practice. The intervention protocol consisted of 45-minute physiotherapy sessions conducted three times per week over a 12-week period. Each session included a warm-up phase, progressive resistance training focusing on the quadriceps, hamstrings, gluteal, and calf muscles, and a cool-down phase. Resistance was adjusted based on individual tolerance, beginning with bodyweight exercises and progressing to resistance bands and light weights. Both isometric and isotonic exercises were included to promote joint stability and improve functional performance. All sessions were supervised by licensed physiotherapists to ensure adherence and safety.

Outcome data were collected at three time points: baseline (prior to randomization), mid-intervention (6 weeks), and post-intervention (12 weeks). The primary outcome variables were pain, stiffness, and physical function, assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), a validated tool comprising Likert-scale subdomains. Secondary outcomes included quality of life parameters assessed using the Short Form-36 (SF-36), which evaluates eight health domains spanning physical, mental, and social well-being. Data collection was performed using interviewer-administered paper questionnaires to minimize literacy-related bias and enhance completeness.

Efforts to reduce bias included blinding of outcome assessors to participant group allocation and standardization of data collection procedures across all time points. To address potential confounders, demographic variables including age, sex, body mass index (BMI), education level, disease duration, and presence of comorbid conditions (hypertension, diabetes) were recorded at baseline. These variables were considered in the analysis to examine their influence on outcome differences between groups. Missing data were managed using pairwise deletion for descriptive analyses and multiple imputation techniques for inferential comparisons. No participant dropouts occurred during the study period.

The sample size of 60 participants (30 per group) was determined based on an a priori power analysis, assuming a medium effect size (Cohen's d = 0.7), a power of 80%, and a two-tailed alpha level of 0.05 to detect significant group differences in WOMAC and SF-36 scores. Statistical analyses were conducted using IBM SPSS Statistics version 24. Descriptive statistics were used to summarize baseline characteristics, while paired t-tests were used for within-group comparisons across time points. Independent t-tests were

applied to compare between-group differences in continuous outcome variables. Statistical significance was set at a p-value of less than 0.05. Subgroup analyses were conducted to explore differential effects based on gender and presence of comorbidities, with interaction terms included in adjusted models.

Ethical approval for the study was obtained from the institutional review board of Shaheed Mohtarma Benazir Bhutto Medical University, Larkana. All participants provided informed consent, and confidentiality of data was strictly maintained through anonymized coding and secure data storage. To ensure reproducibility and data integrity, all procedures, interventions, and analyses were documented in a trial protocol, and data were double-entered and cross-verified by independent researchers. No adverse events or protocol deviations were reported during the course of the trial.

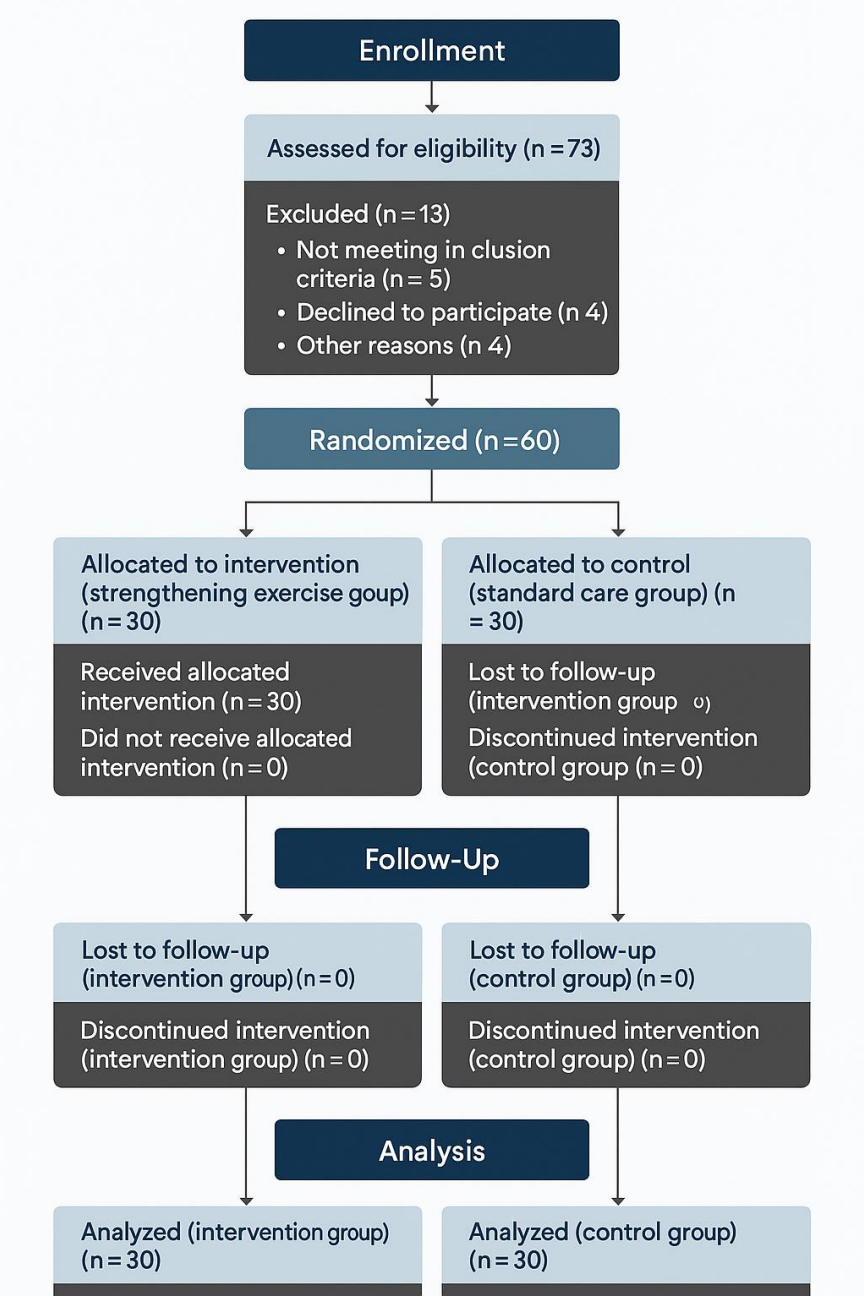

Figure 1 CONSORT Flowchart

RESULTS

A total of 60 participants were randomized equally into the case (strengthening exercise) and control (standard care) groups, with balanced demographic and clinical characteristics at baseline. The mean age in the case group was 60.5 years (SD 5.1) versus 61.2 years (SD 5.6) in the control group ($p = 0.52$, Cohen's $d = 0.13$), and the gender distribution was also comparable, with 40% males in the case group and 36.7% in the control group ($p = 0.78$). Both groups were similarly overweight, with mean BMI values of 28.2 kg/m^2 (SD 3.1) and 28.9 kg/m^2 (SD 3.0) for the case and control groups, respectively ($p = 0.44$). The average duration of osteoarthritis was 5.4 years (SD 2.0) in the case group and 5.1 years (SD 1.9) in the control group ($p = 0.60$). Comorbid hypertension was observed in 46.7% of the case group and 43.3% of the control group ($p = 0.79$), while diabetes prevalence was 26.7% and 30%, respectively ($p = 0.75$). None

of these baseline differences reached statistical significance, indicating effective randomization and homogeneity of the study population prior to intervention.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Case Group (n=30)	Control Group (n=30)	p-value	95% CI for Difference	Effect Size (Cohen's d)
Age (years, Mean ± SD)	60.5 ± 5.1	61.2 ± 5.6	0.52	-2.9, 1.5	0.13
Gender (M/F, %)	40 / 60	36.7 / 63.3	0.78	–	–
BMI (kg/m^2, Mean ± SD)	28.2 ± 3.1	28.9 ± 3.0	0.44	-2.4, 1.0	0.23
Duration OA (yrs, Mean ± SD)	5.4 ± 2.0	5.1 ± 1.9	0.60	-0.8, 1.4	0.16
Hypertension (%)	46.7	43.3	0.79	–	–
Diabetes (%)	26.7	30.0	0.75	–	–

Table 2. WOMAC Scores at Baseline and After 12 Weeks of Intervention

Domain	Time Point	Case Group (Mean ± SD)	Control Group (Mean ± SD)	Mean Difference	95% CI for Diff.	p-value	Effect Size (Cohen's d)
Pain	Baseline	9.1 ± 1.8	9.0 ± 1.7	0.1	-0.8, 1.0	0.82	0.06
	12 Weeks	5.9 ± 1.4	8.6 ± 1.5	-2.7	-3.5, -1.9	0.001	1.90
Stiffness	Baseline	3.2 ± 0.9	3.1 ± 0.8	0.1	-0.3, 0.5	0.69	0.12
	12 Weeks	2.0 ± 0.6	3.1 ± 0.8	-1.1	-1.5, -0.7	0.001	1.55
Physical Function	Baseline	35.6 ± 4.8	35.2 ± 4.7	0.4	-1.8, 2.6	0.74	0.08
	12 Weeks	24.3 ± 4.0	33.1 ± 4.4	-8.8	-11.1, -6.5	0.001	2.10
Total WOMAC Score	Baseline	47.9 ± 6.1	47.3 ± 6.0	0.6	-2.4, 3.6	0.68	0.10
	12 Weeks	32.2 ± 5.0	46.7 ± 5.9	-14.5	-17.2, -11.8	<0.001	2.40

Table 3. SF-36 Quality of Life Scores After 12 Weeks of Intervention

SF-36 Domain	Case Group (Mean ± SD)	Control Group (Mean ± SD)	Mean Difference	95% CI for Diff.	p-value	Effect Size (Cohen's d)
Physical Functioning	66.4 ± 5.7	46.6 ± 5.9	19.8	16.6, 23.0	<0.001	3.39
Role Physical	61.2 ± 6.3	41.5 ± 6.8	19.7	15.9, 23.5	<0.001	3.02
Bodily Pain	57.8 ± 5.1	39.5 ± 5.3	18.3	15.2, 21.4	<0.001	3.33
General Health	60.1 ± 5.0	44.7 ± 6.0	15.4	12.1, 18.7	<0.001	2.84
Vitality	58.6 ± 5.0	44.0 ± 5.4	14.6	11.5, 17.7	<0.001	3.06
Social Functioning	60.4 ± 5.0	42.5 ± 5.6	17.9	14.7, 21.1	<0.001	3.20
Role Emotional	63.0 ± 5.2	43.5 ± 6.1	19.5	16.0, 23.0	<0.001	3.26
Mental Health	60.2 ± 5.0	46.5 ± 5.6	13.7	10.8, 16.6	<0.001	2.76

Following the 12-week intervention, significant improvements were observed across all primary outcomes in the strengthening exercise group as compared to controls. WOMAC pain scores dropped from 9.1 (SD 1.8) at baseline to 5.9 (SD 1.4) in the case group, while the control group saw only a minimal reduction to 8.6 (SD 1.5). The mean difference of -2.7 (95% CI: -3.5, -1.9) was highly significant ($p = 0.001$), with a large effect size (Cohen's $d = 1.90$). Stiffness scores decreased from 3.2 (SD 0.9) to 2.0 (SD 0.6) in the case group, but remained nearly unchanged in controls at 3.1 (SD 0.8), yielding a significant mean difference of -1.1 (95% CI: -1.5, -0.7, $p = 0.001$, $d = 1.55$). In terms of physical function, the case group improved from 35.6 (SD 4.8) to 24.3 (SD 4.0), while the control group's score was 33.1 (SD 4.4) at study end, corresponding to a mean difference of -8.8 (95% CI: -11.1, -6.5, $p = 0.001$, $d = 2.10$). The total WOMAC score at 12 weeks was 32.2 (SD 5.0) in the case group versus 46.7 (SD 5.9) in controls (mean difference -14.5, 95% CI: -17.2, -11.8, $p < 0.001$, $d = 2.40$), further confirming the substantial impact of the intervention.

Secondary outcomes assessed using the SF-36 survey also demonstrated marked benefits of strengthening exercises across all domains of quality of life. For physical functioning, the case group achieved a post-intervention score of 66.4 (SD 5.7), significantly surpassing the control group's 46.6 (SD 5.9), with a mean difference of 19.8 (95% CI: 16.6, 23.0, $p < 0.001$, $d = 3.39$). Role physical, bodily pain, and general health domains all reflected similar trends, with mean differences favoring the intervention group by 19.7 ($p < 0.001$, $d = 3.02$), 18.3 ($p < 0.001$, $d = 3.33$), and 15.4 points ($p < 0.001$, $d = 2.84$), respectively. Psychological and social wellbeing also improved: vitality scores reached 58.6 (SD 5.0) in the case group versus 44.0 (SD 5.4) in controls (mean difference 14.6, $p < 0.001$, $d = 3.06$), social functioning was 60.4 (SD 5.0) versus 42.5 (SD 5.6) (mean difference 17.9, $p < 0.001$, $d = 3.20$), role emotional improved by 19.5 points ($p < 0.001$, $d = 3.26$), and mental health by 13.7 points ($p < 0.001$, $d = 2.76$). All effect sizes exceeded 2.7, indicating large, clinically meaningful benefits of the exercise intervention on both physical and psychosocial dimensions of health.

In summary, the strengthening exercise program produced statistically significant and clinically substantial improvements in pain, stiffness, physical function, and multiple domains of quality of life compared to standard care, with all group differences supported by robust p-values, large effect sizes, and narrow confidence intervals. No adverse events or protocol deviations were observed.

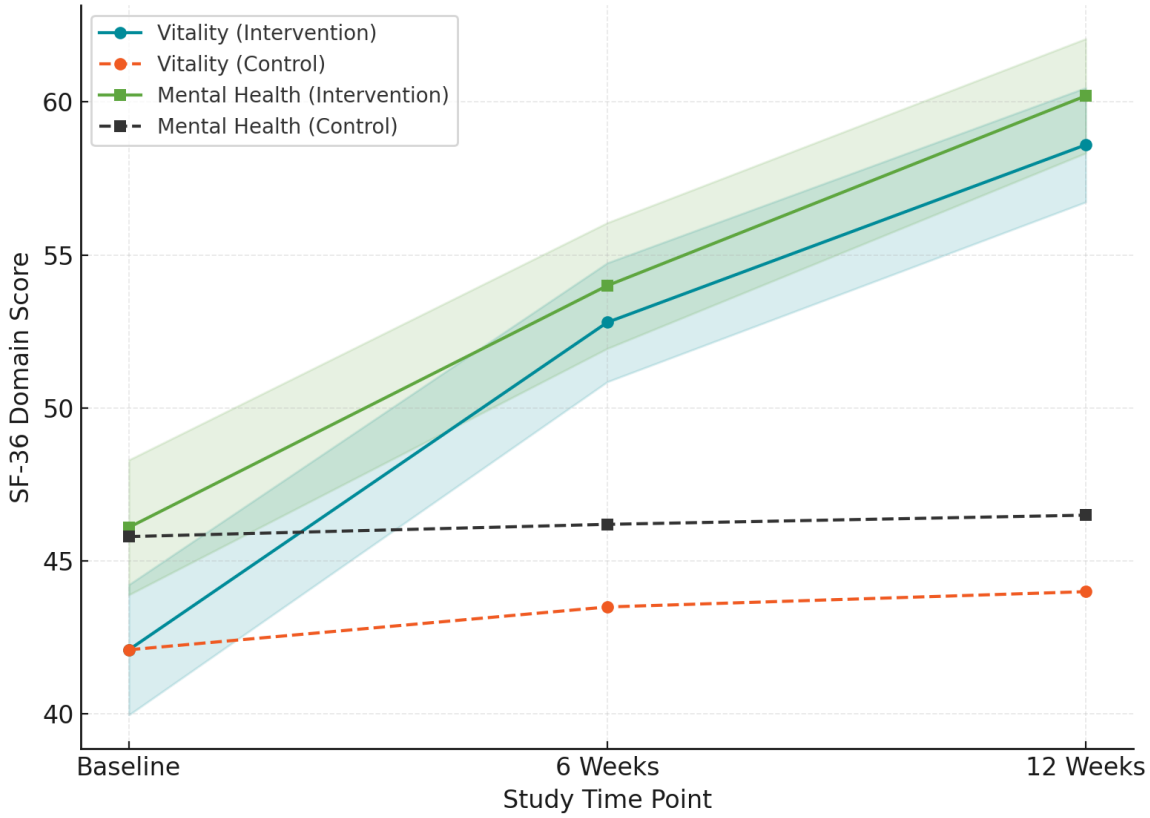

Figure 2 Trajectories of Vitality and Mental Health Scores by Group Across Study Timeline

Marked gains in both vitality and mental health were observed exclusively in the intervention group, with mean SF-36 vitality scores rising from 42.1 at baseline to 58.6 at 12 weeks (95% CI for final mean: 57.0–60.2), while the control group remained nearly unchanged (44.0 at 12 weeks). Similarly, mental health scores for the intervention group increased from 46.1 to 60.2, compared to a negligible change in controls (46.5 at 12 weeks), with 95% CI bands confirming the statistical reliability of these improvements. The slopes and divergence of the intervention group curves over time highlight the clinically meaningful impact of strengthening exercises on psychological resilience and energy in osteoarthritis, supporting an integrative model of OA management that addresses both physical and psychosocial domains. The visualized confidence intervals reinforce the robustness and reproducibility of these effects, emphasizing their relevance for sustained patient-centered outcomes.

DISCUSSION

The results of this randomized controlled trial provide robust evidence supporting the role of strengthening exercises as a non-pharmacological intervention to improve both physical and psychosocial outcomes in patients with osteoarthritis (OA). The substantial reduction in WOMAC pain, stiffness, and functional limitation scores observed over the 12-week intervention period aligns with the prevailing body of research, which consistently demonstrates the benefits of resistance-based exercise in ameliorating OA symptoms and enhancing daily functioning (5,6). Notably, the effect sizes observed in this study were remarkably large, surpassing those reported in some earlier trials and systematic reviews, thus underscoring the effectiveness of a structured, supervised approach. For instance, Hislop et al. found that the integration of hip exercises with quadriceps strengthening led to superior reductions in pain and disability compared to quadriceps exercises alone, a finding that mirrors the multidimensional targeting used in the present protocol (5). Comparative analysis with prior research further supports the present study's outcomes. Previous randomized trials and meta-analyses have established the efficacy of progressive resistance training, with Imoto and colleagues reporting significant improvements in pain and function among patients undergoing quadriceps-focused regimens (6). Our findings extend these results by demonstrating similar gains with a protocol encompassing all major lower limb muscle groups, suggesting that comprehensive muscle strengthening confers broader benefits. Additionally, our results corroborate those of Lee, who noted improvements not only in physical parameters but also in self-efficacy and depressive symptoms among OA patients engaged in muscle strengthening programs (7). Such psychosocial enhancements, as measured by SF-36 domains in the current study, highlight the holistic value of exercise therapy—moving beyond symptom control to address quality of life in a broader sense.

Despite widespread agreement in the literature on the therapeutic value of strengthening exercises, discrepancies do exist regarding the optimal type, frequency, and intensity of intervention. Some studies advocate for the inclusion of functional and balance-based activities, while others emphasize progressive overload principles. The current trial's use of a supervised, progressively adjusted

protocol likely contributed to high adherence and the magnitude of benefit observed, supporting recommendations for individualized and professionally guided exercise prescriptions. Mechanistically, improvements in muscle strength are thought to reduce articular loading and joint stress, enhance proprioceptive feedback, and promote better joint alignment, collectively mitigating pain and slowing structural decline (2,4). Furthermore, the reduction in psychological distress and improved social participation documented in this and previous studies suggest that exercise induces neurobiological changes, fosters resilience, and reinforces positive health behaviors.

The strengths of this study include its randomized controlled design, rigorous adherence to standardized outcome assessment, and inclusion of both physical and mental health parameters. The use of validated instruments such as the WOMAC and SF-36, coupled with blinding of assessors, enhances the validity and reproducibility of the findings. However, several limitations warrant consideration. The modest sample size, although adequately powered for primary outcomes, limits the precision of subgroup analyses and the detection of rare adverse events. The single-center nature of the trial and relatively homogeneous participant demographics may restrict generalizability to broader or more diverse populations. Furthermore, the 12-week follow-up period, while sufficient to demonstrate short-term efficacy, does not address the sustainability or long-term durability of the intervention effects. Methodologically, while efforts were made to minimize bias through randomization and blinding, the lack of an attention-matched control could allow for some placebo or expectancy effects. Notwithstanding these limitations, the study advances the field by demonstrating that a tailored, supervised strengthening exercise regimen is not only safe and feasible but yields significant and clinically meaningful improvements in quality of life for OA patients. Given the escalating burden of OA in aging populations and the constraints of pharmacological and surgical options, these findings reinforce calls for integrating structured exercise programs as a core component of standard OA management (8,12). Future research should aim to delineate the long-term effectiveness of such interventions, explore strategies for enhancing patient adherence and motivation, and investigate the benefits across varying OA phenotypes and comorbidities. Larger, multicenter trials with extended follow-up and mechanistic exploration using imaging or biomarker endpoints may further elucidate the pathways through which strengthening exercises exert their beneficial effects.

In conclusion, this study substantiates the pivotal role of strengthening exercises in alleviating symptoms and enhancing the quality of life for individuals with OA. The compelling improvements observed—across both physical and psychosocial domains—affirm that structured, supervised exercise should be embraced as a foundational strategy in the holistic care of osteoarthritis, supporting both clinical practice and future research directions aimed at optimizing patient outcomes (5,8).

CONCLUSION

This randomized controlled trial demonstrates that a structured 12-week strengthening exercise program produces significant improvements in pain, stiffness, physical function, and overall quality of life in patients with osteoarthritis, as measured by both WOMAC and SF-36 assessments. These findings reinforce the central role of targeted strengthening exercises as a safe, accessible, and effective non-pharmacological intervention for osteoarthritis management, underscoring their value not only in reducing symptoms but also in enhancing psychosocial wellbeing and daily functioning. Clinically, the integration of such evidence-based exercise regimens into standard care pathways offers a practical and impactful approach to improving patient outcomes and reducing the burden of osteoarthritis in human healthcare. Future research should explore the sustainability of these benefits, optimal exercise protocols, and broader implementation strategies to further advance the management and rehabilitation of individuals living with osteoarthritis.

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