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Review Article

Effectiveness of Non-Pharmacological Interventions in Osteoarthritis Management

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ABSTRACT

Background: Osteoarthritis is a major cause of chronic joint pain, stiffness, functional limitation, and reduced quality of life, particularly among middle-aged and older adults. Although pharmacological treatment may provide short-term symptom relief, long-term management requires strategies that address modifiable contributors such as muscle weakness, excess body weight, altered movement patterns, and poor self-management. Objective: This systematic review without meta-analysis aimed to synthesize national and international evidence on the effectiveness of non-pharmacological interventions, particularly exercise therapy, weight management, physical therapy, and combined rehabilitation programs, in osteoarthritis management. Methods: A structured literature search was conducted using PubMed, Google Scholar, Cochrane Library, ScienceDirect, SpringerLink, Web of Science, and selected Pakistani medical journals. Eligible evidence included randomized controlled trials, systematic reviews, meta-analyses, clinical practice guidelines, and relevant local studies involving adults with osteoarthritis and reporting pain, function, stiffness, walking ability, weight-related outcomes, or quality of life. Findings were synthesized narratively because of heterogeneity in study design, intervention content, comparator groups, and outcome measures. Results: Thirty-four studies were included. Exercise therapy was the most frequently represented intervention category and showed favorable effects on pain, stiffness, physical function, mobility, and quality of life. Weight management was most relevant for overweight and obese patients with knee osteoarthritis, while physical therapy supported improvement in pain, mobility, balance, range of motion, and functional performance. Combined lifestyle-rehabilitation programs showed broad clinical relevance. Conclusion: Non-pharmacological interventions are clinically important first-line strategies for osteoarthritis care, especially when individualized and integrated into combined rehabilitation pathways. Keywords: Osteoarthritis, knee osteoarthritis, exercise therapy, physical therapy, weight management, rehabilitation, pain, function.

INTRODUCTION

Osteoarthritis is a chronic, progressive, and highly prevalent musculoskeletal disorder characterized by joint pain, stiffness, functional limitation, and reduced health-related quality of life. It commonly affects the knee, hip, hand, and spine, with knee osteoarthritis representing one of the most disabling forms because of its direct effect on walking, stair negotiation, sit-to-stand transfers, occupational participation, and independent living. The global burden of osteoarthritis has increased substantially over recent decades and is projected to rise further because of population ageing, increasing obesity, reduced

physical activity, and longer survival with chronic non-communicable diseases (1). Current understanding recognizes osteoarthritis as a whole-joint disorder involving cartilage degeneration, subchondral bone remodeling, synovial inflammation, altered biomechanics, periarticular muscle weakness, pain sensitization, and psychosocial contributors, which makes long-term management dependent on more than symptomatic pharmacological relief alone (2).

The clinical and public health importance of osteoarthritis is particularly relevant in low-resource and middle-income settings, where delayed presentation, limited access to structured rehabilitation, self-medication, high physical workload, and poor awareness of conservative care may accelerate disability. In Pakistan and similar contexts, many patients seek care only after pain, stiffness, and mobility restriction interfere with daily activities, and treatment may remain centered on analgesics, injections, rest advice, or episodic medical consultation. Although pharmacological interventions may provide short-term symptom relief, they do not adequately address modifiable contributors such as excess body weight, muscle weakness, reduced balance, altered gait mechanics, poor activity tolerance, fear of movement, and low adherence to self-management. These factors support the need for practical, evidence-based, non-pharmacological strategies that can improve function, reduce symptom burden, and support long-term independence.

International clinical practice guidelines consistently recommend education, exercise therapy, weight management, and rehabilitation-based interventions as core first-line approaches for osteoarthritis care. The American College of Rheumatology/Arthritis Foundation guideline supports exercise, weight loss in overweight or obese patients, self-management, tai chi, and selected physical therapy strategies for hand, hip, and knee osteoarthritis (3). The Osteoarthritis Research Society International guideline similarly recommends non-surgical management through exercise, education, dietary weight control, and individualized care pathways according to joint site, comorbidity profile, and patient preference (4). Updated EULAR and NICE guidance further reinforce therapeutic exercise, patient education, shared decision-making, and weight management as central components of osteoarthritis management rather than optional adjuncts (5,6). Recent reviews of clinical practice guidelines also demonstrate broad agreement that conservative, non-pharmacological care should be prioritized before escalation to long-term medication dependence or invasive treatment pathways (7,8).

Exercise therapy is one of the most extensively investigated non-pharmacological interventions for osteoarthritis and has shown consistent benefit for pain, stiffness, physical function, gait performance, and quality of life. A recent network meta-analysis of randomized controlled trials reported that several exercise modalities improved outcomes in knee osteoarthritis, with aerobic exercise showing consistent benefit across pain, physical function, gait performance, and quality-of-life domains (9). Earlier Cochrane reviews also demonstrated that land-based exercise improves pain and function in knee and hip osteoarthritis, supporting its role as an evidence-based therapeutic intervention rather than general lifestyle advice (10,11). Aquatic exercise may be useful for patients with obesity, high pain levels, or poor weight-bearing tolerance because buoyancy permits active movement with reduced joint loading (12). Different exercise approaches may act through different mechanisms: aerobic exercise improves endurance and cardiometabolic health, strengthening exercise improves quadriceps and hip muscle support, resistance training improves force generation, neuromuscular and balance training improve joint control, and mind-body exercise such as tai chi may influence balance, confidence, and pain coping (13-16).

Weight management is another essential element of osteoarthritis care, especially among overweight and obese patients with knee osteoarthritis. Excess body weight increases mechanical loading across the knee joint during standing, walking, stair climbing, and transitional movements, while adiposity may contribute to systemic low-grade inflammation that influences pain and disease progression. Clinical trials have shown that dietary weight loss combined with exercise can improve pain, physical function, walking performance, inflammatory markers, and biomechanical loading in overweight and obese

adults with knee osteoarthritis (17-19). However, intervention intensity and exercise type require individualized prescription because high-intensity strengthening does not necessarily provide superior pain reduction or joint-load benefit for all patients (20). Evidence also indicates that meaningful weight reduction can reduce knee joint loading, reinforcing weight management as both a symptom-directed and biomechanically rational strategy (21). Additional trials and meta-analyses suggest that structured weight loss is most beneficial when integrated with exercise and behavioral support rather than delivered as isolated advice (22,23).

Physical therapy provides a complementary role because many patients require individualized assessment, supervised progression, gait correction, movement retraining, manual therapy, balance training, and education before they can safely adopt independent exercise. Randomized evidence has shown that physical therapy can produce clinically meaningful functional improvement in knee osteoarthritis and may provide better longer-term outcomes than short-term injection-based care in selected patients (24). Earlier randomized trials also support manual physical therapy combined with exercise for improving pain and disability in knee osteoarthritis (25). Evidence from hip and knee osteoarthritis indicates that manual therapy, exercise therapy, or both may improve outcomes when added to usual care, although treatment response varies according to intervention content, adherence, baseline disability, and follow-up duration (26). Reviews of manual therapy suggest potential benefit when it is delivered as part of a broader rehabilitation plan rather than as a stand-alone passive treatment (27). Digital and remotely delivered exercise and pain-coping interventions may also improve access for patients with chronic knee pain, but their use depends on literacy, technology access, and appropriate clinical monitoring (28). Structured non-surgical care remains important even in advanced disease because conservative rehabilitation may improve function and support decision-making before invasive treatment is considered (29).

Local evidence from Pakistan, although comparatively limited, suggests that rehabilitation-based strategies can be implemented in routine clinical settings. Studies from Pakistani populations have reported improvement in knee osteoarthritis outcomes with physical therapy combined with wedge insoles, hip mobilization and strengthening, Biodex balance training, and isometric quadriceps exercise (30-33). Pakistani observational evidence also links knee osteoarthritis with modifiable risk factors and cardiometabolic problems, highlighting the importance of integrated rehabilitation, weight control, and physical activity promotion in routine care (34,35). Recent local reviews further emphasize the need for evidence-based and context-sensitive conservative interventions, particularly where access to long-term specialist rehabilitation may be limited (36).

Despite the availability of international guidelines and multiple clinical trials, uncertainty remains regarding how different non-pharmacological interventions should be interpreted together for practical osteoarthritis management in low-resource settings. Existing evidence varies widely in study design, intervention type, supervision level, duration, comparator, outcome measure, patient characteristics, and follow-up period, limiting direct comparison across exercise therapy, weight management, physical therapy, and combined rehabilitation programs. In addition, much of the high-quality evidence comes from international settings, whereas local Pakistani studies are fewer, smaller, and methodologically heterogeneous. A systematic review without meta-analysis is therefore justified to synthesize the direction, consistency, and clinical applicability of available evidence where statistical pooling is not appropriate because of heterogeneity. Using a PICO framework, the population of interest included adults with osteoarthritis, particularly knee and hip osteoarthritis; the interventions included exercise therapy, weight management, physical therapy, and combined lifestyle-rehabilitation strategies; the comparators included usual care, education alone, pharmacological care, injection-based care, no active intervention, or alternative conservative approaches; and the outcomes included pain, stiffness, physical function, WOMAC score, walking ability, balance, range of motion, body weight, quality of life, and rehabilitation response. Therefore, this systematic review aimed to synthesize national and international evidence on the effectiveness of non-pharmacological interventions in osteoarthritis management, with

specific focus on exercise therapy, weight management, physical therapy, and combined rehabilitation approaches, and to evaluate their relevance for improving pain, function, mobility, and quality of life in patients with osteoarthritis.

MATERIALS AND METHODS

This study was conducted as a structured literature review to evaluate the effectiveness of non-pharmacological interventions in osteoarthritis management. The review was designed to synthesize evidence on exercise therapy, weight management, physical therapy, and combined lifestyle-rehabilitation interventions in adults with osteoarthritis. Because the included studies differed in design, intervention content, duration, comparator group, outcome measurement, follow-up period, and patient characteristics, a narrative synthesis approach was used instead of statistical pooling. The reporting structure was aligned with PRISMA 2020 principles for systematic reviews and with guidance for synthesis without meta-analysis where quantitative pooling is not appropriate (37,38).

The review question was structured according to the PICO framework. The population comprised adults with diagnosed osteoarthritis, particularly knee and hip osteoarthritis, because these joints are most commonly associated with pain, mobility limitation, disability, and rehabilitation need. Studies on hand osteoarthritis were considered when they addressed conservative management, exercise, education, or rehabilitation strategies relevant to the review objective. The interventions of interest included exercise therapy, strengthening exercise, resistance training, aerobic exercise, aquatic exercise, tai chi, balance training, gait training, manual therapy, joint mobilization, physiotherapy, physical therapy, insoles, weight loss, dietary weight management, lifestyle modification, patient education, self-management, and combined rehabilitation programs. Eligible comparators included usual care, no active intervention, education alone, pharmacological care, injection-based care, or alternative conservative interventions. The primary outcomes were pain and physical function. Secondary outcomes included stiffness, WOMAC score, walking ability, balance, range of motion, body weight, body mass index, quality of life, adherence, and overall rehabilitation response.

A structured literature search was conducted using PubMed, Google Scholar, Cochrane Library, ScienceDirect, SpringerLink, Web of Science, and selected Pakistani medical journals. The search strategy combined free-text terms related to osteoarthritis, non-pharmacological management, rehabilitation, and patient outcomes. Search terms included "osteoarthritis," "knee osteoarthritis," "hip osteoarthritis," "hand osteoarthritis," "exercise therapy," "physical therapy," "physiotherapy," "manual therapy," "joint mobilization," "strengthening exercise," "resistance training," "aerobic exercise," "aquatic exercise," "balance training," "gait training," "tai chi," "weight loss," "weight management," "diet," "lifestyle modification," "non-pharmacological treatment," "conservative management," "rehabilitation," "pain," "stiffness," "WOMAC," "physical function," "walking ability," and "quality of life." Boolean combinations included "osteoarthritis AND exercise therapy," "knee osteoarthritis AND weight loss," "knee osteoarthritis AND physical therapy," "hip osteoarthritis AND rehabilitation," "osteoarthritis AND non-pharmacological management," and "knee osteoarthritis AND conservative management." Searches were limited to English-language publications. Recent evidence was prioritized, but older landmark trials, Cochrane reviews, and major clinical practice guidelines were retained when they remained clinically relevant to osteoarthritis management.

Studies were eligible if they included adult patients with clinically or radiologically diagnosed osteoarthritis and evaluated at least one non-pharmacological intervention relevant to pain reduction, functional improvement, mobility, weight control, quality of life, or rehabilitation response. Eligible study designs included randomized controlled trials, systematic reviews, meta-analyses, clinical practice guidelines, cohort studies, and relevant local studies from Pakistan. Randomized controlled trials were

included when they compared exercise, physical therapy, weight management, or combined rehabilitation programs with usual care, no active treatment, education, pharmacological treatment, injection-based care, or another conservative intervention. Systematic reviews, meta-analyses, and guidelines were included when they provided high-level evidence, recommendations, or comparative synthesis relevant to the review question. Local studies were included where they provided contextual evidence about rehabilitation feasibility, clinical outcomes, modifiable risk factors, or osteoarthritis management in Pakistani populations.

Studies were excluded if they focused exclusively on surgical treatment, pharmacological treatment, intra-articular injection without a conservative management comparator, animal experiments, pediatric populations, traumatic joint injury, rheumatoid arthritis, inflammatory arthropathy, or unrelated musculoskeletal disorders. Articles were also excluded when full text was unavailable, methodology was unclear, the intervention was not relevant to non-pharmacological osteoarthritis care, or the reported outcomes did not address pain, stiffness, function, mobility, weight, balance, quality of life, or rehabilitation response. Duplicate records were removed before screening. Titles and abstracts were screened first to exclude clearly irrelevant records, followed by full-text assessment of potentially eligible reports. The final selection was based on alignment with the PICO framework, relevance to the review objective, clarity of intervention description, appropriateness of outcome reporting, and usefulness for evaluating non-pharmacological osteoarthritis care.

Data were extracted manually using a structured extraction framework. Extracted variables included author name, publication year, country, study design, sample size, osteoarthritis site, participant characteristics, diagnostic basis, intervention type, intervention duration, comparator group, outcome measures, follow-up period, and main findings. Outcomes were grouped into clinically relevant domains, including pain, stiffness, physical function, WOMAC score, walking ability, balance, range of motion, body weight, body mass index, quality of life, and rehabilitation response. Interventions were categorized into four major groups: exercise-based interventions, weight management interventions, physical therapy interventions, and combined lifestyle-rehabilitation programs. Exercise-based interventions included aerobic exercise, strengthening exercise, resistance training, aquatic exercise, tai chi, supervised exercise, and home-based exercise. Weight management interventions included dietary weight loss, lifestyle modification, and combined diet-exercise programs. Physical therapy interventions included manual therapy, joint mobilization, gait training, stretching, strengthening, balance training, insoles, supervised physiotherapy, and patient education. Combined programs included interventions integrating education, exercise, weight control, and physiotherapy within a broader conservative care model.

The methodological quality and strength of evidence were considered during interpretation by assessing study design, sample size, randomization, comparator selection, intervention description, outcome measurement, follow-up duration, attrition, and clarity of reporting. Randomized controlled trials, systematic reviews, meta-analyses, and clinical practice guidelines were interpreted as higher-level sources than small observational or local studies, although Pakistani studies were retained where they provided important contextual relevance. Because the review included mixed evidence types, findings from systematic reviews and guidelines were interpreted separately from primary trials where necessary to reduce the risk of double-counting evidence. When systematic reviews and primary trials addressed similar interventions, the synthesis emphasized whether the direction of evidence was consistent rather than treating all sources as independent primary data.

Narrative synthesis was performed because the included studies showed substantial heterogeneity in design, patient population, intervention content, intervention intensity, comparator type, outcome measurement, and follow-up duration. The synthesis was organized by intervention category and outcome domain. For each intervention category, the direction and consistency of evidence were examined across pain, stiffness, function, mobility, weight-related outcomes, balance, and quality of life.

Greater interpretive weight was given to studies with stronger design, clearer intervention protocols, standardized outcome measures, appropriate comparators, and clinically relevant follow-up. Findings from smaller local studies were interpreted cautiously and used primarily to support contextual applicability rather than to override higher-level evidence. No pooled effect estimates were calculated because the available studies were not sufficiently homogeneous for meta-analysis.

Potential sources of bias and confounding were addressed at the synthesis level by separating evidence according to intervention category, study design, and clinical context. Caution was applied when interpreting studies with small sample sizes, limited follow-up, unclear intervention protocols, heterogeneous outcome measures, or high likelihood of overlapping evidence. To reduce overinterpretation, conclusions were based on consistent patterns across multiple sources rather than isolated favorable results. The review also distinguished between evidence of clinical effectiveness and evidence of implementation feasibility, because interventions shown to be beneficial in controlled trial settings may require adaptation for routine practice in low-resource environments.

Ethical approval was not required because this review used previously published evidence and did not involve direct patient recruitment, intervention delivery, biological sampling, private medical record review, or identifiable patient data. Academic integrity was maintained by summarizing the findings without altering the meaning of original studies and by citing all included sources. Data integrity was supported through duplicate removal, structured extraction, intervention categorization, outcome grouping, and consistency checks between the review objective, eligibility criteria, included studies, tables, figures, and narrative synthesis. This approach was used to provide a transparent and clinically interpretable synthesis of non-pharmacological osteoarthritis interventions, with particular attention to exercise therapy, weight management, physical therapy, and combined rehabilitation strategies relevant to Pakistan and comparable low-resource settings.findi

RESULTS

The database and journal-source search identified 428 records related to non-pharmacological interventions for osteoarthritis. After removal of 72 duplicate records, 356 records were screened by title and abstract. Records not addressing osteoarthritis, non-pharmacological care, exercise therapy, weight management, physiotherapy, rehabilitation, or relevant clinical outcomes were excluded. Full-text reports were then assessed for eligibility according to the predefined PICO framework, and 34 studies were included in the final synthesis. Because the included evidence differed substantially in study design, intervention type, comparator, follow-up duration, and outcome measurement, findings were synthesized narratively rather than through meta-analysis.

Table 1. Study Selection Summary

Selection Stage	Number
Records identified through database and journal-source searching	428
Duplicate records removed	72
Records screened by title and abstract	356
Full-text reports assessed for eligibility	NR
Studies included in final synthesis	34
Studies included in quantitative meta-analysis	0

NR, not reported in the available manuscript text.

The final synthesis included evidence from randomized controlled trials, systematic reviews and meta-analyses, clinical practice guidelines, and observational or local studies. Randomized controlled trials represented the largest proportion of included evidence, followed by systematic reviews and meta-analyses. Most included studies focused on knee osteoarthritis, while fewer studies addressed hip osteoarthritis or mixed knee and hip osteoarthritis populations.

Table 2. General Characteristics of Included Evidence

Characteristic	Number	Percentage
Total included studies	34	100.0
Randomized controlled trials	16	47.1
Systematic reviews / meta-analyses	9	26.5
Clinical practice guidelines	5	14.7
Observational / local studies	4	11.7
Knee osteoarthritis-focused studies	24	70.6
Hip osteoarthritis-focused studies	4	11.8
Mixed knee and hip osteoarthritis studies	6	17.6

The included evidence base was dominated by knee osteoarthritis studies, which accounted for 24 of 34 included studies. Hip osteoarthritis was less frequently represented, while mixed knee and hip osteoarthritis evidence contributed to broader interpretation of rehabilitation and conservative management strategies. This distribution supports the clinical relevance of the findings for knee osteoarthritis while indicating more limited direct evidence for hip and hand osteoarthritis.

Table 3. Intervention Categories and Main Outcome Domains

Intervention Category	Number of Studies	Pain	Stiffness	Physical Function	Walking / Mobility	Weight-Related Outcomes	Quality of Life	Overall Direction
Exercise therapy	13	Improved	Improved	Improved	Improved	NR	Improved	Favorable
Weight management	7	Improved	NR	Improved	Improved	Improved	Improved	Favorable
Physical therapy	9	Improved	Improved	Improved	Improved	NR	NR	Favorable
Combined lifestyle and rehabilitation programs	5	Improved	Improved	Improved	Improved	Improved	Improved	Favorable

Exercise therapy was the most frequently represented intervention category and showed consistent favorable effects across pain, stiffness, physical function, walking ability, and quality-of-life outcomes. Weight management showed the clearest relevance for overweight and obese patients with knee osteoarthritis, particularly where reduction in body weight and mechanical joint loading were linked with improved pain and mobility. Physical therapy interventions showed favorable effects on pain, movement, function, balance, range of motion, and confidence with daily activity. Combined lifestyle and rehabilitation programs demonstrated the broadest outcome coverage because they addressed multiple modifiable mechanisms, including muscle weakness, excess joint loading, low activity, poor self-management, and functional limitation.

Table 4. Detailed Evidence Matrix of Included Sources

Ref.	Author / Year	Evidence Type	OA Site / Scope	Intervention or Focus	Comparator / Comparison	Main Outcomes Reported	Synthesis Role
3	Kolasinski et al., 2020	Clinical practice guideline	Hand, hip, knee	Exercise, weight loss, self-management, tai chi, conservative care	Recommendation-based	Pain, function, management pathways	Guideline support
4	Bannuru et al., 2019	Clinical practice guideline	Knee, hip, polyarticular OA	Non-surgical management	Recommendation-based	Pain, function, patient-centered care	Guideline support
5	Moseng et al., 2024	Clinical practice guideline	Hip, knee	Non-pharmacological core management	Recommendation-based	Education, exercise, self-management	Guideline support
6	Wood et al., 2023	Guideline summary	Adults >16 years with OA	Diagnosis and management	Recommendation-based	Pain, function, self-management	Guideline support
7	Gibbs et al., 2023	Systematic review of guidelines	Hip, knee	Guideline recommendations	Cross-guideline comparison	Management recommendations	Guideline synthesis
8	Whittaker et al., 2023	Systematic review of guidelines	OA care	Core recommendations	Cross-guideline comparison	Exercise, education, weight control	Guideline synthesis
9	Yan et al., 2025	Systematic review and network meta-analysis	Knee	Exercise modalities	Comparative exercise modalities	Pain, function, gait, quality of life	Exercise evidence

Ref.	Author / Year	Evidence Type	OA Site / Scope	Intervention or Focus	Comparator / Comparison	Main Outcomes Reported	Synthesis Role
10	Fransen et al., 2015	Cochrane systematic review	Knee	Land-based exercise	Control / usual care	Pain, function	Exercise evidence
11	Fransen et al., 2014	Cochrane systematic review	Hip	Exercise	Control / usual care	Pain, function	Exercise evidence
12	Bartels et al., 2016	Cochrane systematic review	Knee, hip	Aquatic exercise	Control / usual care	Pain, function, mobility	Exercise evidence
13	Goh et al., 2019	Systematic review and network meta-analysis	Knee, hip	Different exercise types	Comparative exercise modalities	Pain, function, performance, quality of life	Exercise evidence
14	Uthman et al., 2013	Systematic review and network meta-analysis	Lower limb OA	Exercise	Comparative exercise modalities	Pain, disability	Exercise evidence
15	Juhl et al., 2014	Systematic review and meta-regression	Knee	Exercise type and dose	Comparative exercise doses/types	Pain, disability	Exercise evidence
16	Wang et al., 2016	Randomized controlled trial	Knee	Tai chi	Physical therapy	Pain, function, patient-reported outcomes	Exercise / mind-body evidence
17	Messier et al., 2004	Randomized controlled trial	Knee	Exercise and dietary weight loss	Usual care / comparison groups	Pain, function, body weight	Weight management evidence
18	Messier et al., 2013	Randomized clinical trial	Knee	Intensive diet and exercise	Diet, exercise, or control comparison	Joint load, inflammation, pain, function	Weight management evidence
19	Messier et al., 2022	Randomized clinical trial	Knee	Diet and exercise	Comparator intervention	Pain, body weight, function	Weight management evidence
20	Messier et al., 2021	Randomized clinical trial	Knee	High-intensity strength training	Comparator training/control	Pain, compressive force	Exercise intensity evidence
21	Aaboe et al., 2011	Intervention study	Knee	Intensive weight loss	Pre-post / comparator	Knee joint loading	Weight management evidence
22	Bliddal et al., 2011	Randomized controlled trial	Knee	Weight loss	Comparator group	Symptoms, body weight	Weight management evidence
23	Christensen et al., 2007	Systematic review and meta-analysis	Knee	Weight reduction	Included-study comparisons	Pain, function, body weight	Weight management evidence
24	Deyle et al., 2020	Randomized clinical trial	Knee	Physical therapy	Glucocorticoid injection	Pain, function	Physical therapy evidence
25	Deyle et al., 2000	Randomized controlled trial	Knee	Manual physical therapy and exercise	Comparator care	Pain, function	Physical therapy evidence
26	Abbott et al., 2013	Randomized controlled trial	Hip or knee	Manual therapy, exercise therapy, or both	Usual care	Pain, function	Physical therapy evidence
27	Feng et al., 2023	Overview of reviews/meta-analyses	Knee	Manual therapy	Review-level comparison	Pain, function, safety	Physical therapy evidence
28	Bennell et al., 2017	Randomized trial	Chronic knee pain / knee OA context	Internet-delivered exercise and pain-coping skills	Control / comparator	Pain, function, coping	Digital rehabilitation evidence
29	Skou et al., 2015	Randomized controlled trial	Knee	Non-surgical care pathway / total knee replacement context	Total knee replacement comparison	Pain, function, treatment pathway	Conservative care context
30	Shah et al., 2022	Randomized controlled trial	Knee	Physical therapy with and without wedge insole	Physical therapy comparison	Pain, function	Local physical therapy evidence

Ref.	Author / Year	Evidence Type	OA Site / Scope	Intervention or Focus	Comparator / Comparison	Main Outcomes Reported	Synthesis Role
31	Mehwish et al., 2023	Randomized controlled trial	Knee	Hip mobilization and strength training	Comparator treatment	Pain, physical function, dynamic balance	Local physical therapy evidence
32	Javed et al., 2021	Randomized controlled trial	Knee	Biodex balance training	Comparator treatment	Balance, symptoms	Local balance-training evidence
33	Anwer and Alghadir, 2014	Randomized controlled study	Knee	Isometric quadriceps exercise	Comparator treatment	Muscle strength, pain, function	Strengthening evidence
34	Iqbal et al., 2019	Case-control study	Knee	Risk factors	Cases and controls	Modifiable risk factors	Local risk-factor evidence
35	Khan et al., 2023	Observational study	Knee	Cardiovascular risk factors	Risk-factor comparison	Cardiometabolic factors	Local risk-factor evidence
36	Rathore et al., 2025	Mini-review	Knee	Evidence-based interventional approaches	Review-level synthesis	Conservative and interventional management	Local contextual evidence

The detailed evidence matrix shows that the synthesis drew on multiple evidence layers, including international guidelines, high-level systematic reviews, randomized trials, and local Pakistani studies. Exercise evidence was supported by several systematic reviews and trials across land-based, aquatic, strengthening, aerobic, and mind-body exercise approaches. Weight management evidence was mainly derived from randomized trials and meta-analytic evidence in overweight or obese adults with knee osteoarthritis. Physical therapy evidence included manual therapy, supervised exercise, joint mobilization, balance training, insoles, and digital rehabilitation approaches. Local studies provided contextual evidence for feasibility and relevance in Pakistani clinical settings, although their contribution should be interpreted cautiously because they were fewer and generally narrower in scope than the international evidence base.

Table 5. Summary of Main Findings by Intervention Type

Intervention Type	Evidence Base	Main Beneficial Outcomes	Most Relevant Patient Group	Interpretation
Aerobic exercise	Systematic reviews, network meta-analysis, trials	Pain, function, gait, quality of life	Knee OA, physically able patients	Consistent first-line option
Strengthening / resistance exercise	Trials, systematic reviews	Pain, function, muscle strength, disability	Knee and hip OA with weakness	Useful when dose is individualized
Aquatic exercise	Cochrane review	Pain, function, mobility	Obese patients, high-pain patients, poor weight-bearing tolerance	Useful low-load option
Tai chi / mind-body exercise	Randomized trial, guideline support	Pain, function, balance, confidence	Knee OA with balance or movement-confidence limitation	Useful adjunctive option
Dietary weight loss	Randomized trials, meta-analysis	Pain, weight, function, joint loading	Overweight or obese knee OA	Stronger when combined with exercise
Combined diet and exercise	Randomized trials	Pain, function, body weight, walking, inflammation, joint load	Overweight or obese knee OA	Broad clinical benefit
Manual physical therapy	Randomized trials, review evidence	Pain, function, mobility	Knee and hip OA with movement restriction	Best used with active exercise
Joint mobilization and strengthening	Local randomized trial	Pain, function, dynamic balance	Knee OA	Contextually relevant rehabilitation option
Balance training	Local randomized trial	Balance, symptoms, function	Symptomatic knee OA with instability or poor control	Useful functional adjunct
Insoles with physical therapy	Local randomized trial	Pain, function	Knee OA with biomechanical contribution	Potential adjunct to rehabilitation
Digital exercise and pain coping	Randomized trial	Pain, function, coping	Chronic knee pain / knee OA context	Access-enhancing option

The strongest and most consistent evidence supported exercise therapy as a core intervention for osteoarthritis, particularly knee osteoarthritis. Weight management showed clinically important relevance for overweight and obese patients, especially when combined with exercise. Physical therapy demonstrated benefit when delivered as an individualized program that included active exercise, manual techniques, movement retraining, balance work, and education. Combined programs appeared clinically

advantageous because they addressed multiple mechanisms simultaneously, although the available manuscript synthesis does not provide pooled comparative estimates to confirm superiority across all outcomes.

Table 6. Methodological Appraisal by Evidence Category

Evidence Category	Number of Studies	Main Strengths	Main Limitations	Interpretive Weight
Randomized controlled trials	16	Comparative design, intervention testing, outcome measurement	Variable intervention dose, follow-up duration, comparator type, blinding feasibility	High
Systematic reviews / meta-analyses	9	Broad evidence coverage, synthesis of multiple trials, higher evidence level	Possible overlap with primary trials, heterogeneity across included studies	High
Clinical practice guidelines	5	Consensus-based recommendations, clinical applicability, evidence grading in source documents	Not primary evidence, dependent on included literature and guideline methodology	Moderate to high
Observational / local studies	4	Contextual relevance, Pakistani clinical applicability, real-world risk-factor insight	Smaller evidence base, non-randomized designs, limited causal inference	Moderate to low

The methodological appraisal shows that randomized trials and systematic reviews contributed the highest interpretive weight to conclusions about effectiveness, while guidelines provided clinically useful confirmation of recommended care pathways. Observational and local Pakistani studies strengthened contextual relevance but should not be interpreted as equivalent to randomized or systematic-review evidence. Because the review included mixed evidence types, the synthesis should avoid treating all included sources as independent primary trials and should interpret overlapping evidence cautiously.

Table 7. Appraisal of Risk-Related Methodological Concerns Across the Review

Appraisal Domain	Review-Level Finding	Impact on Interpretation	Recommended Reporting Fix
Search reproducibility	Full database-specific search strings not reported	Limits reproducibility	Add complete search strategy for at least one database
Search date range	Exact search period not reported	Limits transparency	Report final search date and publication date limits
Study selection	Independent reviewer process not reported	Possible selection bias	State screening process and conflict resolution method
Evidence overlap	Reviews, trials, guidelines, and local studies included together	Possible double-counting	Separate primary studies from review-level evidence
Risk-of-bias assessment	Formal tool not reported	Limits certainty assessment	Add RoB 2, AMSTAR 2, AGREE II, or JBI/NOS as appropriate
Intervention heterogeneity	Multiple intervention types and doses included	Prevents valid pooling	Maintain narrative synthesis and report direction of effect
Outcome heterogeneity	Pain, function, WOMAC, mobility, balance, weight, QoL varied across studies	Limits direct comparison	Present outcome-domain synthesis table
Local applicability	Pakistani evidence limited	Limits generalizability to local practice	Interpret local findings as contextual support
Quantitative figure support	Mean symptom improvement source unclear	Risk of unsupported numeric summary	Provide source calculations or replace with evidence map

The review-level appraisal identifies several reporting limitations that should be addressed before submission. The most important are the absence of full search strategy details, lack of formal risk-of-bias assessment, unclear study selection procedures, and potential evidence overlap between primary trials and review-level sources. These limitations do not invalidate the clinical direction of the findings, but they reduce confidence in the precision and reproducibility of the synthesis.

Table 8. Outcome-Domain Synthesis Across Non-Pharmacological Interventions

Outcome Domain	Exercise Therapy	Weight Management	Physical Therapy	Combined Programs	Overall Evidence Pattern
Pain	Improved	Improved	Improved	Improved	Consistently favorable
Stiffness	Improved	NR	Improved	Improved	Favorable where reported
Physical function	Improved	Improved	Improved	Improved	Consistently favorable

Outcome Domain	Exercise Therapy	Weight Management	Physical Therapy	Combined Programs	Overall Evidence Pattern
Walking ability	Improved	Improved	Improved	Improved	Favorable
WOMAC score	Improved	Improved	Improved	Improved	Favorable where reported
Balance	Improved	NR	Improved	Improved	Favorable where assessed
Range of motion	NR	NR	Improved	Improved	Limited but favorable
Body weight	NR	Improved	NR	Improved	Specific to weight-loss interventions
Quality of life	Improved	Improved	NR	Improved	Favorable where reported
Rehabilitation response	Improved	Improved	Improved	Improved	Broadly favorable

NR, not reported as a consistent outcome domain across the available manuscript synthesis.

Across outcome domains, pain and physical function showed the most consistent improvement across intervention categories. Exercise therapy and combined programs had the broadest outcome coverage, while weight management was most directly relevant to body weight, joint loading, walking ability, pain, and function in overweight and obese patients. Physical therapy was particularly relevant for function, balance, range of motion, movement confidence, and supervised progression. The evidence supports an integrated rehabilitation model rather than reliance on isolated passive treatment or medication-centered care.

Narrative Synthesis of Findings

The findings of this systematic review indicate that non-pharmacological interventions provide clinically relevant benefits for patients with osteoarthritis, particularly those with knee osteoarthritis. Among the 34 included studies, exercise therapy was the most frequently represented and consistently favorable intervention category. Evidence from systematic reviews, network meta-analyses, Cochrane reviews, and randomized trials supported aerobic exercise, land-based exercise, aquatic exercise, strengthening, resistance training, tai chi, and supervised or home-based exercise as useful strategies for improving pain, stiffness, physical function, walking performance, and quality of life. The consistency of benefit across different forms of exercise suggests that exercise should be considered a central first-line intervention, although the type, intensity, and progression should be individualized according to age, pain severity, obesity status, disease stage, comorbidity profile, and access to supervision.

Weight management was most relevant for overweight and obese patients with knee osteoarthritis. Evidence from randomized trials and meta-analytic work showed that dietary weight loss and combined diet-exercise programs improved pain, body weight, physical function, walking ability, and knee joint loading. The findings support the biomechanical and metabolic rationale for weight reduction in knee osteoarthritis, particularly where excess body weight contributes to greater compressive loading during standing, walking, and stair climbing. Weight loss alone may provide benefit, but the synthesis indicates broader improvement when dietary intervention is combined with structured exercise and lifestyle modification.

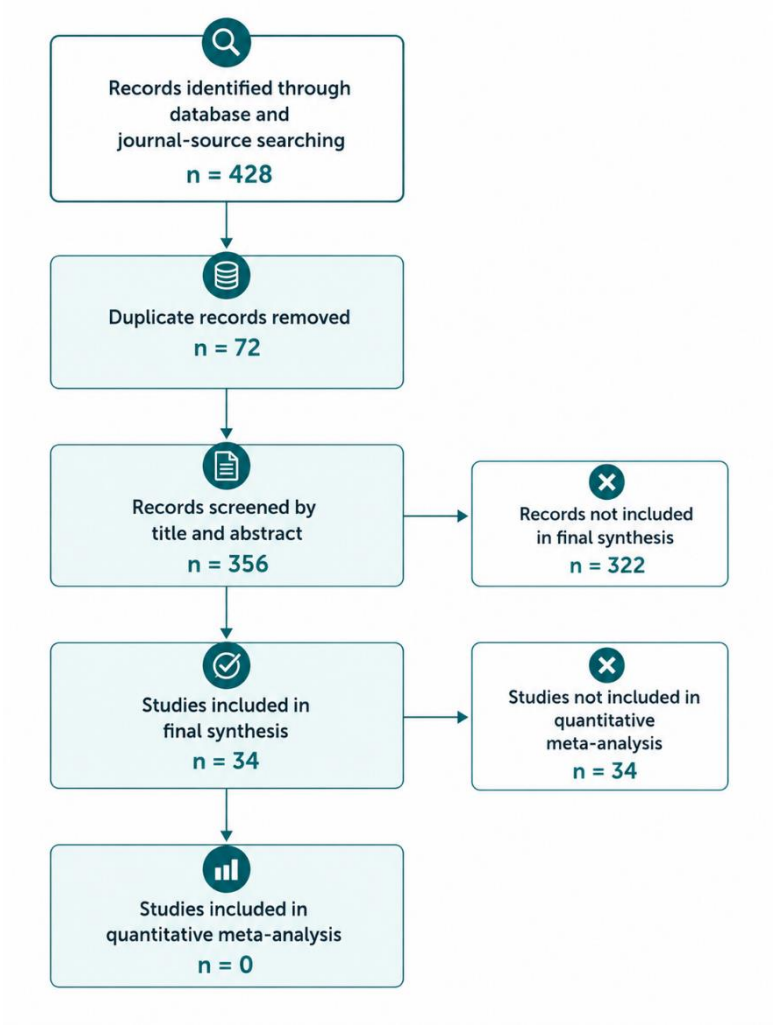

Figure 1 Participants flowchart

Physical therapy interventions showed favorable effects across pain, function, balance, mobility, and movement-related outcomes. Manual therapy, joint mobilization, strengthening, stretching, gait training, balance training, insoles, supervised physiotherapy, and patient education were all represented in the included evidence. Randomized evidence supported physical therapy as a meaningful conservative intervention, including comparisons with injection-based care. Local Pakistani studies also supported the use of physical therapy with wedge insoles, hip mobilization with strengthening, Biodex balance training, and isometric quadriceps exercise. Although local studies contributed useful contextual evidence, their smaller number and narrower scope require cautious interpretation.

Combined lifestyle and rehabilitation programs showed the broadest clinical relevance because they addressed multiple modifiable contributors to osteoarthritis symptoms simultaneously. These programs integrated education, exercise, weight control, physical therapy, self-management, and functional rehabilitation. The direction of evidence favored combined care for pain, function, mobility, quality of life, and weight-related outcomes. However, because the review did not include a meta-analysis and did not report pooled comparative estimates, combined programs should be described as clinically comprehensive and consistently favorable rather than definitively superior across all patient groups.

Overall, the synthesis supports non-pharmacological care as a first-line and long-term management approach for osteoarthritis. Exercise therapy, weight management, and physical therapy appear safe, practical, and clinically relevant when individualized and delivered with patient education. For Pakistan and similar low-resource settings, the most applicable model is likely a combined rehabilitation pathway involving patient education, home-based strengthening, walking or low-impact aerobic activity, weight-control counseling, supervised physiotherapy when available, and periodic follow-up to support

adherence. Future studies from Pakistan should use larger samples, longer follow-up, standardized outcomes such as WOMAC and quality-of-life measures, and clearer reporting of intervention dose, adherence, and adverse events.

DISCUSSION

This systematic review synthesized evidence on non-pharmacological interventions for osteoarthritis, with emphasis on exercise therapy, weight management, physical therapy, and combined lifestyle-rehabilitation programs. The principal finding was that non-pharmacological care was consistently associated with favorable clinical and functional outcomes, particularly for pain and physical function in knee osteoarthritis. Among the 34 included studies, exercise therapy represented the most frequently reported intervention category and showed favorable effects across pain, stiffness, physical function, walking ability, and quality of life. Weight management was most relevant for overweight and obese patients with knee osteoarthritis, especially when dietary intervention was combined with exercise. Physical therapy demonstrated benefit across pain, function, mobility, balance, range of motion, and supervised rehabilitation response. Combined programs appeared clinically comprehensive because they addressed multiple modifiable contributors to osteoarthritis symptoms, including muscle weakness, excess joint loading, reduced activity tolerance, poor self-management, and functional limitation.

The findings are consistent with contemporary clinical practice guidelines that recommend education, exercise, weight management, and rehabilitation-based care as core first-line strategies for osteoarthritis management. International guidelines from the American College of Rheumatology/Arthritis Foundation, OARSI, EULAR, and NICE all support non-pharmacological management as a central component of care rather than a secondary option after medication failure (3-6). These recommendations are also reinforced by guideline syntheses showing broad agreement across international clinical practice guidelines that exercise, self-management, and weight control should be prioritized in routine osteoarthritis care (7,8). The present review extends this guideline-based position by organizing the evidence into clinically practical categories that are relevant for low-resource settings, where repeated pharmacological care, injections, advanced imaging, and surgical referral may be less accessible or less affordable for many patients.

Exercise therapy was the most consistently supported intervention in the synthesis. Evidence from systematic reviews, Cochrane reviews, network meta-analyses, and randomized trials supports exercise as an effective intervention for reducing pain and improving function in knee and hip osteoarthritis (9-15). The consistency of findings across aerobic exercise, land-based strengthening, resistance training, aquatic exercise, tai chi, and home-based or supervised programs suggests that the therapeutic value of exercise is not restricted to a single modality. Rather, exercise appears to work through multiple mechanisms, including improved muscle strength, better joint control, enhanced gait performance, reduced stiffness, improved balance, greater confidence in movement, and improved general physical capacity. This is clinically important because patients with osteoarthritis vary widely in age, pain severity, body weight, comorbidities, disease stage, physical tolerance, and access to facilities. Therefore, the most appropriate exercise prescription should be individualized rather than standardized for all patients.

The evidence also indicates that exercise dose and type require careful clinical judgment. Although strengthening and resistance training are important for improving muscle function, high-intensity strength training may not necessarily produce superior symptom improvement or joint-load reduction for all patients (20). This finding supports a pragmatic rehabilitation approach in which exercise is progressed according to pain response, baseline strength, adherence capacity, and functional goals. Aquatic exercise may be useful for patients who cannot tolerate full weight-bearing activity because of obesity, severe pain, or poor balance (12). Tai chi and other mind-body approaches may be useful adjuncts where balance, confidence, and pain coping are important components of disability (16). These findings

support a flexible exercise framework in which the central principle is sustained, safe, progressive movement rather than adherence to one preferred exercise modality.

Weight management was an important component of osteoarthritis care, particularly for overweight and obese patients with knee osteoarthritis. Trials evaluating diet, exercise, and combined diet-exercise programs showed improvement in pain, body weight, function, walking ability, inflammatory markers, and knee joint loading (17-19). These findings are biomechanically plausible because excess body weight increases compressive load across the knee during daily activities such as walking, stair climbing, standing, and sit-to-stand transfers. Weight reduction may also influence systemic metabolic and inflammatory pathways that contribute to pain and disease burden. Evidence showing reduced knee joint loading after intensive weight loss further supports the mechanical rationale for weight control in knee osteoarthritis (21). However, weight management should not be interpreted as isolated dietary restriction alone. The evidence pattern suggests greater clinical relevance when weight reduction is combined with exercise, education, and behavioral support, particularly because pain-related inactivity and obesity may reinforce each other.

Physical therapy showed favorable effects across several clinically important domains, including pain, function, mobility, balance, range of motion, and confidence with daily activity. Randomized evidence indicates that physical therapy can provide meaningful improvement in knee osteoarthritis and may offer better functional outcomes than injection-centered short-term care in selected patients (24). Earlier trials also support manual physical therapy combined with exercise, and evidence from hip and knee osteoarthritis suggests that manual therapy, exercise therapy, or their combination may improve outcomes when added to usual care (25,26). These findings support the role of physiotherapists in assessing impairments, guiding exercise progression, correcting gait and movement patterns, improving balance, and helping patients overcome fear of activity. Manual therapy may be useful when integrated with active rehabilitation, although it should not replace strengthening, aerobic activity, education, and self-management.

Local Pakistani evidence contributed important contextual relevance to the synthesis. Studies from Pakistan reported favorable outcomes with physical therapy combined with wedge insoles, hip mobilization and strengthening, Biodex balance training, and other rehabilitation approaches in knee osteoarthritis (30-32). Additional local evidence linking knee osteoarthritis with modifiable risk factors and cardiometabolic problems reinforces the importance of weight control, physical activity, and broader lifestyle management in routine care (34,35). These findings are particularly relevant because many patients in Pakistan present after symptoms begin to affect daily living, and access to structured rehabilitation may be limited by cost, distance, awareness, and availability of trained professionals. However, the local evidence base remains smaller and less methodologically extensive than the international literature, so it should be interpreted as contextual support rather than as the sole basis for practice recommendations.

The results support a combined rehabilitation model for osteoarthritis care. Osteoarthritis symptoms are influenced by multiple interacting contributors, including weak periarticular muscles, excess body weight, altered biomechanics, reduced activity, balance impairment, low self-efficacy, fear of movement, and inadequate education. A single intervention may improve one component of disability, but combined programs can address several mechanisms simultaneously. The direction of evidence in this review favored combined care across pain, function, mobility, weight-related outcomes, and quality of life. However, because this review did not perform meta-analysis and did not generate pooled comparative estimates, combined programs should be described as clinically comprehensive and consistently favorable rather than definitively superior to all single-component interventions across all populations. This cautious interpretation is important for maintaining alignment between the Results and the strength of the available evidence.

The findings have practical implications for clinicians, physiotherapists, public health workers, and policy planners in Pakistan and similar low-resource settings. A feasible care model may include patient education, home-based strengthening, low-impact aerobic activity, weight-control counseling, activity pacing, balance work, gait advice, and periodic physiotherapy review. Such an approach is likely more sustainable than reliance on medication alone because it targets function, self-management, and modifiable risk factors. It may also help reduce unnecessary dependence on passive treatment and improve patient confidence in movement. For patients with obesity, weight management should be integrated with exercise rather than delivered as isolated advice. For patients with severe pain or poor tolerance to land-based exercise, aquatic activity, graded walking, supervised strengthening, or modified home-based routines may be more acceptable starting points.

This review has several limitations. First, the included evidence was heterogeneous in study design, intervention content, comparator type, outcome measures, follow-up duration, and osteoarthritis site, which prevented quantitative pooling. Second, the evidence base was dominated by knee osteoarthritis, so conclusions are most directly applicable to knee osteoarthritis and less certain for hip, hand, or mixed osteoarthritis populations. Third, the review included different evidence types, including randomized trials, systematic reviews, meta-analyses, clinical practice guidelines, and local observational studies. This approach strengthened breadth and contextual relevance but introduced possible evidence overlap, particularly where systematic reviews included trials that were also discussed as individual studies. Fourth, formal certainty grading and study-level risk-of-bias scoring were not available within the extracted manuscript data, limiting the ability to assign precise confidence ratings to each outcome. Fifth, local Pakistani evidence was limited in quantity, and several local studies had narrower intervention scope and smaller evidence contribution than international trials and reviews.

Future research in Pakistan and comparable settings should prioritize adequately powered randomized trials with standardized diagnostic criteria, clearly described intervention protocols, longer follow-up, adherence monitoring, and validated outcome tools such as WOMAC, pain scales, performance-based mobility tests, and quality-of-life measures. Studies should also report intervention dose, supervision level, home-program adherence, adverse events, body weight change, and clinically meaningful change thresholds. Comparative trials evaluating combined rehabilitation pathways against usual care would be particularly useful because clinical practice often requires integrated interventions rather than isolated exercise, diet, or manual therapy. Implementation research is also needed to determine how structured osteoarthritis rehabilitation can be delivered affordably through outpatient physiotherapy clinics, community-based programs, tele-rehabilitation, and patient education models in low-resource environments.

CONCLUSION

This systematic review without meta-analysis found that non-pharmacological interventions are consistently associated with favorable clinical and functional outcomes in osteoarthritis management, particularly for knee osteoarthritis. Exercise therapy showed the strongest and most consistent support across pain, stiffness, physical function, walking ability, and quality-of-life outcomes, while weight management was especially relevant for overweight and obese patients because of its effects on body weight, joint loading, pain, and mobility. Physical therapy contributed important benefits through supervised exercise, manual therapy, joint mobilization, gait training, balance work, strengthening, and patient education. Combined lifestyle-rehabilitation programs appeared clinically comprehensive because they addressed multiple modifiable mechanisms of osteoarthritis-related disability, although pooled comparative estimates were not available. For Pakistan and similar low-resource settings, osteoarthritis care should prioritize practical, individualized, and active rehabilitation strategies that combine patient education, progressive exercise, weight-control support, and physiotherapy follow-up, while future local studies should strengthen evidence through larger samples, standardized outcomes, longer follow-up, and clearer reporting of intervention dose and adherence.

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