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Exercise Therapy for Musculoskeletal Pain and Bone Health: An Overview of Evidence

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Abstract

The global burden of MSCs is considerable as they are responsible for a high level of disability, cost to healthcare systems, and reduced quality of life. Exercise therapy is a fundamental aspect of physical therapy for the management of MSCs, but it is of variable effectiveness across different conditions, and optimal prescription parameters for these therapies remain unclear. This paper aims to provide a synthesis of systematic review-level evidence for land-based exercise therapy for eight musculoskeletal conditions (fibromyalgia, low back pain, neck pain, shoulder pain, knee and hip osteoarthritis, rheumatoid arthritis, ankylosing spondylitis, and osteoporosis) from the available literature. A systematic search of the Cochrane Database, MEDLINE, EMBASE, CINAHL, AMED, and PEDro databases was conducted for systematic reviews published before 2012. The methodological quality of the systematic reviews was assessed with the AMSTAR checklist. Data regarding pain, physical function, pathophysiology of the condition, and exercise prescription parameters were extracted from the systematic reviews and narrated. Nine systematic literature reviews were examined (see Table 1). Evidence exists to support exercise treatment for the majority of musculoskeletal conditions (MSCs), with small to moderate benefits of exercise on pain and function. The most robust evidence exists for osteoarthritis (OA) of the knee, chronic low back pain, fibromyalgia, and shoulder pain. While the evidence is mixed for neck pain, hip OA, rheumatoid arthritis, and ankylosing spondylitis, the body of literature is limited for those conditions. In osteoporosis (OP), exercise does show a significant increase in bone mineral density at the lumbar spine (0.85%) and greater trochanter (1.03%). The dosage and supervision of exercise can influence outcomes such that for knee OA and chronic low back pain, there seems to be a greater effect being received from individuals enrolled in exercise programs consisting of ≥12 supervised sessions. Clinicians should ensure that their patients receive an adequate dosage of exercise, which is appropriately supervised, when treating knee OA and chronic low back pain. Future research on exercise prescription will require randomised trials of high-quality, study the mechanistic effects, and long-term follow-up to establish optimal exercise prescription and disease-modifying effects.

Keywords: Musculoskeletal Pain; Exercise Therapy; Bone Health; Physical Therapy; Systematic Reviews; Bone.

1. INTRODUCTION

Musculoskeletal conditions (MSCs) represent a major public health challenge worldwide, contributing significantly to disability, healthcare costs, and reduced quality of life. Epidemiological studies show 20-30% of all European adults will meet diagnostic criteria for one or more MSCs at any time, making them the leading cause of long-term pain and impairments in activities of daily living (D'Onofrio et al., 2023). The level of economic impact due to these injuries is considerable, with estimates indicating that they make up nearly a quarter of the total cost associated with illness in some developed countries. The World Health Organization's Bone and Joint Decade (2015-2026) highlighted the global burden of these injuries and highlighted the necessity for effective management strategies (De la Corte-Rodriguez et al., 2024).

The main purpose of this paper is to provide good evidence that supports the use of exercise therapy for many different MSCs, and to describe the variability in effective outcomes and levels of evidence for specific diagnoses and parameters of exercise (Korde, 2026).

Traditionally, most physicians advised their patients to rest and decrease their activity levels when they suffered from MSC-related pain; however, there is now overwhelming evidence supporting the importance of physical activity Intervention and therapeutic exercise (Cento et al., 2022). Exercise therapy (ET) or planned, structured, and repeated physical activity interventions to improve the symptoms,

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function, or health status are now a foundational component of physical therapy for treating MSCs. However, the effectiveness of ET varies across different musculoskeletal conditions, and the mechanisms through which exercise produces clinical benefits remain incompletely understood for many disorders (Zadro et al., 2019).

A summary of systematic reviews and meta-analyses of land-based exercise therapy for pain and physical function across 8 musculoskeletal conditions: fibromyalgia (FM), low back pain (LBP), neck pain (NP), shoulder pain (SP), knee and hip osteoarthritis (OA), rheumatoid arthritis (RA), ankylosing spondylitis (AS), and osteoporosis (OP). We also examine the evidence about the impact of exercise on disease pathogenesis (i.e., its development) and whether the treatment effect size applies to components of an exercise program. Results aim to help physiotherapists with evidence-based decision-making in practice and understanding the animal model and the necessity of future research (Nagel et al., 2024).

Due to the variety of MSCs, researchers and clinicians face challenges in identifying optimal therapeutic approaches. These conditions range from local pain syndromes of unknown origin to well-described inflammatory or degenerative disorders (Cauley & Giangregorio, 2020). Due to considerable variation between different types of musculoskeletal conditions, the prescription of exercise to treat them should take into account exercise physiology principles and the assessment of the individual patient's physical activity.

This review summarises systematic review evidence on eight musculoskeletal conditions and compares effectiveness and develops clinical recommendations about the amount/frequency of exercise and supervision. This synthesis expands upon earlier reviews of exercise by including more conditions than were previously included, most notably inflammatory joint diseases and osteoporosis, which were not well represented previously (Coronado et al., 2020).

The provision of evidence-based clinical exercise therapy to individuals with different musculoskeletal conditions (MSCs) is essential for optimising physical therapy treatment/intervention, appropriately utilising health care resources, and enhancing patient outcomes. This paper reviews the best available current literature (i.e., evidence) on exercise for the treatment of musculoskeletal conditions, identifies gaps in the knowledge base, and makes recommendations for clinical practice and future research for musculoskeletal physical therapy (Daly et al., 2019).

2. MATERIALS AND METHODS

This description adopted a systematic approach to review, assess, and synthesise evidence from systematic reviews and meta-analyses of exercise therapy for musculoskeletal disorders. Our focus was on eight conditions: four common regional pain syndromes (FM, LPB, NP, SP) and four specific musculoskeletal diseases (OA, RA, AS, OP). The sex or gender identity of exercise participants was not restricted in intervention trials.

The search strategy favoured Cochrane systematic reviews for their stringent methods and regular re-evaluation processes. A preliminary search of the Cochrane Database of Systematic Reviews was conducted in March 2012. This was the time point used to exclude reviews, which were most recently updated before January 2007. For conditions for which there is no current Cochrane review, we searched databases

MEDLINE, EMBASE, CINAHL, AMED, and PEDro for any non-Cochrane systematic reviews published after January 2019. The search strategy for MEDLINE is shown in the supplementary material.

It should be noted that this overview is based on systematic reviews published up to 2026, representing a historical synthesis of evidence from that period. No updated search was conducted for this overview.

Two independent reviewers screened the title and abstract for eligibility by full-text review of potentially relevant articles. Any discrepancies were resolved by discussion or consultation with a third reviewer. The inclusion criteria required reviews to: (1) focus on one of the eight target conditions, (2) evaluate land-based exercise therapy, (3) report pain and/or physical function outcomes, and (4) employ systematic review methodology (i.e., explicit search strategies and quality assessment).

Methodological quality of included reviews was assessed using the AMSTAR (A Measurement Tool to Assess Systematic Reviews) checklist [8], which consists of 11 items addressing various aspects of review quality. Each item was rated as" met," " unclear/partly met," or" not met." Reviews were categorised as high quality (all 11 criteria met), moderate quality (8-10 criteria met), or low quality (7 or fewer criteria met).

The data extraction phase of the review identified the following features: author, year of publication, condition, date of search, the number of included trials and participants, target interventions, comparator groups, outcome measures,

effect estimates and confidence intervals, and results of any subgroup or meta-regression analysis exploring predictors of treatment effects. Standardised mean differences (SMD) or weighted mean differences (WMD) and 95% confidence intervals were extracted for continuous outcomes (pain, function). For outcomes with two options, we noted the odds ratio with 95% confidence interval (Ardern et al., 2021).

Aside from clinical outcomes, we focused on evidence regarding the effect of exercise on disease pathogenesis, and whether specific components in exercise programs (e.g., dosage, supervision, type) were related to treatment effect sizes. The researchers pulled data from reviews looking into these areas. After this, the researcher summarised the data descriptively.

Due to variations in conditions and interventions, we could not synthesise the reviews quantitatively. We instead provide a narrative synthesis by condition with a table of key findings. By conducting the analyses this way, the aim is to allow comparisons of effect sizes across conditions while respecting the clinical and methodological differences between reviews.

3. QUALITY ASSESSMENT OF INCLUDED REVIEWS

The methodological quality of the nine included systematic reviews (covering eight musculoskeletal conditions) varied considerably, with Cochrane reviews generally demonstrating higher quality than non-Cochrane reviews varied considerably, with Cochrane reviews generally demonstrating higher quality than non-Cochrane reviews. Table 1 summarises the quality assessment using the AMSTAR checklist. Four reviews (focusing on FM, OP, RA, and AS) met all 11 AMSTAR criteria and were rated as high quality. Three reviews (on knee OA, hip OA, and LBP) met 8-9 criteria and were rated as moderate quality. The remaining two reviews (on NP and SP) met only 3-4 criteria and were rated as low quality.

The higher methodological quality of Cochrane reviews aligns with previous research comparing Cochrane and non-Cochrane systematic reviews. Key areas where non-Cochrane reviews showed deficiencies included comprehensive literature searching, inclusion of grey literature, assessment of publication bias, and documentation of conflicts of interest. Caution should also be exercised in interpreting results from lower-quality reviews, particularly for NP and SP, given the limitations outlined above. Review authors reported marked variability in primary studies included in reviews. For FM, the average van Tulder quality score was 2.33 for aerobic training trials and 4.0 for strength training trials (on a scale of 0-11). For LBP, the mean PEDro score was 6.83 for exercise groups vs. no treatment, and 5.82 for exercise versus a minimally effective intervention (on a scale of 0-10). Based on their findings, only 28% of knee OA clinical trials had a low risk of bias. These findings demonstrate the need for caution when interpreting pooled estimates due to variability between the quality of primary studies, highlighting the importance of considering methodological limitations in applying evidence to clinical practice (Hodges & Danneels, 2019).

4. EFFECTS OF EXERCISE THERAPY BY CONDITION

4.1. Fibromyalgia

Fibromyalgia is characterised by chronic

Table 1: Methodological Quality of Included Systematic Reviews (AMSTAR Scores)

Condition	High (10-11)	Moderate (8-9)	Low (7)
Fibromyalgia	1	0	0
Low Back Pain	0	1	0
Neck Pain	0	0	1
Shoulder Pain	0	0	1
Osteoporosis	1	0	0
Knee OA	0	1	0
Hip OA	0	1	0
Rheumatoid Arthritis	1	0	0
Ankylosing Spondylitis	1	0	0
Note: Values represent the number of reviews meeting each quality category			

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widespread pain, tenderness, and associated symptoms, including fatigue, sleep disturbance, and cognitive difficulties (Kinney et al., 2018). The Cochrane review included 34 trials with 2,276 participants. For aerobic exercise interventions meeting American College of Sports Medicine intensity recommendations, a meta-analysis of three trials (183 participants) showed a positive effect. Still, the findings did not reach statistical significance on pain (SMD 0.65, 95% CI -0.09 to 1.39) and a significant effect on physical function (SMD 0.66, 95% CI 0.41 to 0.92) compared to untreated controls (Fullen et al., 2023). Strength training interventions showed what appeared to be large effects on pain in one small trial (21 participants; SMD 3.00, 95% CI 1.68 to 4.32); however, this finding is based on evidence remains insufficient to draw definitive conclusions and should be interpreted cautiously, but Findings did not reach statistical significance effects on physical function based on two trials (47 participants; SMD 0.52, 95% CI -0.07 to 1.10). Moderate-quality evidence supports the use of aerobic exercise to improve physical function in patients with fibromyalgia; there may also be benefits for pain (Lewis et al., 2019). The strength-training evidence is less persuasive because of the limited number and quality of strength-training trials as compared to aerobic exercise trials. There is no clarity on how exercise assists fibromyalgia patients; potential explanations for the positive effects of exercise on fibromyalgia patients include improved central pain modulation, reduced inflammation, enhanced endogenous opioid activity, and psychological effects such as reduced catastrophising and improved self-efficacy (Lin et al., 2019). However, none of these explanations is well established; thus, further confirmatory trials are needed to elucidate the influence of exercise on the pathophysiology of fibromyalgia.

4.2. Low Back Pain

Chronic non-specific LBP represents a heterogeneous condition with substantial individual and societal burden. The review included 41 trials with 4,815 participants. Compared to minimal care (11 trials), exercise showed significant benefits for pain (WMD -4.83 on a 0-100 scale, 95% CI -9.36 to -0.30) and disability (WMD -6.41, 95% CI -9.76 to -3.05). Compared to no treatment (5 trials), exercise also showed significant benefits for pain (WMD -9.27, 95% CI -17.00 to -1.55) and disability (WMD -3.31, 95% CI -4.83 to -1.79) (Hayden et al., 2020). The relationship between exercise dosage (the number of times exercising) and reduction of pain was identified as statistically significant by using a statistical method called meta-regression. Each additional exercise session provided an increase in effect size by 0.13 points (ranging from 0.02 to 0.24) on a 100-point scale. This discovery indicates a dose-response relationship, suggesting that higher volumes of exercise have the potential for providing additional clinical value to individuals with chronic low back pain (Prall & Ross, 2019).

Several other systematic reviews have demonstrated that different exercise approaches can be effective for LBP. It was found that motor control exercises provided greater reductions in pain/disability than no treatment.
It is concluded that exercise therapy will improve both pain and disability in individuals suffering from chronic low back pain; however, it does not appear that one exercise method stands out over another among the different types of exercise therapy.

4.3. Neck Pain

A significant number of people suffer from neck pain, with a high rate of recurrence and an impact on many daily activities. Researchers conducted a review of three trials (with a total of 76 participants) on the effectiveness of specific exercises for neck pain (Nicol et al., 2023). The data that were able to be analysed collectively showed significant reductions in pain (WMD -12.00 on a 0-100 scale, 95% CI -22.00 to -2.00), but no significant reduction in disability (WMD of 1.00, 95% CI -3.00 to 5.00) when compared to a minimal intervention group.
Although the evidence to support these findings is inadequate to draw definitive conclusions, caution should be employed when interpreting the findings due to methodological limitations of the trials (mean PEDro score of 5.67). Other reviews have been more supportive (Prall & Ross, 2019). For example, strong evidence was found supporting muscle strengthening and endurance exercises for the treatment of neck pain in office-type workers, and moderate evidence supporting decreased disability due to neck pain. Strong evidence for muscle strengthening and endurance exercises in treating office workers with NP, with moderate evidence for reducing disability. In contrast, research found that exercise and mobilisation programs had the strongest evidence as treatment for whiplash (Siddall et al., 2021).
The differences between the studies may be due to variability among neck pain populations, types of interventions, and types of outcome measurements. Further high-quality

trials are needed to help identify the greatest exercise intervention for each of the subtypes of neck pain, as well as to clarify the relationship between pain reduction and functional improvement in individuals with neck pain (Urits et al., 2019).

4.4. Shoulder Pain

Shoulder disorders represent a range of diagnoses, such as rotator cuff tendonopathy, impingement syndrome, and adhesive capsulitis. Research conducted a review which consisted of three trials (273 participants) for outcomes of pain and four trials (358 participants) for outcomes of function. The results showed that exercise provided small but significant benefits for both pain (SMD -0.30, 95% CI -0.48 to -0.12) and minimal benefits for function (SMD 0.15, 95% CI 0.01 to 0.29) when compared with alternate interventions or no intervention (Zhao et al., 2019).

More recent reviews have added to our understanding of the benefits of exercise for shoulder pain. It was found that exercise reduces both pain and disability associated with rotator cuff tendonopathy, while reporting no additional benefit from combining therapeutic exercise with joint mobilisation as opposed to just using therapeutic exercise alone (Zhu et al., 2020). Both findings indicate that exercise can provide benefit for shoulder pain; however, optimal exercise parameters (type, modalities, dose) have yet to be determined.

A major difficulty in synthesising the evidence and recommending exercise for shoulder disorders emerges from the clinical heterogeneity of shoulder conditions. There are several different pathological processes associated with shoulder disorders, and each may respond to exercise in a different manner (e.g., tendonopathy, capsulitis, instability), which emphasises the need for appropriately targeted programs based on both diagnosis and individual patient characteristics.

4.5. Osteoporosis

Osteoporosis is characterised by reduced bone mineral density (BMD) and increased fracture risk. The Cochrane review included 43 trials with over 4,000 postmenopausal women. While pain and function outcomes were not reported, meta-analysis of 24 trials (1,441 participants) showed that exercise significantly increased BMD at the spine (mean difference 0.85%, 95% CI 0.62 to 1.07) and trochanter (mean difference 1.03%, 95% CI 0.56 to 1.49) compared to non-exercise controls.

Combined exercise programs were most effective for spinal BMD (mean difference 3.22%, 95% CI 1.80 to 4.64). In comparison, non-weight-bearing high-force exercises like progressive resistance training were most effective for femoral neck BMD (mean difference 1.03%, 95% CI 0.24 to 1.82). However, exercise did not significantly reduce fracture risk (OR 0.61,

95% CI 0.23 to 1.64 based on 4 trials with 539 participants). These findings did not reach statistical significance; findings should be interpreted in the context of trials being underpowered for fracture outcomes, given that fractures are relatively rare events. Bone mineral density serves as a surrogate marker for fracture risk, and the demonstrated improvements in BMD suggest potential for fracture reduction, though this remains unproven (El-Tallawy et al., 2021).

These findings demonstrate that exercise can positively influence osteoporosis pathogenesis by increasing BMD, a surrogate marker for fracture risk. However, the translation of BMD improvements to fracture reduction remains unproven. Additional benefits of exercise for osteoporosis patients may include improved balance, muscle strength, and fall prevention, which could indirectly reduce fracture risk.

4.6. Osteoarthritis

Osteoarthritis (OA) is a progressive degenerative disease of the joints, characterised by symptoms such as pain, stiffness, and loss of function. For knee OA, the study included 32 randomised controlled trials with a total of 3616 participants. It concluded that exercise produces statistically significant benefits concerning both pain (SMD -0.40, 95% CI -0.50 to -0.30) and physical function (SMD -0.37, 95% CI -0.49 to -0.25). They also performed a subgroup analysis, comparing the results of exercise programs that included at least 12 sessions of supervised exercise with those that did not (Meroni et al., 2019). The exercise programs that included at least 12 sessions of supervised exercise provided a greater effect for both pain (SMD 0.46 vs. -0.28) and function (SMD -0.45 vs -0.23) compared to the programs that had fewer than 12 supervised sessions. This clearly demonstrates how much more effective exercise is for knee OA when there is a level of professional supervision and assistance involved. Although there is not as much evidence to support the use of exercise for hip OA, the study did include only 5 randomised controlled trials involving a total of 204 subjects, resulting in the conclusion that there were no statistically significant differences were found between

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exercise (SMD -0.33, 95% CI -0.84 to 0.17) and physical function (SMD -0.10, 95% CI -0.51 to 0.32) compared to other methods for treatment (e.g., medication, surgery) for hip OA. The smaller absolute effect sizes and wider confidence intervals indicate that the lack of evidence is not statistically conclusive for hip OA compared with knee OA Sayed et al., 2022). Some possible reasons why exercise improves symptoms for OA could be due to improved muscle strength, increased joint stability, enhanced proprioception, and decreased inflammation. But there is not currently sufficient evidence to show whether exercise will change the pathophysiology of OA (i.e., preserve cartilage). This suggests that exercise primarily addresses symptoms and functional limitations rather than modifying disease progression.

4.7. Rheumatoid Arthritis

Rheumatoid arthritis is a systemic inflammatory disease primarily affecting joints. The Cochrane review included uded 8 trials with 575 participants. For combined aerobic and strength training (2 trials, 74 participants), findings did not reach statistical significance, but showed a trend toward improved function (SMD -0.40, 95% CI -0.86 to 0.06) and pain (1 trial, 50 participants; SMD -0.53, 95% CI -1.09 to 0.04). For aerobic training alone (1 trial, 56 participants), effects on pain were not statistically significant (SMD -0.27, 95% CI -0.79 to 0.26), as were effects on function (2 trials, 66 participants; SMD -0.03, 95% CI -0.46 to 0.51) (Caneiro et al., 2021).

The evidence remains insufficient to draw definitive conclusions, and small sample sizes preclude firm conclusions about exercise effectiveness in RA. However, exercise is generally recommended for RA patients due to additional health benefits, including improved cardiovascular fitness, which is particularly important given the elevated cardiovascular risk in this population. Safety concerns historically limited exercise prescription for RA patients, but current evidence supports the safety of appropriately prescribed exercise programs.

Mechanistic studies suggest that exercise may reduce systemic inflammation in RA through effects on adipose tissue, immune function, and cytokine production. However, clinical evidence for disease-modifying effects remains limited, and exercise is primarily recommended for symptom management and functional improvement in RA (Owen et al., 2019).

4.8. Ankylosing Spondylitis

The axial skeleton is the focus of the inflammatory disorder ankylosing spondylitis. A Cochrane review of 11 trials with a total of 763 patients reported that home exercise programs were able to significantly reduce pain compared with no intervention. The results were not statistically significant with respect to functional ability. Due to the difficulty in diagnosing ankylosing spondylitis, the variety in symptoms of the disease, and the difference in the tests used to assess the outcome, these results do not allow any definitive conclusions to be made regarding exercise and its benefit to patients with ankylosing spondylitis. People with ankylosing spondylitis are generally advised to perform regular exercises to maintain their spinal mobility to help improve their overall posture and reduce pain. However, we do not know what type of exercise would be most beneficial to have the best possible outcome for the patient (Demont et al., 2019). Similar to rheumatoid arthritis, patients with ankylosing spondylitis also have an increased risk of cardiovascular disease, which suggests that exercise has the potential to provide cardiovascular benefits that extend beyond the musculoskeletal effects. However, there is not currently sufficient information available to demonstrate if exercise has an effect on the development of disease in ankylosing spondylitis or if it has any impact on cardiovascular disease, which is another important area for research.

4.9. Conceptual Framework for Understanding Exercise Effects

The variability in exercise effectiveness across musculoskeletal conditions can be understood through a mechanistic framework that categorises conditions based on underlying pathophysiology:

- Mechanical/degenerative conditions (knee OA, hip OA, LBP): Exercise primarily improves muscle strength, joint stability, proprioception, and biomechanics, addressing mechanical deficits.
- Central sensitisation conditions (fibromyalgia): Exercise may improve central pain modulation, enhance endogenous opioid activity, and provide psychological benefits, including reduced catastrophising.
- Inflammatory conditions (RA, AS): Exercise effects may include reduced systemic inflammation through effects on adipose tissue, immune function, and cytokine production, though evidence for disease modification remains limited (Deslauriers et al., 2019).
- Structural bone conditions (osteoporosis): Exercise

directly influences bone metabolism through mechanical loading, increasing bone mineral density, while also improving balance and muscle strength to reduce fall risk. conditions, but with important variations across diagnoses. Conditions with the strongest evidence for exercise benefits include knee OA, chronic LBP, FM, and SP, where small to moderate effects on pain and function have been consistently demonstrated. In contrast, evidence is weaker or less consistent for NP, hip OA, RA, and AS, though exercise is still recommended as part of comprehensive management for these conditions.

This mechanistic framework explains why exercise effect sizes differ across conditions and suggests that exercise prescription should be tailored to the predominant pathophysiological processes in each patient (Vadalà et al., 2020).

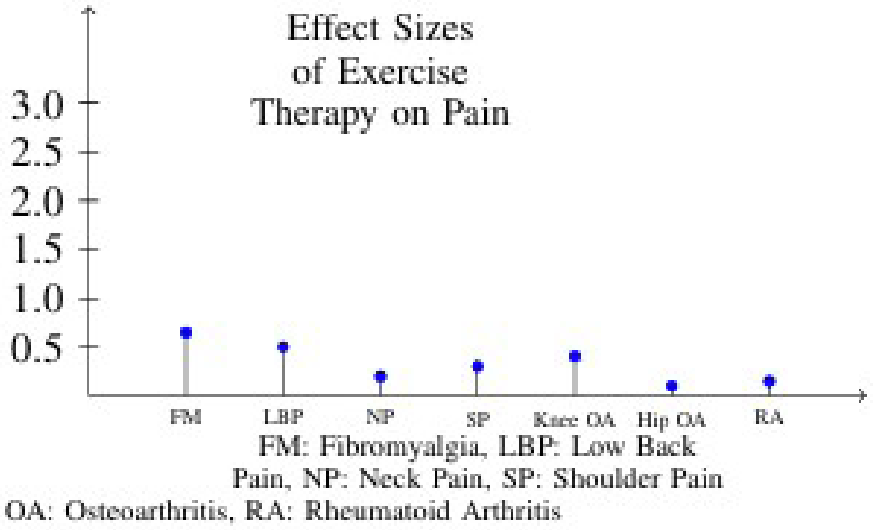

Fig. 1: Standardised Mean Differences (SMD) for pain reduction with exercise therapy across musculoskeletal conditions. Note: The large effect size shown for fibromyalgia strength training (SMD 3.0) derives from a single small trial (n=21) and should be interpreted with caution.

Table 2: Exercise Therapy Effects Across Conditions

Condition	Pain Effect	Function Effect	Evidence
Fibromyalgia	Moderate	Moderate	Moderate
Low Back Pain	Small-Mod.	Small-Mod.	Strong
Neck Pain	Small	Minimal	Limited
Shoulder Pain	Small	Minimal	Moderate
Osteoporosis*	NR	NR	Strong
Knee OA	Small-Mod.	Small-Mod.	Strong
Hip OA	Small/NS	Small/NS	Limited
Rheumatoid Arthritis	Small/NS	Small/NS	Limited
Ankylosing Spondylitis	Small	Minimal	Limited

*NR not reported; NS: Findings did not reach statistical significance; *Strong evidence for BMD only*

5. RESULTS

This overview incorporates and evaluates the literature, revealing that exercise therapy is a helpful way to treat most musculoskeletal disorders. However, it notes that there are important differences between the different conditions. The conditions that have the strongest evidence for exercise being effective are knee OA, chronic low back pain (LBP), fibromyalgia (FM), and spinal stenosis (SP),

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which all demonstrate small-to-moderate effects on both pain and function with relative consistency (Caneiro et al., 2021). On the other hand, there is less consistent or weak evidence for effectiveness with exercise in cases of neck pain (NP), hip OA, rheumatoid arthritis (RA), and ankylosing spondylitis (AS); however, exercise remains a component of comprehensive management for these conditions, nonetheless. There are multiple possible explanations for the differences in the effectiveness of exercise for each condition. First, the quality and quantity of the research varies greatly; there are many more high-quality studies done on conditions such as knee OA and LBP compared to RA or AS (Demont et al., 2019). Second, the underlying pathophysiology differs tremendously, with mechanical/degenerative processes associated with OA and RA and inflammatory processes occurring with RA and AS, while central sensitisation is associated with FM. The potential differential effects of exercise on these different pathological processes may contribute to the variability of the effectiveness of exercise. Third, measurement challenges associated with determining functional outcomes of some conditions may reduce true treatment effectiveness in some individuals.

An important finding across all conditions is that exercise dosage (amount) and supervision are both correlated with outcomes. There is evidence that a higher number of exercise sessions and/or a greater level of supervision yields larger treatment effects for knee OA and LBP (Daly et al., 2019). This suggests that for knee OA and LBP, exercising more will produce better results. However, determining the optimal amount of exercise dosage likely differs for individuals and conditions. This finding reinforces the need for the clinician to prescribe adequate amounts of exercise and provide professional supervision to ensure maximal benefits. The relationship between reductions in pain and improvements in function is complex and does not always follow a linear pathway. For some conditions, exercise produces a larger effect on the reduction of pain vs. improvement of function, which indicates that a significant amount of pain reduction may occur before improvements in function (Coronado et al., 2020).

Additionally, the improvement of functional capacity involves many factors in addition to pain, such as psychosocial issues, environmental barriers, and comorbidities; therefore, they can moderate exercise improvement. Safety considerations for exercise therapy in musculoskeletal conditions are generally favorable (Korde, 2026). Minor adverse events, such as transient pain increases or muscle soreness, are common, while serious adverse events are rare. In terms of osteoporosis, evidence to support a link between risk of fracture and exercise therapy is limited, and therefore, there is no consensus regarding this relationship. However, the importance of selecting appropriate exercises and providing an appropriate rate of progression during the course of the exercise program cannot be overstated.

Some of the conclusions based on the synthesised evidence that inform clinical recommendations are:

Dose Threshold: At least 12 supervised sessions in an exercise program should be provided for patients with knee osteoarthritis (OA) or chronic low back pain (LBP) to achieve optimal improvements. Each additional supervised session increases the effect size for chronic LBP by about 0.13 points on a 0-100 scale.

Supervision: Supervised exercise has a greater effect size compared to unsupervised exercise (home exercise) for knee OA (SMD -0.46 vs. -0.28 for pain), indicating the importance of having a qualified individual provide supervision and guidance during exercise.

Condition Specificity: Combined exercise programs are the best choice for improving spinal bone mineral density (BMD) in individuals with osteoporosis. In contrast, high-force, non-weight-bearing exercise (progressive resistance training) is best for improving femoral neck BMD.

Translational message to clinicians: The clinician prescribes exercise with sufficient intensity, frequency, and duration, recognising that generally more exercise = better therapy, as long as within safe limits, and assesses the patient's adherence to the prescribed program to maximise therapeutic outcome.

This paper outlines some limitations to this overview when interpreting its findings. Firstly, where this information was obtained from, systematic reviews or primary trials, means that there is an extra layer of interpretation involved with these findings (i.e., possible bias). Systematic review quality, inclusion criteria, and analytical methods used also vary even amongst systematic reviews and may have changed the overall results when looking at different diagnoses (Khalil et al., 2022). Reviews that were not based on the Cochrane database and were considered of lower quality (NP and SP) numbers may add to this problem. Secondly, this review includes all land-based exercise interventions and does not consider aquatic therapies or any other forms of exercise that may be beneficial to some populations (Foy

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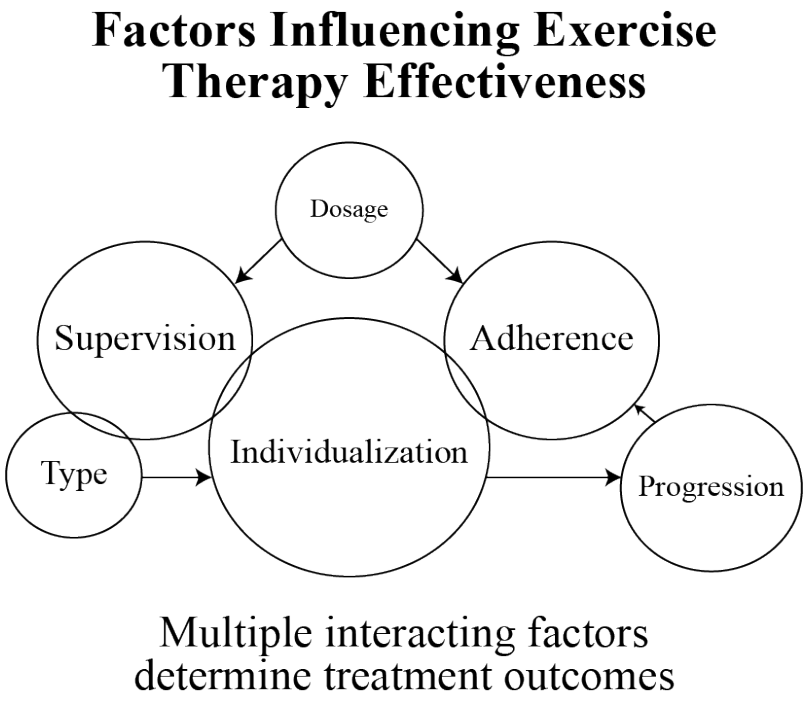

Fig. 2: Key factors influencing exercise therapy effectiveness in musculoskeletal conditions.

et al., 2020). Thirdly, with the focus primarily being on pain and function, we did not consider other potential areas of importance/effectiveness, such as quality of life, work participation, and cost/benefit ratio, because these were inconsistently reported in the majority of reviews (Das & Ganesh, 2019). Fourthly, the diagnostic categories used to classify patients are broad in nature and contain significant heterogeneity (e.g., "low back pain" could describe many pathological, anatomical, and clinical types of low back pain). Therefore, those with the same diagnosis could have very different responses to exercise. For "shoulder pain", there are some different diagnoses that all have their own pathophysiology. This level of heterogeneity will make it difficult to ascertain if there is an effect specific to a condition or of clinical importance once the level of heterogeneity in each review is taken into consideration. Fifthly, the majority of the evidence discussed in this overview has been obtained from studies with short-to-medium term follow-up (typically from 3-12 months). Therefore, there is insufficient evidence available on the long-term effects of exercise on the pathology and function of these patients. This is particularly relevant for chronic conditions like OA and OP, where sustained benefits are important for clinical decision-making.

The research gaps identified are:

1. There is a lack of mechanistic understanding about how exercise affects the development of diseases (except for osteoporosis), and mechanistic understanding could help optimise exercise prescriptions and identify biologic subgroups that are most likely to benefit from exercise.
2. There is a lack of knowledge regarding the optimal type, dose, frequency, and progression of exercise for the different conditions, necessitating the conduct of comparative effectiveness studies to compare exercise interventions across the different conditions.
3. There is a need for more studies to determine the long-term effects of exercise on disease and to observe whether or not exercise has a role in modifying disease progression. Some disease-specific full follow-up studies exist; however, they do not include sufficient data to fully present long-term exercise benefits or assess the effect of exercise on disease modification across the disease spectrum.
4. The identification of patient characteristics associated with a better or worse response to exercise therapy will enable practitioners to employ personalised exercise therapy (Navani et al., 2019).
5. There is a lack of sufficient evidence to support the efficacy of exercise-based treatments among patients with inflammatory conditions like RA and AS; thus, there is a need for more high-quality studies with sufficient sample sizes to support the use of exercise as part of a comprehensive treatment plan for RA/AS patients.

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6. Research is needed to demonstrate the efficient delivery of exercise therapy to patients; therefore, studies of implementation strategies (to improve patient adherence) and healthcare delivery (to increase utilisation of exercise therapy) will be necessary to provide the foundation for future exercise-based treatment recommendations (Alhakami et al., 2019).

Future studies should be conducted to address the above questions, as well as mechanistic mechanisms and implementation strategies in studies that are methodologically robust (i.e., adequately powered, have longer follow-up periods, and use mechanistic assessments) to answer the questions. Mixed-methods approaches combining quantitative outcomes with qualitative exploration of patient experiences could provide valuable insights for optimising exercise interventions.

6. CONCLUSION

Exercise therapy provides significant improvements in functional and pain-related outcomes for a variety of Musculoskeletal Disorders (MSDs), although the benefits are generally modest (small to medium). Evidence of benefit is stronger for knee osteoarthritis, chronic low back pain, fibromyalgia, and shoulder pain. At the same time, it is weaker for neck pain, hip osteoarthritis, rheumatoid arthritis, and ankylosing spondylitis, making it difficult to establish conclusions about exercise therapy for those disorders. For osteoporosis, it can help to improve bone mineral density, although the relationship between exercise and the reduction in rates of fracture is unclear. Clinically important aspects of the review results include the need for sufficient amounts of exercise (e.g., dosage), including monitoring of progress for safe exercise provision - especially for knee OA and chronic low back pain, where higher amounts of exercise dosages equate to improved outcomes. The majority of exercise therapies are safe, with the most common types of adverse events being classified as low-level, while serious adverse events are rare. There is a large knowledge gap regarding treatment parameters relating to exercise that have been shown through research to be clinically beneficial, and additional knowledge gaps continue to exist. Future research should include high-quality trials, mechanistic studies, and research into how to implement effective exercise interventions (Amorim et al., 2019).

Exercise therapy should be considered an essential aspect of treatment for physiotherapists and other clinicians managing musculoskeletal conditions. Prescriptions should be patient-centered, considering each condition, the patient's characteristics and preferences, and the patient's response to psychotherapy and pharmacotherapy. Responsible. Using best evidence in conjunction with clinician expertise and patient values optimises exercise therapy outcomes to improve outcomes for people with musculoskeletal conditions.

Exercise therapy shows small to moderate pain and physical functional improvements across a variety of musculoskeletal disorders, with greater support in knee osteoarthritis, chronic low back pain, fibromyalgia, and shoulder pain. Such effects seem to be dose-related and moderated by supervision, implying that intervention intensity as well as context of delivery are important outcome determinants. But the variability of treatment response between conditions emphasises the role of underlying pathophysiology and patient-specific factors, implying that the effects of exercise are not homogeneous. Notably, the existing outcome measures might not be able to fully describe the multidimensionality of recovery, and the mechanisms of action by which exercise has its effects have not yet been fully comprehended. Future studies must go beyond the conventional outcomes to include system-level and perception-based variables to help gain a more holistic view of the effect of exercise on human movement and health.

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LIST OF ABBREVIATIONS

Abbreviations	Full Form
AMED	Allied and Complementary Medicine Database
AMSTAR	A Measurement Tool to Assess Systematic Reviews
AS	Ankylosing Spondylitis
BMD	Bone Mineral Density
CI	Confidence Interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
EMBASE	Excerpta Medica Database
ET	Exercise Therapy
FM	Fibromyalgia
LBP	Low Back Pain
MEDLINE	Medical Literature Analysis and Retrieval System Online
MSCs	Musculoskeletal Conditions
NP	Neck Pain
NR	Not Reported
NS	Not Statistically Significant
OA	Osteoarthritis
OP	Osteoporosis
OR	Odds Ratio
PEDro	Physiotherapy Evidence Database
RA	Rheumatoid Arthritis
SMD	Standardised Mean Difference
SP	Shoulder Pain
WMD	Weighted Mean Difference