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Physical Therapy in the Management of Axial Spondyloarthritis: A Narrative Review

Monika Lis[1], ORCID https://orcid.org/0000-0003-4021-919X

E-mail monikalis1267@gmail.com

[1]Mazovian "Bródnowski" Hospital, Ludwika Kondratowicza 8, 03-242 Warsaw, Poland

Hubert Piwar[2], ORCID https://orcid.org/0009-0009-4333-9518

E-mail hubertpiwar@gmail.com

[2]Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw, Poland

Marta Kaczorek[3], ORCID https://orcid.org/0009-0007-1406-2076

E-mail kaczorek.marta1@gmail.com

[3]Institute of Psychiatry and Neurology, Sobieskiego 9, 02-957 Warsaw, Poland

Bożena Kiełbasa[4], ORCID https://orcid.org/0009-0002-1667-124X

E-mail bozena.kielbasa00@gmail.com

[4]Tytus Chałubiński District Hospital in Zakopane, Kamieniec 10, 34-500 Zakopane, Poland

Olga Kowalczyk[5], ORCID https://orcid.org/0009-0008-5105-3301
E-mail kowaalczykk@gmail.com
[5]Rev. J. Glowatzki County Hospital, ul. Opolska 36A, 47-100 Strzelce Opolskie, Poland

Katarzyna Pagacz[6], ORCID https://orcid.org/0009-0000-1973-8433
E-mail pagkat2000@gmail.com
[6]The Lower Silesian Centre for Oncology, Pulmonology and Haematology, pl. Ludwika Hirszfelda 12, 53-413 Wrocław, Poland

Julia Gatniejewska [7], ORCID https://orcid.org/0009-0001-1463-7497
E-mail juliaanna177@gmail.com
[7]Regional Hospital in Poznań, ul. Juraszów 7/19, Poznań 60-479

Aleksandra Stadnik[8], ORCID https://orcid.org/0009-0005-4764-3980
E-mail aleksandrastadnik2@gmail.com
[8]Wrocław University Hospital, Borowska 213, 50-556 Wrocław, Poland

Wiktoria Kolasa[9], ORCID https://orcid.org/0009-0005-4809-7053
E-mail ekwiktoriakolasa@gmail.com
[9]Wrocław University Hospital, Borowska 213, 50-556 Wrocław, Poland

Maria Jędryka[10], ORCID https://orcid.org/0009-0000-9052-8914
E-mail mjedryka2000@gmail.com
[10]Public health care institution in Oława, Baczyńskiego 1 55-200 Oława, Poland

Corresponding Author
Monika Lis, E-mail monikalis1267@gmail.com

Abstract (Structured)

Background. Axial spondyloarthritis (axSpA) is a chronic immune-mediated rheumatic disease in which genetic susceptibility interacts with tissue-specific inflammatory processes. The disease can impair spinal mobility, physical function, cardiorespiratory fitness,

participation, and quality of life. Exercise and patient education are recommended alongside pharmacological treatment, but the comparative value of specific exercise modalities and delivery models remains uncertain.

Aim. To synthesize current evidence on exercise therapy and adjunct physical therapy interventions in axSpA, with emphasis on clinical outcomes, programme content, supervision, home and technology-supported delivery, adherence, psychosocial factors, and limitations of the evidence.

Material and methods. PubMed/MEDLINE, Scopus, and Web of Science were searched for English-language publications from 2009 through June 2026 concerning axSpA epidemiology, genetic susceptibility, pathophysiology, physical therapy, and exercise.

Results. Structured exercise is associated with modest short-term improvements in self-reported disease activity, physical function, pain, fatigue, and cardiorespiratory fitness.

Conclusions. Regular exercise is a recommended core component of axSpA management. Programmes can be individualized to functional goals, symptoms, comorbidities, safety, access, and patient preference; physiotherapist input may be used for assessment, instruction, progression, and adherence support. Current evidence supports symptom and function management, not disease modification, and does not define a single optimal protocol.

Key words. axial spondyloarthritis; ankylosing spondylitis; exercise therapy; physical therapy; physiotherapy; rehabilitation; physical activity

1. Introduction

Axial spondyloarthritis (axSpA) is a chronic immune-mediated rheumatic disease with a predilection for the sacroiliac joints and spine. The term encompasses radiographic axSpA (r-axSpA; equivalent to ankylosing spondylitis [AS]) and non-radiographic axSpA (nr-axSpA). These categories are distinguished by the presence or absence of definite radiographic sacroiliitis on conventional radiography; nr-axSpA is not simply an early or mildly symptomatic form, and the two groups can have a similar patient-reported disease burden and impairment in quality of life. Common manifestations include inflammatory back pain, stiffness, fatigue, restricted spinal or chest-wall mobility, peripheral arthritis, and enthesitis. Uveitis, psoriasis, and inflammatory bowel disease may coexist [1, 2].

1.1 Epidemiology and Disease Burden

Axial spondyloarthritis usually emerges in young adulthood, most often during the third decade of life. Population estimates vary substantially across regions. A recent Lancet Seminar

reports prevalence estimates of approximately 0.3% to 1.4%, with geographic variation influenced by the background prevalence of human leukocyte antigen B27 (HLA-B27) and by differences in case ascertainment. Most incidence studies cited in that review reported approximately 7 new cases per 100,000 persons per year; however, these data were derived mainly from the USA and northern Europe and should not be treated as a worldwide rate [2].

Sex distribution differs across the radiographic spectrum. Radiographic axSpA typically shows a male predominance, with a male-to-female ratio of approximately 2-3:1, whereas nr-axSpA has an approximately equal sex distribution. These patterns do not support applying a single sex ratio to all axSpA or attributing the difference to HLA-B27 alone. Comparative cohorts also indicate that symptoms begin at a similar young-adult age in the two groups, while diagnosis is often delayed for several years [1, 2].

Radiographic status does not correspond directly to patient-reported burden. A systematic review and meta-analysis of 60 studies found broadly comparable patient-reported disease activity, physical function, and quality of life in r-axSpA and nr-axSpA, despite greater structural damage and poorer spinal mobility in r-axSpA. The burden also extends to work and participation: approximately two thirds of actively employed people with axSpA report work-related problems, although estimates vary by setting and measurement. Rehabilitation needs should therefore be assessed from symptoms, function, participation, and individual goals rather than inferred from radiographic category alone [1, 2].

1.2 Genetic Susceptibility

Axial spondyloarthritis has a substantial polygenic component, with heritability estimates exceeding 90%. HLA-B27 is the strongest established genetic susceptibility factor, but it is neither necessary nor sufficient for disease: axSpA occurs in HLA-B27-negative individuals, while more than 95% of HLA-B27 carriers in the general population do not develop ankylosing spondylitis. The frequency of HLA-B27 and the strength of its association with disease vary by ancestry and clinical phenotype. HLA-B27 should therefore be understood as a susceptibility allele that modifies diagnostic probability in an appropriate clinical context, not as a standalone diagnosis or a deterministic predictor [2, 3, 4].

Beyond HLA-B27, endoplasmic reticulum aminopeptidase 1 (ERAP1) is among the most important susceptibility loci outside the major histocompatibility complex (MHC). ERAP1 trims peptides in the endoplasmic reticulum before their presentation by MHC class I molecules. The reported gene-gene interaction between ERAP1 and HLA-B27 supports a role

for peptide processing and antigen presentation in disease susceptibility. This interaction does not mean that every ERAP1 variant confers the same risk, nor does it establish a single obligatory mechanism through which HLA-B27 leads to inflammation; the relative contributions of altered peptide presentation, protein misfolding, and other proposed HLA-B27-related mechanisms remain incompletely resolved [3, 4].

Additional susceptibility signals, including variation in the interleukin-23 receptor gene (IL23R), implicate type 17 immunity, innate immune signalling, epithelial or barrier function, and tissue remodelling. These associations help identify disease pathways at population level but do not establish current inflammatory activity or functional limitation in an individual [2, 4]. None of the rehabilitation studies synthesized in this review evaluated genotype-guided physiotherapy. Exercise content, dose, supervision, and setting should therefore be individualized according to clinical phenotype, symptoms, functional impairments, goals, comorbidities, safety, access, and patient preference rather than genetic profile.

1.3 Pathophysiology Relevant to Rehabilitation

The enthesis and adjacent bone are considered central tissue compartments in axSpA. Entheses are load-transmitting insertions of tendons, ligaments, joint capsules, or fascia into bone. Their close vascular connection with peri-entheseal marrow, including transcortical vessels, permits communication between local stromal and immune cells and may facilitate adjacent osteitis. In the axial skeleton, signals arising from entheses and subchondral bone are thought to contribute to inflammation in nearby structures; synovial membrane pathology is considered mainly secondary rather than the primary initiating lesion [2, 5].

This genetic background interacts with local mechanical and microbial or barrier-related triggers. Mechanistic models propose that prostaglandin E2 promotes vasodilatation and recruitment of innate immune cells, while tumour necrosis factor (TNF) and interleukin-17 (IL-17) act as important effector cytokines [5]. Interleukin-23 (IL-23) can activate type 17 responses in experimental models, but the pathway is not a simple linear IL-23-to-IL-17 cascade in established human axial disease: IL-17 can be produced independently of IL-23, and IL-23 inhibition has not shown clinical efficacy in axSpA despite strong preclinical rationale. Access to inflamed human entheseal tissue is limited, and much of the cellular evidence derives from animal models or normal enthesis obtained during surgery [2, 4].

Mechanical strain is therefore a biologically plausible contributor to local immune activation and repair, but the strength of evidence differs by setting. Causal links between

mechanical loading, enthesitis, and new bone formation have been demonstrated mainly in animal models; human evidence is largely anatomical, imaging-based, or observational. Following inflammation, mesenchymal responses involving hedgehog, bone morphogenetic protein, and Wnt signalling may promote chondrocyte and osteoblast differentiation and contribute to enthesophytes or syndesmophytes. This is not an obligatory linear sequence: fatty lesions are not necessary intermediates, and many new syndesmophytes arise at sites without preceding MRI bone-marrow oedema or fatty change [2, 4, 5].

These mechanisms provide context for rehabilitation but do not establish disease modification by exercise. Occupational overload, experimental mechanical strain, and therapeutic exercise are not interchangeable exposures, and mechanistic data cannot be used to infer that prescribed exercise either accelerates or prevents structural damage. Clinical exercise studies support modest short-term improvement in symptoms, function, and selected fitness outcomes, but have not shown statistically significant pooled reductions in CRP or ESR and have not tested long-term radiographic progression. Exercise should therefore be prescribed for mobility, function, fitness, symptom management, and participation, with load adapted to symptoms, structural limitations, comorbidity, and individual response; control of immune-mediated inflammation remains part of rheumatological treatment [6, 7].

The goals of management are to control symptoms and inflammation, preserve function and social participation, and prevent or limit progressive structural damage. The 2022 Assessment of SpondyloArthritis International Society-European Alliance of Associations for Rheumatology (ASAS-EULAR) recommendations state that optimal care combines pharmacological and non-pharmacological treatment. Patients should be educated about axSpA and encouraged to exercise regularly; physiotherapy should be considered as part of non-pharmacological management [2, 8].

The rationale for exercise is strong, but the evidence is more nuanced than a simple statement that all forms of physical therapy are effective. Exercise trials vary substantially in diagnosis, disease activity, pharmacological background, programme content, dose, supervision, comparators, and outcome selection. Many studies are small and unblinded, and several recent meta-analyses include overlapping trials or multiple reports from the same cohort. Improvements in patient-reported disease activity also should not be equated with suppression of biological inflammation or prevention of structural progression.

This narrative review evaluates the role of physical therapy in axSpA with four aims: to summarize the magnitude and certainty of benefit from structured exercise; compare major

exercise modalities and delivery settings; examine adherence, psychosocial, and biomechanical factors relevant to rehabilitation; and distinguish clinically reasonable practice from claims not yet supported by direct evidence.

2. Narrative Review Methods

A comprehensive literature search was performed using major biomedical databases, including PubMed, Scopus, ScienceDirect, and Google Scholar. The search focused on epidemiology, genetic susceptibility, pathophysiology, physical therapy, exercise, rehabilitation, mobility, cardiorespiratory fitness, pain, fatigue, quality of life, adherence, psychosocial factors, gait, and adjunct rehabilitation modalities in axial spondyloarthritis and ankylosing spondylitis. Eligible sources included management recommendations, narrative and systematic reviews, meta-analyses, randomized or controlled trials, prospective cohort studies, and cross-sectional studies.

Genetic and mechanistic publications were used to establish disease context and the biological limits of rehabilitation inference, not as evidence of clinical effectiveness. Publications were included in the clinical synthesis when they directly informed exercise therapy, physical therapy delivery, functional outcomes, adherence, psychosocial factors, gait, or adjunct rehabilitation modalities. Papers concerned primarily with diagnostic biomarkers, pharmacological mechanisms, or bibliometric trends were not used as evidence of clinical effectiveness. Duplicate records were identified by DOI and title and consolidated before citation renumbering.

For treatment studies, the extracted elements were study design, population, sample size, intervention and comparator, duration, between-group results, adverse events, and reported limitations. When an article's narrative conclusion conflicted with its forest plot or confidence interval, the numerical result and confidence interval guided interpretation. Within-group improvement was not treated as evidence of superiority over a comparator. Systematic reviews and randomized trials were prioritized for treatment effects; observational studies were used only to describe associations or potential assessment targets.

3. Role and Goals of Physical Therapy

In this review, physical therapy is used as an umbrella term for assessment, individualized exercise prescription, education and self-management support, progression and monitoring, and selected adjunct techniques. Potential rehabilitation targets include spinal and peripheral

mobility, posture, strength and endurance, cardiorespiratory fitness, breathing mechanics, balance, walking capacity, and confidence in physical activity. Target selection should be individualized and linked to participation and patient priorities rather than treated as a fixed protocol [2].

For clarity in this review, exercise therapy refers to planned, structured, and repetitive activity intended to improve health or function, whereas physical activity also includes work, transport, domestic tasks, and leisure activity. A patient may complete prescribed mobility exercises yet remain sedentary for most of the day, or may be active but lack the specific mobility, strength, or aerobic stimulus needed to address an impairment. Assessment and planning can therefore consider both a structured exercise programme and sustainable daily physical activity, with the relative emphasis determined by individual goals and barriers.

Physical therapy complements rather than replaces anti-inflammatory treatment [2]. The Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) is a patient-reported measure that includes fatigue, pain, tenderness, and morning stiffness; a lower BASDAI after exercise does not by itself establish suppression of biological inflammation or disease modification. The 2025 meta-analysis found no statistically significant pooled effect on C-reactive protein (CRP) or erythrocyte sedimentation rate (ESR) [6], and the available short-duration exercise trials did not test prevention of syndesmophytes or ankylosis [6, 7].

4. Overall Effectiveness of Structured Exercise

4.1 Disease activity and physical function

Recent meta-analyses generally agree that exercise produces short-term improvement in patient-reported disease activity and function, but the size and certainty of effect vary. A 2026 review of 15 randomized trial reports found lower BASDAI (standardized mean difference [SMD] -0.75, 95% confidence interval [CI] -1.19 to -0.31), lower Ankylosing Spondylitis Disease Activity Score (ASDAS; SMD -0.91, 95% CI -1.54 to -0.29), and better Bath Ankylosing Spondylitis Functional Index (BASFI; SMD -0.37, 95% CI -0.47 to -0.26) after exercise than after control conditions [7]. The review rated certainty as low for BASDAI, ASDAS, BASFI, and fatigue, moderate for the Bath Ankylosing Spondylitis Metrology Index (BASMI), and very low for chest expansion. Publication bias was detected for BASFI and chest expansion.

A 2025 meta-analysis of 20 randomized trial reports similarly found improvements in BASDAI, ASDAS, BASFI, pain, fatigue, peak oxygen uptake, and 6-minute walk distance [6].

It reported a BASFI weighted mean difference of -0.49 (95% CI -0.65 to -0.32), an ASDAS difference of -0.44 (95% CI -0.64 to -0.24), and a 6-minute walk distance difference of 27.64 m (95% CI 12.04 to 43.24). However, some pooled outcomes were heterogeneous, blinding was frequently absent, and the review did not apply the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. Both recent meta-analyses included overlapping studies and, in some instances, separate reports from the same underlying trials; their participant totals should therefore not be interpreted as independent replication.

The most defensible conclusion is that structured exercise can produce modest short-term improvement in symptoms and physical function. The evidence does not support describing these estimates as uniform across all patients, clinically large for every outcome, or proof of long-term disease control.

4.2 Spinal mobility, chest expansion, and cardiorespiratory outcomes

Effects on spinal mobility are smaller and less consistent than effects on patient-reported function. The 2026 meta-analysis found a small improvement in BASMI (SMD -0.26, 95% CI -0.49 to -0.04) with moderate-certainty evidence [7]. In the 2025 analysis, the initial pooled BASMI estimate was heterogeneous; after sensitivity analysis it was close to the null (weighted mean difference -0.17, 95% CI -0.34 to 0.00) [6]. These findings suggest that mobility can improve, but the expected average change is limited and may depend on baseline restriction, programme content, and measurement method.

Chest expansion illustrates the uncertainty created by different study selections. The 2026 review reported a small benefit (SMD 0.35, 95% CI 0.04 to 0.65), based on four small trials and very-low-certainty evidence with possible publication bias [7]. The 2025 review found no statistically significant pooled effect on chest expansion [6]. Exercise nevertheless improved peak oxygen uptake and walking capacity in selected studies, supporting inclusion of aerobic conditioning when clinically appropriate. Respiratory or chest-mobility exercises may be useful components, but current evidence does not show that they reverse established pulmonary disease.

4.3 Inflammatory biomarkers and structural outcomes

The 2025 meta-analysis found no significant effect on CRP or ESR [6]. Most trials were too short to evaluate radiographic progression, and none of the reviewed exercise syntheses established prevention of new bone formation. Mechanistic hypotheses involving cytokine regulation, body composition, or cardiovascular health are biologically plausible, but they

should not be presented as confirmed clinical pathways without direct biomarker or imaging evidence. Exercise should be recommended for symptom, function, fitness, and general health benefits while pharmacological control of inflammation remains coordinated by the rheumatology team.

4.4 Safety and tolerability

Adverse-event reporting was sparse and inconsistent across exercise trials. In the mind-body meta-analysis, only 7 of 15 trials reported harms and none reported a serious exercise-related event; broader exercise reviews did not provide sufficient data to estimate event frequency or comparative safety [6, 9, 10]. Trials often excluded patients with major cardiopulmonary, neurological, or orthopaedic comorbidity, severe functional limitation, or contraindications to exercise testing. Absence of reported harm in selected samples is therefore not equivalent to comprehensive safety evidence. As a pragmatic safety approach, baseline assessment and appropriate modification are particularly important in advanced structural disease, severe pain, cardiovascular risk, poor balance, or suspected fracture. New neurological symptoms, acute severe spinal pain, or a significant change in function require medical assessment rather than routine progression of exercise [2].

5. Exercise Content and Modality

5.1 Mobility, posture, and respiratory exercise

Mobility and postural exercise remain logical components of axSpA rehabilitation because spinal stiffness, reduced chest-wall movement, and postural adaptation can directly limit function. Programmes commonly include cervical, thoracic, lumbar, hip, and shoulder mobility; stretching; spinal extension; postural control; and breathing exercises. The available evidence supports their inclusion within a multimodal programme but does not identify a single superior method.

Global Postural Reeducation (GPR), which uses prolonged active stretching of muscle chains with breathing control, has been evaluated in four small controlled studies. A systematic review found no reliable superiority over conventional exercise for BASDAI, BASFI, pain, cervical rotation, chest expansion, or modified Schober testing [11]. A pooled advantage for finger-to-floor distance was based on two highly heterogeneous studies with effects in opposite directions. GPR can be considered an alternative structured stretching approach, but claims of broad superiority are not justified.

5.2 Aerobic and strengthening exercise

Aerobic and strengthening exercise address reduced cardiorespiratory fitness, fatigue, muscle deconditioning, and cardiovascular risk. The pooled improvements in peak oxygen uptake and walking distance support their use [6]. However, exercise intensity, frequency, and duration varied widely across trials, and meta-regression findings about sex or session length are exploratory study-level associations, not reliable patient-level prescribing rules.

Programmes should be progressed from the patient's baseline capacity and treatment goals. Aerobic activity can be delivered through walking, cycling, aquatic activity, or other tolerated modes. Strengthening should address trunk and limb function without assuming that high-intensity training is appropriate for every patient. Current evidence does not support a universal dose or the claim that one intensity is safer or more effective for a particular age or sex subgroup.

5.3 Mind-body exercise, yoga, and Pilates

A 2024 meta-analysis of 15 randomized trials involving 855 participants found that pooled mind-body exercise programmes, encompassing Tai Chi, yoga, Pilates, and Qigong, improved BASFI, BASDAI, BASMI, pain, and Ankylosing Spondylitis Quality of Life (ASQoL) relative to heterogeneous control conditions [9]. This does not mean that every modality was evaluated for every outcome: the pain analysis included only Tai Chi and Qigong trials. Certainty was moderate for BASFI, BASDAI, and BASMI and low for pain and ASQoL. Only 7 of the 15 trials reported adverse events; two reported mild stomach or abdominal symptoms, while the remaining reporting studies identified no serious events.

A sparse network meta-analysis ranked running, Pilates, stretching, yoga, and Tai Chi above conventional care for BASFI, but most nodes were supported by one small trial, indirect comparisons did not show significant differences between modalities, and the network did not justify a clinically robust ranking [12]. Exercise selection should therefore be guided by goals, access, safety, and preference rather than by claims that one named modality is universally best.

Two recent randomized trials illustrate both the potential and the limitations of combined programmes. In 51 completers with AS, adding 30 minutes of yoga-based mobility, breathing, relaxation, and meditation to 30 minutes of physician-supervised aerobic exercise twice weekly for 6 weeks improved chest expansion, BASMI, and 6-minute walk distance after correction for multiple testing [13]. The combined group received twice the total session duration, so the independent effect of yoga cannot be isolated. In a separate 8-week trial with 26 completers,

aerobic exercise plus clinical Pilates produced greater improvement than aerobic exercise alone in BASMI, BASDAI, selected flexibility and balance measures, ASQoL, and fatigue, but not in BASFI, muscle strength, 6-minute walk distance, sleep, anxiety/depression, or kinesiophobia [14]. These small trials support offering multimodal exercise, not categorical superiority.

5.4 Aquatic and land-based exercise

Aquatic exercise may reduce loading, facilitate movement, and provide an alternative for patients who find land exercise difficult or unpleasant. In an assessor-blinded randomized trial, 57 patients with AS were assigned to supervised multidimensional mobility exercise in water or on land, or to a home programme; 46 completed 8 weeks [15]. Both supervised groups improved selected clinical and pulmonary-function measures, while the home group showed no significant change. Between-group analyses suggested additional effects of aquatic exercise on inspiratory and expiratory muscle pressures. Participants did not have clinical pulmonary involvement, dropout was substantial, and the findings do not establish treatment of pulmonary disease.

A second three-arm trial compared Aqua Stretch, Aqua Pilates, and usual care in men with AS. Forty of 51 randomized participants were analyzed after 24 sessions over 6 weeks. Both aquatic programmes improved pain, BASFI, 40-m walking time, ASQoL, and spinal inclination range of motion within groups. Time-by-group effects indicated differential improvement for pain, BASFI, and walking time, but not for ASQoL or spinal range of motion; there was no statistically significant difference between Aqua Stretch and Aqua Pilates [16]. Adverse events were not systematically reported. Aquatic exercise is therefore a reasonable option, but evidence does not show that a specific aquatic method is superior or that water-based exercise is required for all patients.

6. Delivery, Supervision, and Long-Term Engagement

6.1 Supervised versus home exercise

Supervision provides opportunities to assess safety, teach technique, individualize progression, and address barriers. It should not, however, be assumed to be an active treatment component that always produces better clinical outcomes. A 2022 systematic review found small benefits of supervised physiotherapy over usual care for BASDAI and BASFI, but no clear advantage over home-based exercise [10]. Most evidence was rated low or very low

because of bias, heterogeneity, and imprecision. The review's forest plots did not support broad superiority for pain, spinal mobility, or quality of life.

One assessor-blinded trial randomized 45 adalimumab-treated patients with AS, of whom 40 were analyzed, to pamphlet-based home exercise, a 2-hour instruction session followed by home exercise, or fully supervised clinic exercise for one month; both home groups also received adherence messaging and telephone monitoring [17]. The fully supervised arm improved chest expansion more than the pamphlet-only arm and improved ASDAS more than both home arms. However, both full supervision and the 2-hour instruction arm outperformed pamphlet-only exercise for BASMI, with no difference between those two supported arms, and BASFI did not differ among groups. This small, brief trial suggests that intensive support may improve selected short-term outcomes in adalimumab-treated patients, but it does not establish general superiority over a well-instructed and monitored home programme.

A systematic review of five trials found that supervised group exercise improved depression more than unsupervised home exercise (three trials; SMD -0.54, 95% CI -0.89 to -0.18) and also improved BASFI [18]. Evidence for anxiety and broader mental health came from one trial each, and long-term maintenance was uncertain. Group delivery may offer peer support and a structured routine, while home exercise reduces travel and scheduling barriers. A practical model is to use supervision for assessment, instruction, progression, or periods of difficulty and to support independent exercise between reviews.

6.2 Technology-supported home programmes

Technology may extend contact beyond the clinic, but the independent effect of a device is difficult to separate from the wider programme in which it is embedded. A 16-week pilot trial in 54 Chinese adults with AS and no regular exercise habit evaluated a multicomponent home programme supported by a heart-rate wristband and smartphone application [19]. The intervention also included counselling, two supervised instruction periods, an individualized functional exercise plan, and regular reporting. Median adherence was 84.2%, and the programme improved ASDAS and several secondary clinical and fitness outcomes relative to usual activity. Three participants reported transient ankle or hip pain that resolved after exercise modification; no serious adverse events occurred. The study supports feasibility of a technology-supported package, not the efficacy of the wristband alone.

Digital delivery can be useful where access, travel, or work schedules limit attendance. It also creates risks: incorrect technique may be missed, digital literacy varies, and symptom

algorithms do not replace clinical judgment. Technology should support feedback, monitoring, and communication rather than be presented as an autonomous source of individualized rehabilitation advice.

6.3 Adherence and psychosocial factors

Long-term benefit depends on continued participation. In a 6-month prospective cohort of 225 predominantly male patients with AS in remission who were discharged from a tertiary rheumatology ward to home-based rehabilitation, self-reported physical activity varied over time [20]. In the multivariable generalized estimating equation model, activity was associated with education, biologic use, BASFI, anxiety, perceived exercise benefits and barriers, and social support; depression and exercise self-efficacy were associated only in univariable analyses. These observational associations identify potential targets for discussion and follow-up but do not show that changing any single factor will increase activity.

Cross-sectional studies have described associations among pain catastrophizing, fear of movement, competence frustration, body awareness, depression, and physical function [21, 22]. Statistical mediation in a cross-sectional survey is compatible with an indirect relationship through fear of movement or competence frustration, but it cannot establish temporal or clinical causality. Rehabilitation can reasonably use collaborative goal setting, graded exposure, education, and referral for psychological support when indicated, yet trials are still needed to determine whether specifically targeting these constructs improves axSpA outcomes.

7. Gait, Enthesitis, and Impairment-Specific Rehabilitation

Gait alterations in AS may reflect pain, spinal rigidity, posture, reduced hip movement, fatigue, or foot involvement. Three cross-sectional studies reported non-uniform differences in cadence or walking speed, step or stride length, support or coordination measures, and plantar loading, together with selected associations between gait variables and clinical status [23, 24, 25]. In Yentur et al., ultrasound-measured plantar fascia thickness, used by the authors as an indicator of enthesitis, correlated with selected gait measures; the design cannot establish that enthesitis caused those differences. In the smallest pedobarographic study, the AS group was older, age was a significant covariate for stride length, and the adjusted group effect for dynamic midfoot force fell short of statistical significance.

These studies are useful for hypothesis generation but do not demonstrate that gait variables predict future disease progression, nor do they test whether gait, balance, or foot-focused rehabilitation improves clinical outcomes. Associations were often weak, samples were

small or clinically heterogeneous, and multiple comparisons increased the risk of chance findings. Clinically, gait and foot assessment may help identify a relevant impairment and guide an individualized plan. It should not be presented as an evidence-based requirement for every patient with axSpA.

8. Adjunct Physical Therapy Modalities

8.1 Manual soft-tissue mobilization

Evidence for manual therapy is limited. In a small randomized study, 21 of 28 allocated participants completed 4 weeks of supervised spinal-mobility exercise with or without individualized soft-tissue mobilization [26]. Between-group changes favored the combined intervention for BASFI and selected BASMI measures, but not for BASDAI, pain, total Nottingham Health Profile, Roland-Morris Disability Questionnaire, modified Schober test, or cervical rotation. The groups were small and unbalanced after dropout and differed in medication use. Gentle soft-tissue mobilization may be considered an adjunct for selected mobility or soft-tissue restrictions, but the evidence does not support a broad claim that it reduces disease activity or adds benefit across all outcomes.

8.2 Whole-body cryotherapy

A non-randomized, assessor-blinded comparative study allocated 92 inpatients with AS to exercise alone or the same exercise following whole-body cryotherapy at −60 °C or −110 °C for 8 treatment days [27]. All groups improved in symptoms, function, and mobility, while CRP did not change. The only significant comparison favoring cryotherapy was a lower post-treatment BASDAI after −110 °C plus exercise than after exercise alone; no advantage was shown for ASDAS-CRP, pain, function, mobility, chest expansion, or CRP. Three participants in the cryotherapy groups discontinued because of respiratory infection. The absence of randomization, short duration, lack of follow-up, and limited between-group effect make the evidence insufficient for routine recommendation.

9. Clinical Implications

Regular exercise is recommended as a core element of axSpA care [2]. A clinically reasonable individualized assessment can consider symptoms and functional goals alongside spinal and peripheral mobility, strength and endurance, cardiorespiratory fitness, balance and gait when relevant, fatigue, physical activity, confidence, comorbidities, treatment status, and safety. Exercise planning should be integrated with medical management; the reviewed

evidence does not define a disease-activity threshold that must be reached before exercise begins.

Depending on identified goals, a programme may include mobility and postural exercise, aerobic conditioning, strengthening, and functional practice. Breathing or chest-mobility exercise, mind-body methods, aquatic exercise, or balance and gait work may be added when they match an identified need or patient preference. Current evidence does not establish an optimal combination or justify prescribing a named modality solely because it ranked highly in a sparse network meta-analysis [6, 9, 12].

Potential roles for physiotherapist input include assessment of precautions, instruction, adaptation to pain or structural restriction, progression, and adherence support. Current evidence does not identify which patients require ongoing supervision or the optimal review frequency. Some patients may benefit from supervised or group programmes, whereas others may exercise effectively at home with periodic review; access, cost, travel, work, digital literacy, and patient preference can inform delivery [2, 10, 17, 18].

Outcomes should be monitored across more than one domain. Improvement in pain or BASDAI can represent symptomatic benefit even when CRP is unchanged, but it should not be interpreted as biological disease modification. Goal-based monitoring can include walking capacity, fatigue, confidence, or participation alongside BASMI, because effects differ across outcome domains [6, 7]. In clinical practice, programme review is reasonable when goals are not met, adherence is low, symptoms change unexpectedly, or new safety concerns emerge; this is a pragmatic recommendation rather than a comparative-effectiveness finding from the reviewed trials.

10. Limitations of the Evidence and Research Priorities

The evidence base has several recurring limitations. Most trials enrolled people with established AS/r-axSpA, so generalization to nr-axSpA is uncertain. Samples were commonly small, interventions lasted weeks rather than years, and participants and therapists could rarely be blinded. Exercise dose, comparators, medication use, and outcome definitions differed substantially. Some meta-analyses included overlapping cohorts or multiple reports from the same trial, and several outcomes showed heterogeneity, imprecision, or publication bias. Adverse events were inconsistently collected. Within-group improvement was sometimes emphasized despite no significant between-group difference.

The present review used a narrative search rather than a preregistered systematic-review protocol. Although PubMed/MEDLINE, Scopus, and Web of Science were searched, the selection process was not designed to be exhaustive and may have omitted relevant studies. No independent risk-of-bias assessment was performed beyond the judgments available in source reviews. Its purpose is to provide a clinically calibrated narrative synthesis rather than a definitive comparative effectiveness ranking.

Future trials should preregister a primary outcome, use concealed allocation and blinded outcome assessment where possible, report adherence and adverse events consistently, and distinguish unique participants from secondary trial reports. Longer follow-up is needed to test maintenance, participation, cardiovascular outcomes, and structural progression. Studies should include nr-axSpA and more diverse age, sex, disease-severity, and comorbidity profiles. Factorial or pragmatic designs could help separate the effects of exercise content, supervision, group support, digital feedback, and total dose. Psychosocial and gait-related interventions require prospective testing rather than inference from cross-sectional associations.

11. Conclusions

Regular exercise is a recommended core component of multidisciplinary axSpA management. The strongest evidence supports modest short-term improvements in symptoms and physical function. Average effects on spinal mobility are small, chest-expansion findings are inconsistent, and pooled improvements in peak oxygen uptake and walking capacity are based on relatively few trials without GRADE assessment. Exercise has not produced statistically significant pooled reductions in CRP or ESR, and available trials have not evaluated whether it prevents long-term structural progression.

No single modality or delivery setting is universally superior. Supervision, group exercise, mind-body methods, aquatic exercise, and technology-supported home programmes can each be useful when matched to patient needs, but their comparative evidence is limited. Manual soft-tissue mobilization has preliminary evidence for selected functional and mobility outcomes, whereas whole-body cryotherapy lacks sufficient evidence for routine use.

A clinically grounded approach is a shared, individualized programme that may combine mobility, strengthening, aerobic, and functional components according to patient goals, capacity, safety, access, and preference. Physiotherapist input may be used for assessment, instruction, progression, and adherence support, while the programme remains integrated with rheumatological care. Future research should prioritize long-term, methodologically rigorous,

and generalizable trials rather than increasingly precise rankings from small heterogeneous studies.

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Author Contributions:

Conceptualization: Monika Lis,

Methodology: Hubert Piwar,

Investigation: Monika Lis, Marta Kaczorek

Resources: Monika Lis, Aleksandra Stadnik, Olga Kowalczyk

Data curation: Wiktoria Kolasa, Bożena Kiełbasa

Writing-rough preparation: Monika Lis,

Writing review and editing: Hubert Piwar, Katarzyna Pagacz

Visualization: Monika Lis,Maria Jędryka

Supervision: Hubert Piwar, Julia Gatniejewska

All authors have read and agreed with published version of the manuscript.

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Abbreviations

The following abbreviations are used in this manuscript: AS, ankylosing spondylitis; ASAS-EULAR, Assessment of SpondyloArthritis International Society–European Alliance of Associations for Rheumatology; ASDAS, Ankylosing Spondylitis Disease Activity Score; ASQoL, Ankylosing Spondylitis Quality of Life; axSpA, axial spondyloarthritis; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index; BASFI, Bath Ankylosing Spondylitis Functional Index; BASMI, Bath Ankylosing Spondylitis Metrology Index; CI, confidence interval; CRP, C-reactive protein; ERAP1, endoplasmic reticulum aminopeptidase 1; ESR, erythrocyte sedimentation rate; GPR, Global Postural Reeducation; GRADE, Grading of Recommendations Assessment, Development and Evaluation; HLA-B27, human leukocyte antigen B27; IL-17, interleukin-17; IL-23, interleukin-23; IL23R, interleukin-23 receptor (gene); MHC, major histocompatibility complex; MRI, magnetic resonance imaging; nr-axSpA, non-radiographic axial spondyloarthritis; r-axSpA, radiographic axial spondyloarthritis; SMD, standardized mean difference; TNF, tumour necrosis factor.

References

1. Lopez-Medina C, Ramiro S, van der Heijde D, Sieper J, Dougados M, Molto A. Characteristics and burden of disease in patients with radiographic and non-radiographic axial spondyloarthritis: a comparison by systematic literature review and meta-analysis. RMD Open. 2019;5(2):e001108. https://doi.org/10.1136/rmdopen-2019-001108
2. Navarro-Compan V, Sepriano A, Capelusnik D, Baraliakos X. Axial spondyloarthritis. Lancet. 2025;405(10473):159-172. https://doi.org/10.1016/S0140-6736(24)02263-3
3. Khan MA. HLA-B*27 and Ankylosing Spondylitis: 50 Years of Insights and Discoveries. Curr Rheumatol Rep. 2023;25(12):327-340. https://doi.org/10.1007/s11926-023-01118-5
4. van de Sande MGH, Elewaut D. Pathophysiology and immunolgical basis of axial spondyloarthritis. Best Pract Res Clin Rheumatol. 2023;37(3):101897. https://doi.org/10.1016/j.berh.2023.101897
5. Schett G, Lories RJ, D'Agostino MA, Elewaut D, Kirkham B, Soriano ER, McGonagle D. Enthesitis: from pathophysiology to treatment. Nat Rev Rheumatol. 2017;13(12):731-741. https://doi.org/10.1038/nrrheum.2017.188
6. Zhang M, Liang Z, Tian L, Han Y, Jiang X, Li Y, et al. Effects of exercise therapy in axial spondyloarthritis: a systematic review, meta-analysis, and meta-regression of randomized trials. Arch Phys Med Rehabil. 2025;106(1):113-123. https://doi.org/10.1016/j.apmr.2024.06.005
7. Yu C, Guo L, Gao X, Shen X, Ma X, Li J, et al. Exercise prescription for axial spondyloarthritis: a systematic review and meta-analysis of randomized controlled trials. Front Med (Lausanne). 2026;13:1783569. https://doi.org/10.3389/fmed.2026.1783569
8. Ramiro S, Nikiphorou E, Sepriano A, Ortolan A, Webers C, Baraliakos X, et al. ASAS-EULAR recommendations for the management of axial spondyloarthritis: 2022 update. Ann Rheum Dis. 2023;82(1):19-34. https://doi.org/10.1136/ard-2022-223296
9. Wang J, Li X, Yang F, Guo P, Ren C, Duan Z, et al. Efficacy and safety of mind-body exercise for patients with axial spondyloarthritis: a systematic review and meta-analysis. J Orthop Surg Res. 2024;19(1):586. https://doi.org/10.1186/s13018-024-05072-5
10. Pontone Gravaldi L, Bonetti F, Lezzerini S, De Maio F. Effectiveness of physiotherapy in patients with ankylosing spondylitis: a systematic review and meta-analysis. Healthcare (Basel). 2022;10(1):132. https://doi.org/10.3390/healthcare10010132
11. Gonzalez-Medina G, Perez-Cabezas V, Marin-Paz AJ, Galan-Mercant A, Ruiz-Molinero C, Jimenez-Rejano JJ. Effectiveness of Global Postural Reeducation in ankylosing spondylitis: a systematic review and meta-analysis. J Clin Med. 2020;9(9):2696. https://doi.org/10.3390/jcm9092696
12. Luo Y, Chen Y, Yan X, Zhang L, Shang Y, Seo JC. Effectiveness of exercise intervention in relieving symptoms of ankylosing spondylitis: a network meta-analysis. PLoS One. 2024;19(6):e0302965. https://doi.org/10.1371/journal.pone.0302965
13. Onal R, Ordu Gokkaya NK, Dizdar D, Korkmaz S, Alemdaroglu E, Guler T, et al. Enhancing spinal mobility and functional capacity through aerobic exercise and yoga

in ankylosing spondylitis: a randomized controlled trial. Rheumatol Int. 2026;46:140. https://doi.org/10.1007/s00296-026-06185-2
14. Oksuz S, Unal E. Comparison of the effects of aerobic training alone versus aerobic training combined with clinical Pilates exercises on the functional and psychosocial status of patients with ankylosing spondylitis: a randomized controlled trial. Physiother Theory Pract. 2023;39(1):61-71. https://doi.org/10.1080/09593985.2021.2005199
15. Gurpinar B, Ilcin N, Savci S, Akkoc N. Do mobility exercises in different environments have different effects in ankylosing spondylitis? Acta Reumatol Port. 2021;46(4):297-316.
16. Gandomi F, Soufivand P, Ezati M, Salimi M, Assar S, Pournazari M, et al. The effect of Aqua Stretching exercises and Pilates on pain, function and spine posture in patients with ankylosing spondylitis: a randomized controlled trial. BMC Sports Sci Med Rehabil. 2022;14(1):183. https://doi.org/10.1186/s13102-022-00577-0
17. Hosseini M, Rahimibarghani S, Ghorbanpour S, Movassaghi S, Emami-Razavi SZ, Azadvari M, et al. The effects of supervision on the outcomes of exercise training in patients with ankylosing spondylitis: a single-blind randomized controlled trial. Int J Rheum Dis. 2023;26(6):1120-1128. https://doi.org/10.1111/1756-185X.14711
18. Lane B, McCullagh R, Cardoso JR, McVeigh JG. The effectiveness of group and home-based exercise on psychological status in people with ankylosing spondylitis: a systematic review and meta-analysis. Musculoskeletal Care. 2022;20(4):758-771. https://doi.org/10.1002/msc.1641
19. Wang Y, Liu X, Wang W, Shi Y, Ji X, Hu L, et al. Adherence, efficacy, and safety of wearable technology-assisted combined home-based exercise in Chinese patients with ankylosing spondylitis: randomized pilot controlled clinical trial. J Med Internet Res. 2022;24(1):e29703. https://doi.org/10.2196/29703
20. Fang HY, Pan YH, Zhang YH, Deng YH, Li XW, Huang L, et al. Factors associated with physical activity in home-based rehabilitation patients with ankylosing spondylitis: a prospective longitudinal study. Musculoskeletal Care. 2025;23(3):e70131. https://doi.org/10.1002/msc.70131
21. Rouse PC, Ingram T, Standage M, Sengupta R. Fear of movement and competence frustration mediate the relationship between pain catastrophising and physical function in people living with axSpA: an online cross-sectional survey. Rheumatol Int. 2024;44(5):933-941. https://doi.org/10.1007/s00296-024-05557-w
22. Karaca NB, Arin-Bal G, Sezer S, Kelesoglu Dincer AB, Kinikli G, Bostrom C, et al. Physical activity, kinesiophobia, pain catastrophizing, body awareness, depression and disease activity in patients with ankylosing spondylitis and rheumatoid arthritis: a cross-sectional explorative study. Musculoskeletal Care. 2024;22(4):e1953. https://doi.org/10.1002/msc.1953
23. Yentur SB, Bilek F, Deniz G, Akgol G, Koca SS. Enthesitis of plantar fascia affects gait in patients with ankylosing spondylitis. J Am Podiatr Med Assoc. 2024;114(6):23-159. https://doi.org/10.7547/23-159
24. Brnic V, Grubisic F, Grazio S, Mirkovic M, Gruic I. Optomechanical analysis of gait in patients with ankylosing spondylitis. Sensors (Basel). 2025;25(6):1797. https://doi.org/10.3390/s25061797
25. Park YG, Goh TS, Kim DS, Jung SJ, Lee JS. Relationships between clinical status and gait parameters in ankylosing spondylitis. Clin Orthop Surg. 2023;15(2):249-256. https://doi.org/10.4055/cios22112

26. Gur Kabul E, Basakci Calik B, Oztop M, Cobankara V. The efficacy of manual soft-tissue mobilization in ankylosing spondylitis: a randomized controlled study. Int J Rheum Dis. 2021;24(3):446-455. https://doi.org/10.1111/1756-185X.14072
27. Romanowski MW, Straburzynska-Lupa A. Is the whole-body cryotherapy a beneficial supplement to exercise therapy for patients with ankylosing spondylitis? J Back Musculoskelet Rehabil. 2020;33(2):185-192. https://doi.org/10.3233/BMR-170978