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Exercise for ankylosing spondylitis: An evidence-based consensus statement

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ABSTRACT

Objective: Despite Level 1b evidence and international consensus that exercise is beneficial in ankylosing spondylitis (AS), there is a paucity of detailed information to guide exercise prescription, including the type and dosage of exercise required for the most benefit. This collaborative project, combining evidence with clinical expertise, was established to develop practical recommendations to guide sustainable exercise prescription for individuals with AS.

Methods: Using a modified Delphi technique, 10 clinical questions were generated and a systematic literature review was conducted for each. Draft recommendations were developed at a 2-day meeting, based on the integration of evidence summaries and expert opinion. Feedback was obtained from patient and health professional groups prior to finalisation.

Results: Recommendations and practice points were developed for the following areas: assessment; monitoring; safety; disease management; AS-specific exercise; physical activity; dosage, adherence and setting. A framework was developed that could also be adapted for exercise in other chronic musculoskeletal conditions. Feedback suggests that the final consensus statement provides useful information for those seeking to provide best practice exercise prescription for people with AS.

Conclusion: The recommendations provide an up-to-date, evidence-based approach to the full range of issues related to the use of exercise in AS, as well as identifying evidence gaps for further research. Most importantly, this includes investigation of aspects of exercise programme design required to produce the largest effect, long-term adherence with exercise programs and the specific exercise requirements of sub-groups of people with AS. Widespread dissemination and implementation of the guidelines will be required to optimise exercise outcomes.

Introduction

Individuals with ankylosing spondylitis (AS) experience pain and stiffness, which mainly affects the axial skeleton (spine, hips

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and shoulders). Since the condition is an inflammatory arthritis, fatigue can also be a prominent symptom [1]. The primary pathology includes enthesitis, or inflammation of the anatomical region of the bony attachment of tendons, ligaments or joint capsules [2]. Typically this occurs in the spine; if unchecked, new bone formation may result in ankylosis, or spinal fusion. The most common age of onset is in early adulthood, therefore the lifetime individual impact of AS can be high [3]. Traditionally, the condition has been managed with a combination of anti-inflammatory medication and exercise, with the latter appearing anecdotally to be more effective than for other types of arthritis.

Although exercise recommendations feature prominently in relevant clinical guidelines for the management of ankylosing spondylitis [4–7], and are supported by a body of mixed-quality evidence [8], in clinical practice there is a lack of specific information to guide exercise planning [9,10]. The majority of published evidence focuses on mobility exercise [9], and relatively little attention has been given to other aspects of exercise programme design such as strengthening, balance or cardio-respiratory exercise, despite recognition that AS can affect muscle strength [11], balance [12] and cardio-respiratory function [13]. Similarly, there is little information about dosage (frequency, intensity and duration) or adherence to recommended programs [9]. Several trials are based on intensive, time-limited (often residential) exercise modalities, which are not readily available in many regions—such as in-patient rehabilitation or spa therapy/exercise combinations [14]. Lastly, recent rapid advances in medical management, such as tighter control of disease activity by the use of anti-tumour necrosis factor-alpha (anti-TNFα) agents, have raised questions about the ongoing relevance of exercise in the management of AS [15].

The task of developing an optimally effective, evidence based and sustainable exercise programme for a person or a group with AS therefore remains challenging. The overall objective of this project was to develop more specific recommendations covering a range of topics which need to be considered for exercise prescription—primarily for use by health professionals, but also for people with AS who may wish to acquire more detailed information about the use of exercise as a self-management strategy.

Methods

Systematic review

The Writing Group (WG) comprised 11 physiotherapist members of an ankylosing spondylitis special interest group in Australia, and a rheumatologist (J.Z.) with experience in Delphi methodology and guideline development. WG members independently submitted up to 10 questions of clinical importance to their practice, which were grouped into nine topics by the project co-ordinators (J.M. and J.Z.). These were assessment, monitoring, safety, disease management, AS-specific exercise, physical activity, dosage, adherence and setting. A systematic review was carried out for each topic; details of the methods are shown in Appendix A (Section A1). All WG members then participated in the assessment of included studies, using a pro forma "article summary" tool to record quality, relevance to a non-residential setting and reproducibility of the exercises in a "real-life" context. Meta-analysis was performed using random effects models where data was available to allow pooling, that is, for pain, disease activity, spinal mobility measures (cervical mobility, fingertip to floor distance, chest expansion and lumbar flexion) and physical function. An "evidence matrix" was compiled by the co-ordinators to show the number, type and quality of studies; overall level of evidence; consistency of results and (where applicable) effect sizes. Any discrepancies were resolved by discussion. Details of the flow of studies are shown in Figure A1, included and excluded full-text papers (with reasons for exclusion) at A2 and A3 and evidence for the recommendations at Appendix B.

Consensus meeting

A 2-day face-to face meeting was held to review the evidence and develop recommendations, during which WG members presented topic summaries, as described above. These findings were discussed in the context of the collective clinical experience of the group, before recommendations were derived for each topic. After gaining appropriate ethics approval, consumer and health professional feedback on the draft recommendations was obtained by anonymously surveying people with AS (via patient support groups) and health professionals (via professional organisations). Further information regarding the surveys is provided in Appendix C, Section 1 (C1). The consensus statement wording was adjusted and further independent voting by the WG was used to finalise each recommendation.

Grade of recommendations

The Australian National Health and Medical Research Council (NHMRC) hierarchy [16] was used to grade the recommendations as follows: *Evidence-Based Recommendation (EBR)* based on a body of evidence, graded A–D depending on types of studies and consistency of results; *Consensus Based Recommendation (CBR)* developed by the WG in the absence of direct evidence, or poor quality evidence, to answer the question and *Practice Points (PP)* developed by the WG where there was a need to provide practical guidance to support the implementation of EBRs and CBRs. The derivation of PPs is shown in Appendix C, Section 2 (C2).

Results

The final 10 recommendations with practice points are listed at Box 1. The process of developing the recommendations highlighted the complexities of therapeutic exercise prescription and the potential for multiple interactions between the different topics examined. Figure 1 summarises the recommendations and relationships of these factors, and may be useful in informing joint (patient and health professional) decision making regarding exercise choice. A plain language summary of the recommendations and framework is also provided in Appendix C, Section 3 (C3). Survey results (Table C1) demonstrated a high level of patient importance (mean for all recommendations 8.46/10; range: 8.0–8.9) and health professional (HP) support (mean = 8.66 and range: 7.3–9.58). The mean proportion of HPs who stated that the recommendation was already their practice was 60.2%, whilst 21% stated that the recommendation would modify their practice. 0.8% of HPs reported that they did not wish to change their practice, and the remainder (17.8%) stated that the recommendation did not apply to their practice. The background, clinical question(s), results and rationale for each recommendation are outlined as follows.

Assessment and monitoring

Background

Pre-exercise objective physical measures are an established component of individual exercise prescription, serving to inform individual training goals; appropriate exercise type(s); starting dose precautions (which may indicate exercise modification), and personal information regarding the need for specific exercise [17].

Box 1–Recommendations and practice points

Exercise for ankylosing spondylitis (AS): a consensus statement

Applicability: People who have AS at any stage, including early disease [96,97]

Recommendation 1: Assessment

Individual exercise prescription should be informed by a thorough and reproducible assessment, which includes musculoskeletal and psychosocial factors, and AS-specific measures, including objective axial mobility and chest expansion (CBR).

- The Bath Ankylosing Spondylitis Metrology Index (BASMI) [42] is the most widely reported, validated objective axial mobility measure
- BASMI is associated with quality of life, physical function and psychological status
- The BASMI 10-point scoring scale (tabular or linear) is recommended over the 3-point scale
- Imaging review/discussion with medical team may be indicated for more advanced disease
- Tape-based hip internal rotation is a responsive measure for hip involvement
- Strength, balance or cardiorespiratory function should be assessed as required

Recommendation 2: Monitoring

Sufficient monitoring and feedback should be provided on an individual basis, to achieve confidence and competence with exercise, and to inform changing needs for exercise prescription. This is recommended at least annually, and more often as symptoms, function and mobility indicate (CBR).

- Feedback, particularly mobility measures, can be important for exercise adherence.
- BASMI raw scores are more sensitive to change than index scores
- In BASMI, lumbar side flexion is the most sensitive to change
- The Edmonton AS Metrology Index (EDASMI) [98] may be useful for patient self-monitoring

Recommendation 3: Safety

Throughout all aspects of exercise prescription, especially for those with more severe or later disease, the physical changes of AS must be considered. These include the amount of bony change/ankylosis, balance and mobility changes, osteoporosis and cardiorespiratory consequences of the disease (CBR).

Most types of exercise are safe for the majority of patients. However, the following require assessment on a case by case basis, and may be contra-indicated in more advanced AS:

- High impact exercise/physical activity (e.g., contact sports, martial arts, four wheel driving, boating in rough seas, fairground rides)
- High velocity or strongly resisted exercise, especially trunk flexion/rotation
- Exercise which excessively challenges balance, postural stability or cardiorespiratory function (in a non-controlled environment)
- Excessive spinal or peripheral joint mobility gain where there is adjacent ankylosis
- Excessive end range mobility gain following total hip replacement

Recommendation 4: Disease management

Individuals receiving anti-TNFα therapy should continue with regular exercise prescription as it confers an additional benefit to anti-TNFα therapy alone (EBR, grade B)

- Exercise could theoretically be a mediator of inflammation in AS, but trial results have been conflicting
- Stabilisation with anti-TNF therapy can be a “window of opportunity” to optimise mobility and physical fitness

Recommendation 5: AS-specific exercise—Mobility

Individual exercise prescription with an emphasis on spinal mobility is paramount for best management of AS. Maintaining mobility of peripheral joints is also essential. This can be achieved through a number of approaches. At this time we are unable to recommend one approach over another, therefore individual goals should be informed by assessment findings. (EBR grade A)

- Mobility goals may vary from restoration of full spinal range and normal posture (early, well-controlled disease), to maintenance of existing range (later disease)
- Exercise choice (e.g., specific proprioceptive neuromuscular facilitation techniques) can be tailored to target movement or functional deficits

Recommendation 6: AS-specific exercise—other

Stretching, strengthening, cardiopulmonary and functional fitness are important components to include in a balanced exercise programme (EBR grade A)

- There is preliminary evidence for (modified) Pilates and tai chi, incentive spirometry and global postural re-education as effective modalities

Recommendation 7: Physical activity

Regular physical activity should be encouraged to promote general health, well-being and functional outcomes (EBR, grade B)

- No one activity has been found to be superior
- Regular interruption of sedentary activities should also be encouraged
- Occupational, transport and leisure activities contribute to total physical activity levels

Recommendation 8: Dosage
Exercise frequency, intensity, duration and type must be tailored to the persons assessment findings, goals and lifestyle.
(a) For mobility, stretch and postural exercise, consistency is the most important factor
(b) For other exercise types, national physical activity guidelines may require modification. Consideration should be given to disease stage, activity and progression, whilst aiming for optimal effectiveness (EBR, grade C)

Factors which may indicate modification of baseline exercise dose include pain/fatigue; disease activity and any secondary AS consequences (cardiorespiratory, ankylosis, osteoporosis, balance impairment)

Dosage progression (titration) should balance individual exercise response with training for physiological change
Mobility exercise can be incorporated in regular breaks from sitting
Short-term more intensive doses may be appropriate for specific purposes

Recommendation 9: Adherence
It is important to assess adherence with regular exercise, encourage motivation and promote ongoing self-management (EBR, grade B)

Group settings and monitoring have been shown to support adherence in AS

Recommendation 10: Exercise setting
Priority should be given to patient preference in exercise choice, to enhance adherence and optimise positive outcomes (CBR).

AS-specific group therapy and warm water exercise may be beneficial adjuncts to an individual's regular home exercise programme

Where available, exercise supervision appears to enhance effectiveness

Recommendations are shown in bold type, with supporting practice points where there was a need to provide practical guidance to support the recommendation. Development details, definitions and evidence are shown in Appendix B (recommendations) and Appendix C (practice points).
Evidence-Based Recommendation (EBR), based on body of evidence[99]:
grade A: Body of evidence can be trusted to guide clinical practice
grade B: Body of evidence can be trusted to guide clinical practice in most situations
grade C: Body of evidence provides some support for recommendation, but care should be taken in its application
grade D: Body of evidence is weak and recommendation should be applied with caution
Consensus Based Recommendation (CBR), developed by the WG where there was insufficient direct (or poor quality) evidence to answer the clinical question.

The clinical questions were: *In adults with ankylosing spondylitis, which measures are beneficial for baseline mobility assessment in order to inform exercise prescription? What are the minimum requirements for monitoring these measures?*

Results

Although a number of (largely non-controlled) cross-sectional studies found relationships between axial mobility (anthropometric) measures and self-reported domains such as physical function, disability and quality of life [18–21], Van Weely [22] found that self-reported function was typically reported as being more impaired than objectively measured function. Self-reported scores therefore do not substitute for objective measures, and hence the rationale for an accurate assessment that includes both subjective and objective components. The choice of AS-specific tools is further discussed at B1.1 and C2.1, but as a minimum, validated axial mobility measures and chest expansion should be completed. As reflected in the statement below, a combination of self-reported and objective information usefully informs exercise prescription and identifies where more detailed assessment may be indicated. Analysis of such tests is beyond the scope of this review, but many are simple and quick to perform in the clinical setting, and may be required to assess the consequences of more advanced AS on strength, balance or cardio-respiratory function.

Recommendation 1: Assessment. Individual exercise prescription should be informed by a thorough and reproducible assessment, which includes musculoskeletal and psychosocial factors, and AS-specific measures, including objective axial mobility and chest expansion (CBR).

No direct evidence was found to answer the question regarding monitoring. However, in the experience of the WG, there is also rationale for longitudinal monitoring of AS anthropomorphical measures, in order to evaluate exercise effectiveness, assess change in mobility and provide personal feedback, which may be motivational. In clinical practice, patients appear to value the objective information provided by assessment and it appears to have a positive effect on exercise behaviour [23], hence the following recommendation.

Recommendation 2: Monitoring. Sufficient monitoring and feedback should be provided on an individual basis, to achieve confidence and competence with exercise, and to inform changing needs for exercise prescription. This is recommended at least annually, and more often as symptoms, function and mobility indicate (CBR).

Safety

Background

The WG was anecdotally aware of single case adverse events associated with exercise, including spinal fracture/cord injury, hip arthroplasty dislocation and spinal pseudarthrosis/discitis. The clinical question was: *In adults with AS, what safety aspects should be considered in relation to exercise prescription?*

Results

Direct evidence for exercise safety issues (including adverse events) relating to AS was not found, therefore indirect evidence of secondary disease consequences was reviewed. The AS population includes people for whom the risks of exercise are higher than a non-AS population, secondary to:

(a) small increases in cardio-vascular risk factors and ischaemic heart disease [24];

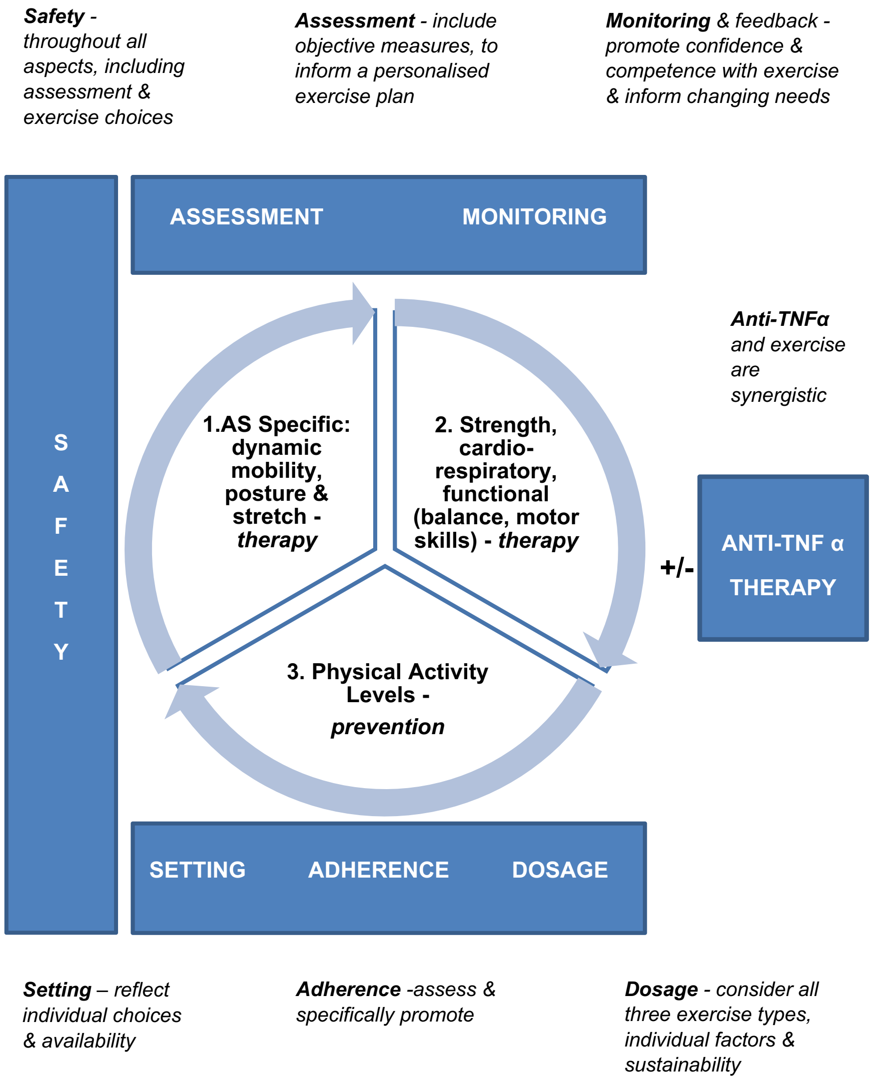


Fig. 1. Framework for exercise and ankylosing spondylitis
Aims:

(1) Address primary (musculoskeletal) consequences of AS.
(2) Address secondary consequences of AS (cardio-respiratory, balance, osteoporosis).
(3) Facilitate physical activity according to national guidelines, with modification for AS symptoms, severity, activity and duration as required.

The three main types of exercise for a balanced programme are shown in the circle, numbered for the sequence in which they would usually be addressed. The upper segments of the circle indicate exercise types that are therapeutic, that is, address specific aspects of AS management. The lower segment addresses exercise for maintenance of health, similar to the general population. The arrows indicate that there is interaction between the exercise types. The surrounding bars show key aspects of exercise prescription for consideration throughout the process, from initial assessment to ongoing practice. Finally, the recommendations are broadly applicable and continue to be relevant, even after commencement of anti-TNFα therapy.

(b) decreased pulmonary function (in association with decreased axial mobility) [13,25];
(c) spinal osteoporosis, which appears related to disease activity and duration, and has an incidence of 18–67% [26];
(d) spinal fracture risk in established AS of between 14% and 19% [27], which (due to the biomechanics of an ankylosed spine) is more likely to result in spinal cord injury (SCI) than in a non-ankylosed spine [28] and
(e) Impaired balance and righting reactions, again in association with spinal ankylosis [12].

Other less frequent but recognised complications of AS that may be impacted by inappropriate exercise include discitis/pseudarthrosis (most prevalent at T11/12 level) [29], anterior total hip arthroplasty dislocation [30] and atlanto-axial subluxation [31].

Co-morbidity prevalence was consistently shown to be related to disease severity and/or duration, so it should be emphasised that the additional risks described are largely restricted to those with more advanced disease. However, the potential consequence for an individual of an adverse event is high, and little attention has been paid to this aspect of exercise prescription to date. It seems likely that the benefits of exercise still outweigh the risks for almost all individuals; however, *appropriate* exercise prescription is paramount for those with more severe disease.

Recommendation 3: Safety. Throughout all aspects of exercise prescription, especially for those with more severe or advanced disease, the physical changes of AS must be considered. These include the amount of bony change/ankylosis, balance and mobility changes, osteoporosis and cardiorespiratory consequences of the disease (CBR).

Disease management

Background

It is not known whether the beneficial effects of exercise in AS occur at a systemic (e.g., anti-inflammatory) or local (e.g., enthesis) level. In healthy adults, and those with a number of chronic diseases, exercise can produce systemic anti-inflammatory effects, [32–35], but interactions between exercise and pathology are complex. It may be that exercise can have either pro or anti-inflammatory consequences for individuals with inflammatory arthritis, depending on the type of exercise and the condition concerned [36]. Two clinical questions were generated by the WG on this topic: (1) *Is exercise effective in disease modification (reduction in progression), compared with no exercise?* and (2) are exercises in combination with an anti-TNFα *medication more beneficial than medication alone?* [15].

Results

Insufficient evidence was found to determine whether exercise produces local and/or systemic effects in AS, and so a recommendation regarding disease modification was not made. However, two RCTs [37,38], two non-randomised experimental trials [39,40] and one interrupted time series without controls [41] were identified in patients on anti-TNFα therapy. The trials consistently demonstrated the beneficial effect of a combination of anti-TNFα therapy and an AS-specific exercise programme, compared with either anti-TNFα treatment or exercise alone, for both self-reported measures (such as function and disease activity) and objective measures, such as the Bath Ankylosing Spondylitis Metrology Index (BASMI) [42]. Further detail is shown in Appendix B, Section 3.

Recommendation 4: Disease management. Individuals receiving anti-TNFα therapy should continue with regular exercise prescription as it confers an additional benefit to anti-TNFα therapy alone (EBR, grade B).

AS-specific exercise

Background

Traditional goals of exercise in AS have focussed on improving and/or maintaining physical function and posture by: mobility exercises for axial and peripheral joints; muscle strengthening (especially "antigravity" muscles); stretching of specific muscle groups; and cardiorespiratory fitness [43]. The combination of soft tissue stretch and dynamic joint mobility exercises for "tight" or shortened soft tissues/restricted joints, and improved recruitment and strengthening of "lengthened" muscles is thought to target the biomechanical, mobility and postural changes of AS. The clinical question was: *In adults with AS, is therapeutic (specifically prescribed) exercise aimed at:*

(a) improving mobility/posture;
(b) increasing strength;
(c) improving cardiorespiratory fitness and
(d) improving function (balance, co-ordination, gait, agility and proprioception),

more beneficial for pain, mobility, disease activity and physical function than no exercise/general advice only?

Results

There were eight systematic reviews (SRs) concerning exercise interventions that were widely available or could be reproduced in a non-residential setting. Three [6,8,9] included meta-analysis of outcome measures, with a consistent trend for small to medium effects (including pain, physical function, axial mobility and other self-reported outcome measures), in favour of various exercise interventions.

A total of 11 individual RCTs met our criteria, and most (9 of 11) met the commonly used benchmark for a "good quality" study, with a score of six or more on the Physiotherapy Evidence Database (PEDro scale) [44]. The results are summarised in Tables 1 and 2, and in more detail in Appendix B (Section B1.4 and Table B1), and again show a high level of consistency for small to moderate benefits for pain, disease activity, axial mobility and function. This was confirmed by our meta-analyses of these studies, displayed as Forest plots in Figure 2. Statistical heterogeneity was low for most outcomes (cervical mobility, finger to floor distance, chest expansion, pain and disease activity) but was moderate for lumbar flexion and substantial for physical function. Potential sources of heterogeneity in exercise trials include the trial participants (in this case, disease severity is particularly relevant); exercise dosage (including variation in trial duration and exercise frequency, intensity and time); programme design (for example, type of exercises, their delivery method and setting) and trial methodology and quality [45].

While these effects are small to modest, recent academic discussion has also highlighted the issue of therapeutic validity of trials [46], that is, whether the exercises described meet guidelines for dosages known to produce physiological improvements. In general, there was poor reporting of exercise goals, programme design, outcome measures and adherence, and the links between these components were not specified. Dosage (particularly intensity) appeared to be insufficient in most trials [9].These factors may account for the trial effect sizes being somewhat disappointing, compared with those reported by patients and clinicians.

Overall, the WG found that the consistent evidence of benefits for exercise in AS was sufficient to form recommendations focussing on axial mobility exercises plus stretch, strength, cardiopulmonary and functional fitness. Evidence for further specificity was not available, and the WG's clinical question regarding the best exercise programme could not be fully answered, although benefits for specific types of exercise could also not be excluded. Given the large spectrum of disease activity, severity and variation in presentation of mobility impairment in AS, it seems likely that "best practice" will continue to be an individualised programme where exercises are selected to target an improvement (or prevention of deterioration) of identified postural, biomechanical and functional changes. Clearly, there is overlap and interaction between the different exercise categories, but in a balanced programme, each aspect should facilitate performance of the other, as shown visually in Figure 1.

Recommendation 5: AS-specific exercise (mobility). Individual exercise prescription with an emphasis on spinal mobility is paramount for best management of AS. Maintaining mobility of peripheral joints is also essential. This can be achieved through a number of approaches. At this time we are unable to recommend one approach over another, therefore individual goals should be informed by assessment findings (EBR grade A).

Recommendation 6: AS-specific exercise (other). Stretching, strengthening, cardiorespiratory and functional fitness are important components to include in a balanced exercise programme (EBR grade B).

Table 1
AS-specific exercise: interventions and outcomes (pain, disease activity and physical function)

Study	Treatment groups	PEDro Score/10	No. in group	Duration	Assess point(s)	Outcome SMD (95% CI)		
						Pain	Disease activity	Physical function
Altan (2012) [54]	Intervention: pilates with trainer, × 3/week Control: standard treatment programme	8	30 25	12 weeks	Week 12 Week 24		−1.00 (−2.00 to −0.00)	−0.36 (−0.90 to 0.19)
Analay (2003) [101]	Intervention: AS education session; supervised exercise programme, × 3/week Control: AS education session; instruction to perform the same exercises at home × 3/week; weekly progress phone call	7	23 22	6 weeks	Week 6 Week 12	0.02 (−0.57 to 0.60)		−0.39 (−0.98 to 0.21)
Cagliyan (2007) [77]	Intervention: AS education session; supervised exercise programme × 2/week Control: AS education session; instruction to perform exercises at home; telephone follow-up	4	23 23	12 weeks	Week 12 Week 24		−1.00 (−1.84 to −0.16)	−0.62 (−1.21 to −0.03)
Fernandez-de-las-Penas (2005) [61]	Intervention: weekly supervised exercise session, global postural re-education method Control: weekly supervised exercise, using conventional exercises	6	20 20	16 weeks	Week 16		−0.02 (−0.64 to 0.60)	−0.04 (−0.66 to 0.58)
Hidding (1993) [102]	Intervention: weekly group physiotherapy: mobility/strengthening exercises, sports and hydrotherapy, plus daily individual home exercise programme Control: daily individual exercise programme	7	67 68	36 weeks	Week 36	not estimable		−0.12 (−0.46 to 0.21)
Ince (2006) [103]	Intervention: supervised multi-modal exercise programme (warm-up, aerobic step, stretching and pulmonary exercises) plus information on exercise benefits Control: information on exercise benefits only	7	15 15	12 weeks	Week 12			
Kraag (1990) [58]	Intervention: home physiotherapy: combination of education, passive techniques plus therapeutic exercise according to individual problem list Control: no treatment	8	22 26	16 weeks	Week 16	−0.73 (−1.31 to −0.14)		−1.78 (−2.47 to −1.10)
Lee (2008) [104]	Intervention: tai chi for RA programme; plus home practice; tai chi video; telephoned by researchers × 2/week Control: no structured exercise programme; telephoned by researchers × 2/week	6	13 17	8 weeks	Week 8		−0.03 (−1.19 to 1.12)	
Lim (2005) [59]	Intervention: home exercise programme (for muscle relaxation, flexibility, strength, breathing and posture) taught individually; requested practise was daily × 30 min Control: no intervention	6	25 25	8 weeks	Week 8	−0.34 (−0.90 to 0.21)	Not estimable	−0.67 (−1.24 to −0.10)
Maseiro (2011) [37]	Intervention A: educational/behavioural meetings × 2, then exercise training × 2/week: flexibility, stretches, proprioceptive, breathing and endurance. Home practice × 3–4/week requested; exercise DVD and monthly phone calls. Intervention B: educational/behavioural meetings only Control: no intervention	7	20 20 22	6 weeks	Week 8 Week 24	−0.63 (−1.25 to −0.01)	−0.38 (−1.72 to 0.96)	−0.56 (−1.18 to 0.06)
So (2012) [60]	Intervention: incentive spirometer exercise programme daily, plus education/conventional home exercise programme (spinal flexibility, stretches and breathing exercises) Control: education and individual counselling plus instruction in a conventional home exercise programme	6	23 23	16 weeks	Week 16		−0.61 (−1.53 to 0.31)	−0.36 (−0.95 to 0.22)
Overall Effect	NB. All in favour of intervention groups					−0.42 (−0.74 to −0.09)	−0.47 (−0.84 to −0.09)	−0.51 (−0.81 to −0.21)

MD = mean difference; SMD = standardised mean difference; PEDro = Physiotherapy evidence database; VAS = visual analogue scale; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; BASFI = Bath Ankylosing Spondylitis Functional Index.

Table 2
AS-specific exercise: axial mobility interventions and outcomes

Study	Exercise type	Mobility/stretch exercise type						Mobility outcomes			
		DF	AcS	BS	PS	PNF	U	Lumbar flexion SMD (95% CI)	Cervical mobility SMD (95% CI)	Chest expansion MD cm (95% CI)	Fingertip to floor distance MD cm (95% CI)
Altan (2012) [54]	Pilates	X					X			0.50 (−0.37, 1.37)	
Analay (2003) [101]	Multi-modal						X	0.40 (−0.19 to 1.00)		0.51 (−0.68 to 1.70)	−2.63 (−12.06 to 6.80)
Cagliyan (2007) [77]	Multi-modal						X		−0.09 (−0.67 to 0.48)		
Fernandez-de-las-Penas (2005) [61]	Global postural re-education	X			X	X		−0.24 (−0.87 to 0.38)	0.00 (−0.62 to 0.62)		
Hidding (1993) [102]	Mobility						X	Not estimable	Not estimable	Not estimable	
Ince (2006) [103]	Multi-modal		X		X			0.77 (0.03– 1.52)		1.46 (0.29– 2.63)	−3.40 (−14.62 to 7.82)
Kraag (1990) [58]	Mobility					X		0.57 (0.01– 1.13)			−8.50 (−16.06 to −0.94)
Lee (2008) [104]	Tai chi						X				0.50 (−9.38 to 10.38)
Lim (2005) [59][a]	Not specified						X		0.41 (−0.11 to 0.93)		−7.20 (−16.71 to 2.31)
Maseiro (2011) [37]	Multi-modal	X			X	X		0.29 (−0.32 to 0.90)	0.43 (−0.18 to 1.05)	0.95 (−0.10 to 2.00)	
So (2012) [60]	Inventive spirometer						X			0.84 (−0.16 to 1.84)	−5.00 (−11.55 to 1.55)
Overall Effect	NB. All in favour of intervention groups							0.35 (0.02– 0.67)	0.20 (−0.09 to 0.49)	0.81 (0.35– 1.28)	−4.87 (−8.38 to −1.37)

DF = dynamic flexibility; PNF = proprioceptive neuromuscular facilitation; BS = ballistic stretch; U = unspecified; PS = passive static stretch; AcS = active stretch; SMD = standardised mean difference; MD = mean difference; NB. All effects in favour of intervention group.

[a] Data estimated from graphical presentation.

Physical activity

Background

There is a large and compelling body of population-based evidence regarding the importance of physical activity (PA) for health [47], resulting in national PA guidelines for "healthy adults" in most countries. Most current guidelines are based on 150–300 min of moderate intensity, or 75–150 min of vigorous intensity PA per week, plus muscle strengthening at least twice per week [48,49]. The WG was interested in the interpretation of such guidelines for people who have AS, the clinical question being: *which types of physical activity are beneficial for pain, mobility, disease activity and function?*

Results

There is long-standing consensus that sports/activities involving high impact, such as some football codes, martial arts or distance road running should be avoided in AS due to the risk of symptom exacerbation or structural damage to an inflamed or ankylosed spine [43,50]. Similarly, activities that excessively challenge balance may increase falls risk and should therefore be avoided. A recent hypothesis [51] suggests that mechanical stress may have a role in the disease pathology, and if proven this could further influence activity choices. For now, the pragmatic advice remains to avoid high impact activities, particularly in disease that is more active, severe or long-standing.

Regarding types of widely available leisure activities, three small RCTs investigated the effects of tai chi [52], swimming [53] and Pilates [54]. These activities combine aspects of mobility, strength and functional (neuromotor) training, suggesting that they could be beneficial in AS, and the trials demonstrated small to moderate improvements for self-reported and performance-based measures. A larger survey of 1538 people with AS found an association with physical activity levels (PALs) and mobility, but evidence was not found for the superiority of one activity over another [55].

In summary, there was insufficient evidence to show that one type of activity is more beneficial, but there is no reason to suggest that people with AS would not benefit from maintaining PALs as per the general population. It seems likely that individuals with early AS would benefit from a different set (and greater range) of activities than those with later/more advanced disease. In the latter case, safety factors are paramount and physical activity guidelines for an older population (such as the National Physical Activity Recommendations for Older Australians) [56] may be appropriate.

Recommendation 7: Physical activity. Regular physical activity should be encouraged to promote general health, well-being and functional outcomes (EBR, grade B).

Dosage

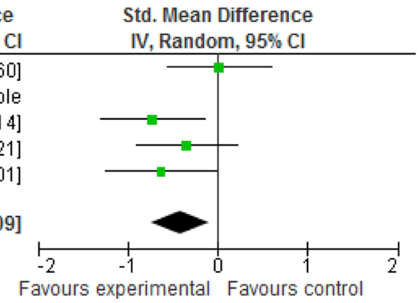
Background

FITT-VP [17] is a widely used framework for exercise dosage and comprises six components: frequency (how often); intensity (how hard); time (duration) and type, resulting in a total exercise volume with the last component being "progression." Exercise dosage should be considered for these parameters in all three of the exercise components shown in Figure 1; however, the many variables contributing to an individual's dose response (including genetics, pathology, physiology, psychosocial factors and settings/environments [57]), mean that personalised adaptation of any recommendations is desirable. A further consideration is the concept of intensive (larger volume) exercise doses that may be

A Pain

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Analay 2003	3.75	2.55	23	3.7	3.45	22	25.1%	0.02 [-0.57, 0.60]
Hidding 1993	0	0	0	0	0	0		Not estimable
Kraag 1990	24.2	25.9	22	43.1	25.4	27	25.2%	-0.73 [-1.31, -0.14]
Lim 2005 (1)	3.078	3.306	25	4.104	2.508	25	27.0%	-0.34 [-0.90, 0.21]
Maseiro 2011	19.55	13.72	20	30.73	20.13	22	22.7%	-0.63 [-1.25, -0.01]
Total (95% CI)			**90**			**96**	**100.0%**	**-0.42 [-0.74, -0.09]**

Heterogeneity: Tau² = 0.02; Chi² = 3.71, df = 3 (P = 0.29); I² = 19%
Test for overall effect: Z = 2.50 (P = 0.01)

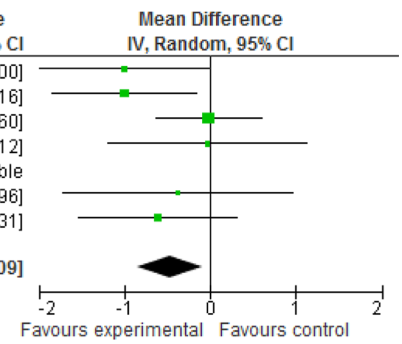


(1) Data estimated from graphical presentation

B Disease activity (BASDAI)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Altan 2012	2.1	2	29	3.1	1.7	24	13.8%	-1.00 [-2.00, -0.00]
Cagliyan 2007	2.4	1	23	3.4	1.8	23	19.0%	-1.00 [-1.84, -0.16]
Fernandez-de-les-Penas 2005	2.6	1.13	20	2.62	0.86	20	33.1%	-0.02 [-0.64, 0.60]
Lee 2007 (1)	2.012	1.6	13	2.045	1.6	17	10.4%	-0.03 [-1.19, 1.12]
Lim 2005	0	0	0	0	0	0		Not estimable
Maseiro 2011	2.74	1.71	20	3.12	2.67	22	7.7%	-0.38 [-1.72, 0.96]
So 2012	1.97	1.54	23	2.58	1.65	23	16.0%	-0.61 [-1.53, 0.31]
Total (95% CI)			**128**			**129**	**100.0%**	**-0.47 [-0.84, -0.09]**

Heterogeneity: Tau² = 0.01; Chi² = 5.27, df = 5 (P = 0.38); I² = 5%
Test for overall effect: Z = 2.41 (P = 0.02)

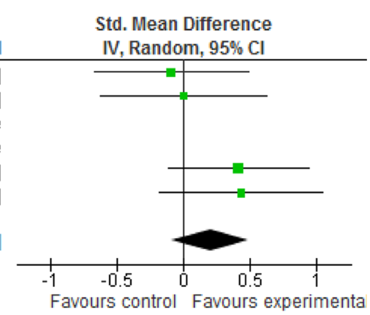


(1) SD imputed from So 2012

C Cervical mobility

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Cagliyan 2007	71	20	23	73	22	23	25.0%	-0.09 [-0.67, 0.48]
Fernandez-de-les-Penas 2005	57	18	20	57	9	20	21.8%	0.00 [-0.62, 0.62]
Hidding 1993	0	0	0	0	0	0		Not estimable
Hidding 1993	0	0	0	0	0	0		Not estimable
Lim 2005	33	18.6	30	26.4	12	28	30.9%	0.41 [-0.11, 0.93]
Maseiro 2011	105.66	37.5	20	90.52	31.16	22	22.3%	0.43 [-0.18, 1.05]
Total (95% CI)			**93**			**93**	**100.0%**	**0.20 [-0.09, 0.49]**

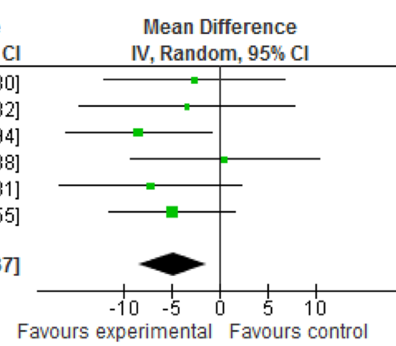
Heterogeneity: Tau² = 0.00; Chi² = 2.59, df = 3 (P = 0.46); I² = 0%
Test for overall effect: Z = 1.36 (P = 0.17)



D Finger to floor distance (cm)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Analay 2003	15.5	14.03	23	18.13	17.92	22	13.8%	-2.63 [-12.06, 6.80]
Ince 2006	14.67	16.55	15	18.07	14.74	15	9.8%	-3.40 [-14.62, 7.82]
Kraag 1990	15.6	11.5	22	24.1	15.2	26	21.5%	-8.50 [-16.06, -0.94]
Lee 2007	11.44	14.1	13	10.94	13.1	17	12.6%	0.50 [-9.38, 10.38]
Lim 2005 (1)	19.2	22.8	30	26.4	13.2	28	13.6%	-7.20 [-16.71, 2.31]
So 2012	8.4	9.9	23	13.4	12.6	23	28.7%	-5.00 [-11.55, 1.55]
Total (95% CI)			**126**			**131**	**100.0%**	**-4.87 [-8.38, -1.37]**

Heterogeneity: Tau² = 0.00; Chi² = 2.54, df = 5 (P = 0.77); I² = 0%
Test for overall effect: Z = 2.72 (P = 0.006)



(1) Data calculated from graphical presentation

Fig. 2. Forest plots of meta-analyses; (A) Pain; (B) disease activity (BASDAI); (C) cervical mobility; (D) finger to floor distance (cm); (E) chest expansion; SD = standard deviation; CI = confidence interval.
Meta-analyses of exercise trials for outcome measures of pain, disease activity, mobility (cervical mobility, finger to floor distance, chest expansion and lumbar flexion) and physical function, summarised as Forest plots for included studies. A random effects model was used due to the heterogeneity of the interventions. The boxes represent point estimates for each study, their size being proportional to the size of study. The horizontal bars represent 95% confidence intervals and the diamond the pooled effect size. Mean differences were calculated where the same scale was used for all studies, and standardised mean differences (SMD) calculated where different scales were reported.

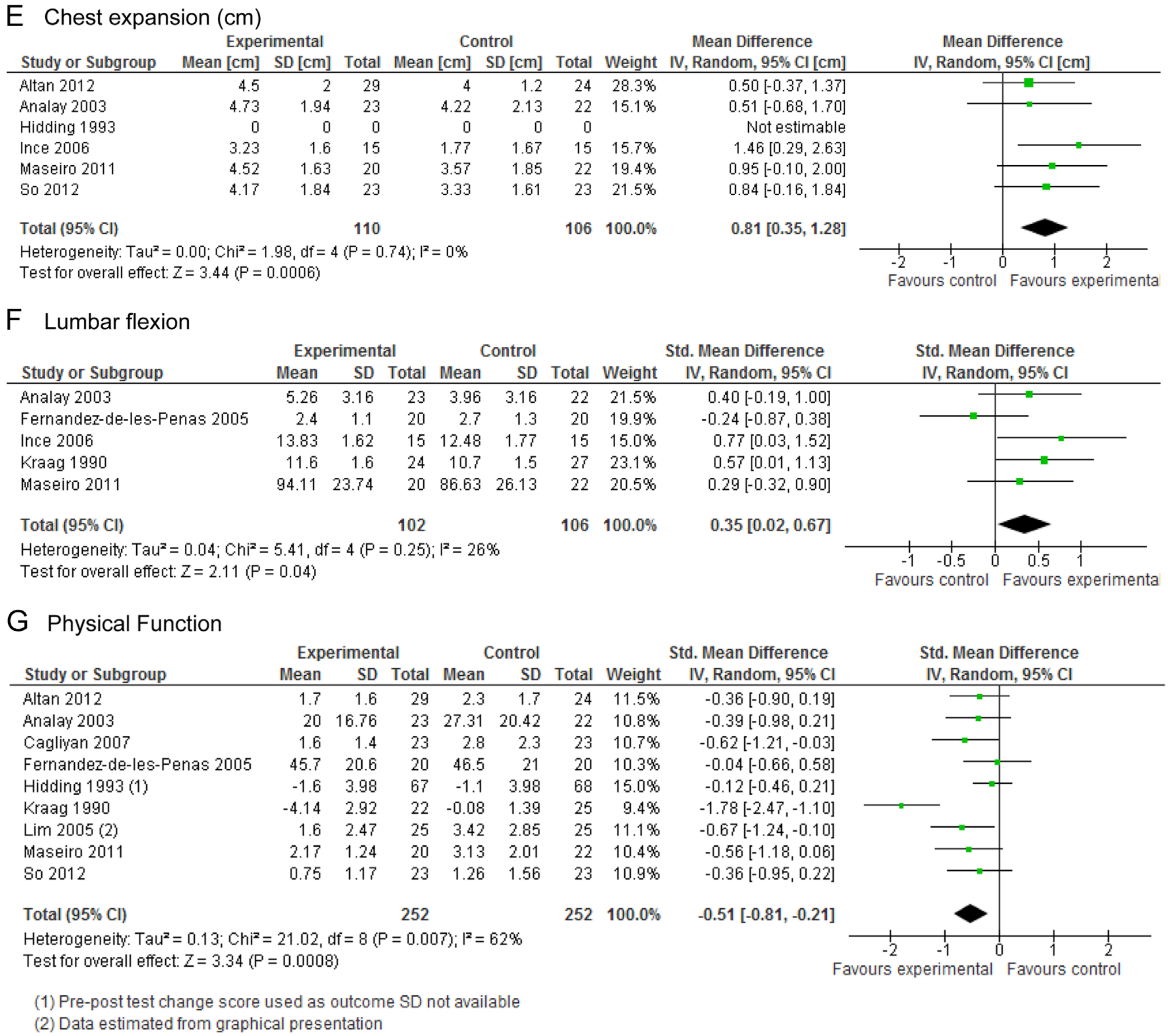


Fig. 2. (*continued*)

indicated in the short-term for a specific purpose, as opposed to sustainable (less intensive, smaller volume) doses for the long term. For mobility, posture and stretch exercise, there is obviously an optimal level that can be achieved: once this is attained and is stable, a "maintenance" dose (rather than progression) is appropriate. The clinical question was: *In adults with AS, what dosage of exercise is beneficial for pain, mobility, disease activity and function?*

Results

The most extensively analysed exercise dosage is that for PALs in healthy adults, as per national physical activity guidelines [48,49]. These are aimed at chronic disease *prevention*, and the evidence for long-term *therapeutic* exercise is less clear.

As can be seen from Table 3, there were limitations to the reported dosage information in included RCTs. In general, information on exercise frequency was available, with "daily" frequency reported in five of 11 studies [52,54,58–60], but with a range down to once per week in one study [61]. Other components of exercise volume were often not reported, including exercise progression.

The association between volume of *habitual* exercise in individuals with AS, and measures of pain, disease activity, mobility and function were examined in 13 cross-sectional studies, and these are presented in Table 4. Again, it was difficult to differentiate between exercise types and reported dosage parameters, and all relied on self-reported measures except Arends et al. [62] who measured PALs with an accelerometer. Following a survey of 4282 people, Santos et al. [63] suggested that exercise consistency is the most important factor. This term was not specified but appeared to relate to 2–4 h of exercise per week on a sustained basis. This was supported by Ward [64] in the USA, who found that back exercises on more than 5 days per week, and recreational exercises for more than 200 min per week, were associated with a decrease in pain and stiffness and improvement in function. The higher frequency of back exercises was also associated with slower progress of functional disability over 5 years. There was no direct evidence to suggest a minimally effective stretch time.

Exercise dosage to address the strength, cardiorespiratory and functional (balance/motor skills) consequences of AS received little attention in the literature. The study by Dagfinrud et al. [9] found no trials that met ACSM criteria for physiological effectiveness for strengthening exercises, and only one trial (of 12) met the criteria for cardiorespiratory exercise. However, it should also be noted that there is a curvilinear dose–response relationship with a steep initial slope [65] and most benefit is therefore to be gained by

Table 3
RCT exercise volume in individuals with AS, compared with pain, disease activity, mobility or function

Author	Country	Frequency (intervention group)	Intensity	Time in minutes/week (session length if reported)	Type	Statistically significant beneficial associations with pain, disease activity, mobility or function
Altan (2012) [54]	Turkey	Daily	n/a	210 balneotherapy; 210 HEP (30 min sessions)	HEP + balneotherapy vs HEP only	Pain, BASDAI, range of mobility measures, BASFI—for both groups
Analay (2003) [101]	Turkey	× 3/week	"To individual tolerance"	150 (50 min sessions)	Stretch, mobility, strength, aerobic	Pain; BASFI
Cagliyan (2007) [77]	Turkey	× 2/week	n/a	120 (60 min sessions)	Joint/spinal mobility, stretching, strength, respiration, posture	Pain, BASDAI, mobility and BASFI
Fernandez-de-las-Penas (2005) [61]	Spain	× 1/week	Mobility 2 × 8–10 reps; stretches up to 4 min	60	Global Postural Re-education	Mobility; function
Hidding (1993) [102]	Netherlands	× 1/week (group) + daily HEP	n/a	180 (group); 156 (HEP)	Physical training (60); sports(60); hydrotherapy (60)	Thoraco-lumbar mobility
Ince (2006) [103]	Turkey	× 3/week	Low intensity aerobic (metronome to standardise intensity)	150 (50 min sessions)	Stretch, aerobic, chest expansion	Range of mobility measures; physical work capacity; vital capacity
Kraag (1990) [58]	Canada	"Daily"	n/a	n/a	Individual exs programme + manual techniques	Finger to floor distance and function
Lee (2008) [104]	South Korea	Instruction × 2/week; daily practice (× 2 daily for last 2 weeks)	n/a	315 (45 min sessions)	Tai chi for RA (warm-up, 21 tai chi movements, cool down)	BASDAI; finger to floor distance
Lim (2005) [59]	South Korea	"Daily"	n/a	210 (30 min sessions)	HEP—mobility; strength; posture	Pain; mobility; function
Masiero (2011) [37]	Italy	× 2/week (group) × 3–4/week (HEP)	Mobility 2 × 10 reps; Stretches 30–40 s; aerobic- low speed, no resistance	120 (60 min group session) HEP n/a	Mobility, breathing exs, balance, posture, proprioception, stretch, strength, aerobic (walk, treadmill, cycle)	BASDAI, BASFI, BASMI
So (2012) [60]	South. Korea	Daily	Incentive spirometer breath holds 3–5 s	Incentive spirometer 350; HEP 350	HEP- mobility; stretch; chest expansion	Mobility; BASDAI, BASFI (both groups); pulmonary function for incentive spirometer group

HEP = Home Exercise Programme; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; BASFI = Bath Ankylosing Spondylitis Functional Index; BASMI = Bath Ankylosing Spondylitis Metrology Index.

Table 4
Habitual ("unsupervised") exercise volume in individuals with AS, and associations with pain, disease activity, mobility or function

Author	Country	Subjects	Frequency	Intensity	Time/week	Type	Other findings
Arends (2011) [62]	The Netherlands	55	n/a	n/a	Measured in kilo counts/day (accelerometer) but values not stated	PAL for 7 days	PAL negatively associated with inflammatory markers, BASFI; positively associated with Schobers test, lateral flexion and neck rotation; no association with chest expansion, BASDAI or occiput to wall distance
Brodin (2007) [105]	Sweden	50	Never 22%; ≤ × 1/week 18%; × 1–2/week but irregular 2%; ≥ × 2/week 58%	n/a	n/a	Pool exs; walk; resistance exs; aerobic exs; cycle; floorball; golf; jogging; Nordic walk; tai chi	Higher exercise frequency (> × 2/week) predicted by long duration of symptoms, prior exercise habits, higher disease activity and living alone
Carter (2006) [69]	UK	131	Daily 35%; × 3–5 /week 26%; × 1–2/week 27%; < × 1/ week or none 12%	n/a	n/a	Walk 73%; swim 27%; HEP 18%; pool exs 14%; cycle 11%	No associations found for pain, BASDAI
Cooksey (2012) [106]	UK	326	Moderate-high PAL by IPAQ-SF score	n/a	n/a	n/a	PALS independently associated with function
Falkenbach (2003) [19]	Austria	132	> × 2/week 19%; × 1–2/ week 36%; < × 1/week 45%	n/a	n/a	Cycle 22%; swim 21%; walk 10%; other sports 47%	PALS positively associated with mobility
Falkenbach (1999) [55]	Austria	132	< × 1/week 36%; × 1–3/ week 46%; > × 3/week 18%	n/a	n/a	AS-specific HEP	Exs frequency positively associated with HAQ score
Fitzpatrick (2006) [70]	Ireland	198	AS-specific 5–7 days/week 20%	n/a	PAL > 200 min/ week 30%	n/a	Barriers to exercise were lack of time and motivation, fear of symptom exacerbation and fatigue
Haglund (2012) [107]	Sweden	2167	Criteria met for moderate (× 5–7/week) or vigorous (2–3/week) physical activity 68%	Criteria for moderate to vigorous PAL met or not met	Exercise sessions > 30 min/week met or not met	n/a	68% met WHO PAL recommendations for healthy adults
O'Shea (2008) [108]	UK	61	Walk × 3 /week 35%; stretch × 3/week 32%	n/a	n/a	n/a	High scores for both perceived benefits and perceived barriers
Santos (1998) [63]	UK	4282	n/a	n/a	0 h 21%; 1 h 20%; 2–4 h 35%; 5–9 h 15%; > 10 h 9%	Sport, AS-specific HEP or hydrotherapy	2–4 h/week positively associated with function and inversely associated with dis. act. > 10 h improved function but not dis. act.
Sundstrom (2002) [109]	Sweden	189	Daily 9%; × 3–6/week 15%; × 1–2/week 30%; < × 1/ week 26%; no exs 17%	n/a	n/a	Walk 57%; pool exs 38%; cycle 33%	Most common exercise barriers were lack of time and fatigue
Uhrin (2000) [110]	USA	220	Back exercises: 30% 0 days/ week; 40% 1–4 days/week; 11% 5–7 days/week	n/a	Median PAL 85 min/week	Back exs Rec exs—several listed	Back exs > 5 days/week and rec. exs > 200 min/week associated with decrease in pain and stiffness, improvement in function
Ward (2002) [64]	USA	212	Back exs 3 ± 2.6 days/week	n/a	Rec. exs. 139 ± 161 min/week	Back exs Rec exs—several listed	More frequent back exs associated with slower progress of functional disability over 5 years

BASDAI = Bath Ankylosing Spondylitis Disease Activity Index; dis. act. = disease activity; BASFI = Bath Ankylosing Spondylitis Functional Index; exs. = exercises; HAQ = health assessment questionnaire; HEP = home exercise programme; PAL = physical activity level; Rec. Exs. = Recreational exercises; WHO = World Health Organisation; IPAQ-SF = international physical activity questionnaire short form.

individuals moving from a sedentary lifestyle to performing some regular exercise, in other words, "some regular exercise is better than none." This may be pertinent to the significant proportion of people with AS who experience persistent pain and/or fatigue [66], particularly when considering a commencement exercise dosage.

In summary, the relative influence of many variables is unique for each person, so a precise "one size fits all" dosage is not possible, and this is reflected in the recommendation. Care should be taken to balance an individual's exercise capacity with attaining an adequate dose for effectiveness. Short-term, more intensive exercise dosage may be indicated to achieve a specific goal. However, long-term "maintenance" AS-specific dosages should be realistic and aim for high frequency (5 or more days per week) and sustainability. This may require compromise from the "ideal" but the dose–response curve suggests that this may be a better outcome than short-lived attempts at unsustainable doses.

Recommendation 8: Dosage. Exercise frequency, intensity, duration and type must be tailored to the person's assessment findings, goals and lifestyle.

(a) For mobility, stretch and postural exercise, consistency is the most important factor and
(b) for other exercise types, national physical activity guidelines may require modification. Consideration should be given to disease stage, activity and progression, whilst aiming for optimal effectiveness (EBR, grade C).

Adherence

Background

The World Health Organisation in its 2003 report "Adherence to long-term therapies: evidence for action" defined adherence as "the extent to which a person's behaviour corresponds with agreed recommendations from a health care provider", and further pointed out that an increase in adherence may be much more effective than a specific improvement in treatment for a population [67]. For people with AS, the data available (Table 4) suggests that this is applicable. Predictors for low levels of exercise in cross-sectional studies appear inconsistent, as they include less disability [19], increased pain [68,69], increased body mass index (BMI) [70] and lower spinal mobility [62]. The relevant clinical question was therefore *which interventions are beneficial for supporting adherence to an exercise plan?*

Results

Adherence was investigated by Barlow and Barefoot [71] in the 1990s, who noted positive short-term effects on adherence with self-help groups and education, but long-term effects were not found. Only one lower quality RCT of participants with AS was found for which exercise adherence was a primary aim [72], and long-term information was not provided.

Due to the paucity of research specific to AS, systematic reviews investigating strategies to increase adherence to exercise for chronic musculoskeletal conditions were also considered. A Cochrane review [73] looking at musculoskeletal pain in adults found moderate evidence that exercise adherence can be enhanced, but identified an urgent need for good quality research into long-term adherence to exercise interventions. Until that time, the authors recommended that patient preference should direct exercise type and setting: however, it should be noted that AS was a specific exclusion from this review. Conn et al. [74,75] investigated physical activity interventions in adults with arthritis , and also the effects of education to increase PALs in adults with chronic illness. Again, there was evidence that PALs can be positively influenced by interventions, with an effect size for educational strategies of 0.45, equivalent to 48 min of physical activity per week. The former study was a large evidence synthesis (22,257 subjects with chronic conditions) and suggested the largest educational effects were those targeting physical activity behaviour, reinforced by some sort of PAL monitoring. The latter study found a number of strategies that promote PALs: these are summarised in Table 5 and reflected in the adherence recommendation.

Recommendation 9: Adherence. It is important to assess adherence with regular exercise, encourage motivation and promote ongoing self-management (EBR, grade B).

Exercise setting

Background

A number of settings for exercise in AS have been studied, including home, clinic/out-patient, gymnasium, out-patient hydrotherapy pool, other leisure activity/sporting environments, spa resort/balneotherapy centres (often residential) and in-patient hospital settings. Balneotherapy refers to baths of warm, mineralised water, usually in combination with both active exercises and more passive treatments such as massage or mud packs [76]. Many countries lack access to traditional spa/balneotherapy centres and so this is not a widely available exercise option, however, "aquatic physiotherapy" and "warm water exercise" are moderately available. Residential or hospital in-patient treatment is much less widely available than in the past. Also relevant here is the mode of delivery, that is, whether the exercise was performed as part of a group and with or without health professional "supervision." The clinical question was therefore: *in adults with AS, which widely available exercise settings and modes of delivery are beneficial for pain, disease activity, mobility and function?*

Results

The Cochrane review of physiotherapy (exercise based) interventions for ankylosing spondylitis included 11 trials, with a total of 763 participants, published prior to January 2007 [8]. The outcomes analysed were pain, stiffness, spinal mobility, physical function and patient global assessment, and all interventions were more beneficial than no intervention or "usual care." In-patient spa exercise therapy (an exclusion from our study) plus group therapy was found to be more effective than group therapy alone; individual home-based or supervised exercise programs were better than no intervention, but supervised group physiotherapy was better than home exercises.

Four further RCTs have been published (Appendix B, Section 1.8), but these collectively demonstrate the difficulties in determining the effects of exercise type versus setting versus mode of delivery [37,53,54,77]. Although different exercise settings appear to play a role in overall outcome, it is not possible to quantify whether benefits are due to the change in setting or environment, or the consequential support for motivation, adherence and higher exercise dosage that may arise from supervision and/or a group mode of delivery. Clinical experience suggests that warm water exercise may be particularly beneficial for more longstanding or severe disease. Unfortunately, since it is not possible to separate the effects of exercise in warm water from other passive components of spa therapy, there is currently insufficient evidence to support this clinical impression. Hence, the WG consensus was that personal preference, local availability and dosage are more important aspects than setting. However, if available, group and/or warm water exercise are likely to provide additional benefit.

Table 5
Intervention attributes or practices that promote physical activity (Adapted with permission from Ruppar and Conn [100].)

Strength of Evidence	Attribute or Practice	Definition
Strong	Single target: physical activity only	Interventions designed to modify only behaviour related to physical activity, rather than multiple health behaviours
	Behavioural approaches	Interventions containing at least one behavioural strategy, designed to produce a direct change in behaviour related to physical activity
	Self-monitoring	Interventions including practices such as keeping an activity diary, tracking activity in a calendar, or recording activity on a website
Moderate	Supervised exercise	Exercise overseen by a member of the research team or a health care provider
	Tailoring	Adapting the intervention to meet the needs of the situation or patient
	Contracting	An agreement between patient and provider defining the level and duration of physical activity the patient will perform
	Exercise prescription	Participants receive written instruction for the mode, duration, frequency, intensity and progression of their physical activity
	Fitness testing	Patient's level of physical fitness is evaluated before any physical activity programme is initiated
	Stimuli and cues	Interventions employ prompts that remind participants to exercise
	Moderate or high intensity recommendations	Recommendations are for moderate or high intensity (as opposed to low intensity) physical activity

Recommendation 10: Settings. Priority should be given to patient preference in exercise choice to enhance adherence and optimise positive outcomes (CBR).

Discussion

This consensus statement provides the first set of comprehensive exercise recommendations to guide practitioners' exercise prescription in AS with practical information. As a result of the consensus process, we developed a framework (Fig. 1) for considering all clinically relevant aspects of exercise prescription for people with AS, which has the potential to be adapted to other chronic musculoskeletal conditions, such as osteoporosis or osteoarthritis.

The process we followed had a number of strengths and limitations. The WG brought considerable experience and expertise in the clinical application of exercise in AS, and the development of key topic areas facilitated the investigation of all the important facets of exercise prescription in a way that has not been previously attempted. However, there were also some limitations to the study. For pragmatic reasons only English language papers were considered, and papers were initially selected by one author only; however, included papers were subsequently independently reviewed by a second author for suitability. Studies of those with axial spondyloarthritis were not included, and more focus on this group may be desirable in future. Although one member of the WG has AS, and additional patient input was obtained once the draft recommendations were developed, this process could have been strengthened by inclusion of people with AS earlier in the process. Professions other than physiotherapy are also involved in exercise prescription, and broadening of the representation on the WG could be considered in future reviews. Although the HP survey results were comparable to external validity testing for other rheumatology recommendations [78], a broader range of participants may have strengthened the feedback process. Lastly, in clinical practice, exercise may be combined with other non-pharmacological modalities, such as joint mobilisation [79], and investigation of such treatment combinations was beyond the scope of this review.

Combining systematic reviews with consensus recommendations is a lengthy process. In order to address the time lag between the initial searches and publication, the review for AS-specific exercise was repeated for publications until 1st July 2015. A total of five SRs (two with meta-analysis) and seven RCTs met the inclusion criteria. The SRs added weight to the recommendations in terms of support for exercise for improved outcomes [80–84]. More specifically, there was support for "multi-modal" programs (the main exercise types as shown in Figure 1) [80,85–87]; cardio-vascular training (as per recommendation 6) [88] and the synergistic effect of exercise and anti-TNFα medication (recommendation 4) [80,82]. There was preliminary evidence for: "McKenzie" (a protocol of repeated spinal mobility exercises) in early AS [89], inspiratory muscle training [90,91] and aquatic exercise [92] in cohorts with more established disease. However, there was agreement that "the most effective exercise protocol remains unclear" [86]. We believe that additional studies targeting sub-groups such as early or later AS (and the spondyloarthropathies) would enable greater specificity regarding exercise recommendations in the future; however, the basic framework (Fig. 1) will apply to all. With regard to exercise settings and supervision, a SR of home-based exercise found small to moderate benefits for pain, function, disease activity and depression [81]. However, reviews by Giannotti et al. [80] and O'Dwyer et al. [84] and a 12-month follow-up to an RCT [93] support supervision and group components, and a large multi-centre trial in Portugal found only small measureable gains for a programme with minimal supervised exercise practice [94]. These findings have been reflected as an additional PP (recommendation 10).

As previous authors have noted [9], major concerns regarding trial quality and clinical relevance remain. In general, future trials should better describe the exercise interventions and dosage, and use validated objective measures, such as the BASMI 10-point scale [95]. Despite consistent findings that exercise is effective in AS, the potential interactions between the physiological effects of exercise and the pathological processes have yet to be clarified. More knowledge about this could facilitate precise targeting of exercise effects by more informed programme design. Investigation of different patient groups (such as those with early, well-controlled AS versus long-standing, advanced disease) could determine if stratification of patient groups would increase effectiveness: it seems unlikely that "one size" will ever "fit all." Further evaluation of the effect of specific programs to address strength, cardiorespiratory and functional factors (such as balance), is also warranted. Exercise programme design should also be clearly linked to treatment aims and address physiological effectiveness, including progression: given that some subjects may start from a relatively low baseline, longer studies are therefore required. Such programs would allow better titration of dosage and thus may reflect the larger effect sizes that people with AS and clinicians often report. Accurate physical activity trackers should in future provide better objective data on exercise dosage, and studies that consider long-term outcomes and self-management strategies would be more relevant to the reality of limited availability of resources. Lastly, this would better inform the most urgently needed area of research, which is identified in this review as long-term adherence to exercise strategies.

Conclusion

The evidence found was of mixed quality, but consistently supported the beneficial effects of exercise in AS. However, lower quality research in some areas means that the current approach remains personalised and targeted to individual therapeutic goals. The 10 recommendations are specific enough to be clinically useful, but flexible for adaptation to the needs of all individuals. This new framework is summarised in Figure 1, and has the potential to be adapted for other chronic musculoskeletal conditions. Although developed for the Australian context, the recommendations would also apply to other regions, particularly where spa or residential centres are not routinely available, or to anyone seeking information on long-term exercise strategies. Widespread dissemination and implementation of the guidelines will be important to ensure a more consistent approach to AS exercise management, and optimise outcomes for people with this condition.

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Appendix A. Supplementary information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.semarthrit.2015.08.003.

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