



Exercise for ankylosing spondylitis: An evidence-based consensus statement



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ARTICLE INFO

Keywords:

Ankylosing spondylitis (AS)
exercise
pain
mobility
function

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.

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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- α (anti-TNF α) 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	Imaging review/discussion with medical team may be indicated for more advanced disease
BASMI is associated with quality of life, physical function and psychological status	Tape-based hip internal rotation is a responsive measure for hip involvement
The BASMI 10-point scoring scale (tabular or linear) is recommended over the 3-point scale	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.	In BASMI, lumbar side flexion is the most sensitive to change
BASMI raw scores are more sensitive to change than index scores	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-TNF α therapy should continue with regular exercise prescription as it confers an additional benefit to anti-TNF α 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	Occupational, transport and leisure activities contribute to total physical activity levels
Regular interruption of sedentary activities should also be encouraged	

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];

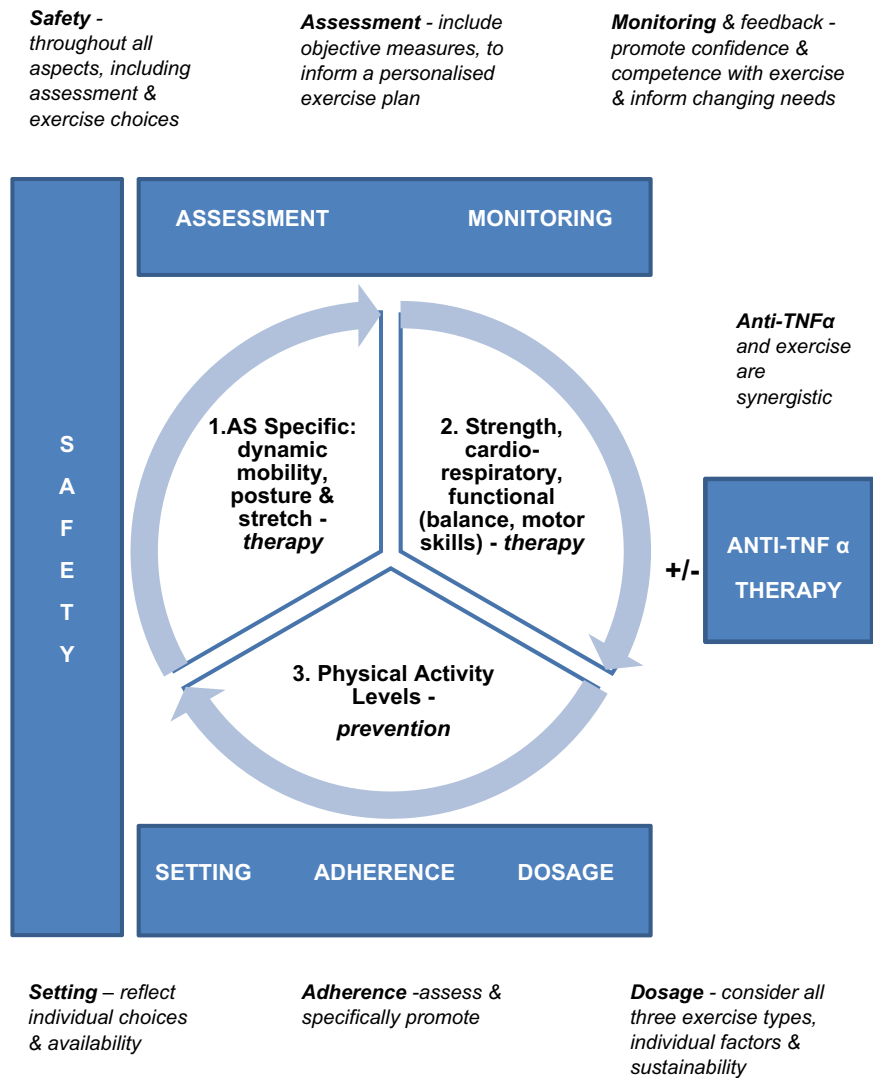


Fig. 1. Framework for exercise and ankylosing spondylitis
Aims:

- (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-TNF α 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., enthesitis) 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-TNF α 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-TNF α therapy. The trials consistently demonstrated the beneficial effect of a combination of anti-TNF α therapy and an AS-specific exercise programme, compared with either anti-TNF α 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-TNF α therapy should continue with regular exercise prescription as it confers an additional benefit to anti-TNF α 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 focusing 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											
Analay (2003) [101]	Multi-modal						X						
Cagliyan (2007) [77]	Multi-modal						X						
Fernandez-de-Ias-Penas (2005) [61]	Global postural re-education	X			X	X							
Hidding (1993) [102]	Mobility						X						
Ince (2006) [103]	Multi-modal		X		X								
Kraag (1990) [58]	Mobility					X							
Lee (2008) [104]	Tai chi						X						
Lim (2005) [59] ^a	Not specified						X						
Maseiro (2011) [37]	Multi-modal	X			X	X							
So (2012) [60]	Inventive spirometer				X		X						
Overall Effect	NB. All in favour of intervention groups							0.29 (−0.32 to 0.90)	0.41 (−0.11 to 0.93) 0.43 (−0.18 to 1.05)	0.95 (−0.10 to 2.00) 0.84 (−0.16 to 1.84) 0.81 (0.35– 1.28)	−2.63 (−12.06 to 6.80)	−3.40 (−14.62 to 7.82) −8.50 (−16.06 to −0.94) 0.50 (−9.38 to 10.38) −7.20 (−16.71 to 2.31) −5.00 (−11.55 to 1.55) −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.

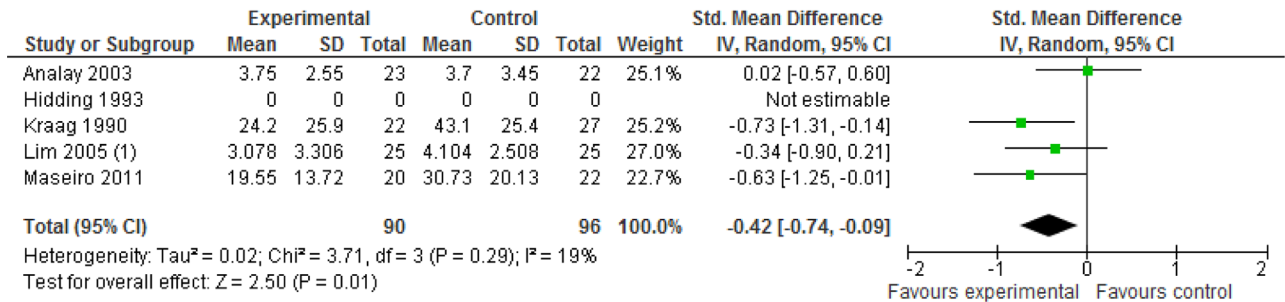
Recommendation 7: Physical activity. Regular physical activity should be encouraged to promote general health, well-being and functional outcomes (EBR, grade B).

Dosage

Background

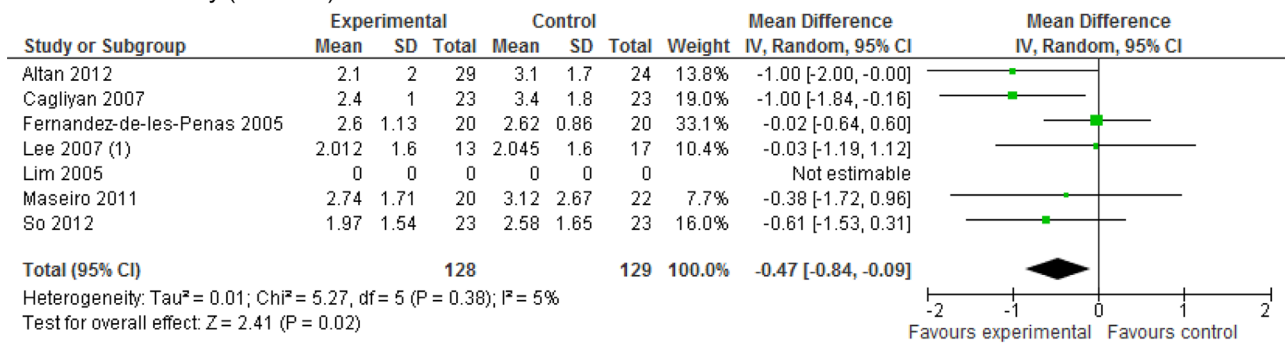
FITT-VP [17] is a widely used framework for exercise dosage and comprises six components: frequency (how often); intensity (how hard); time (duration) and type, resulting in a total exercise volume with the last component being “progression.” Exercise dosage should be considered for these parameters 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



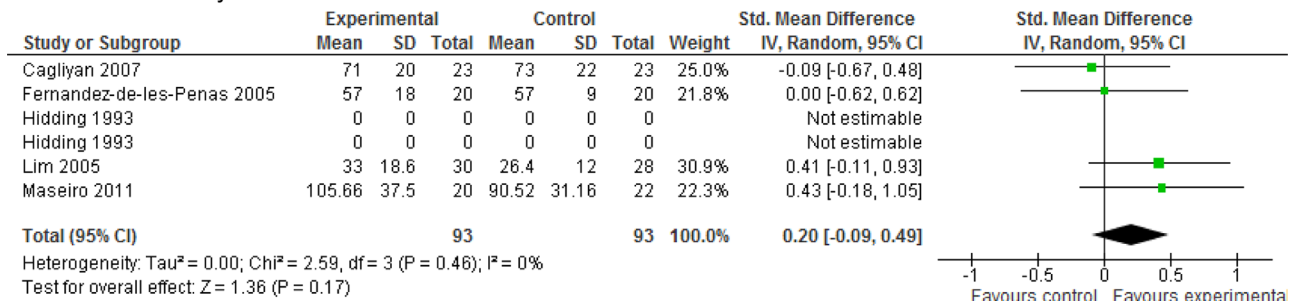
(1) Data estimated from graphical presentation

B Disease activity (BASDAI)

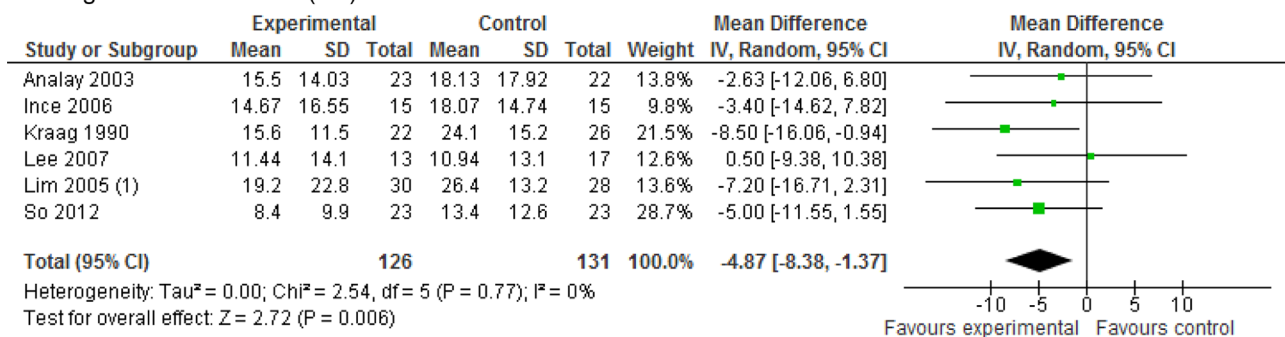


(1) SD imputed from So 2012

C Cervical mobility



D Finger to floor distance (cm)

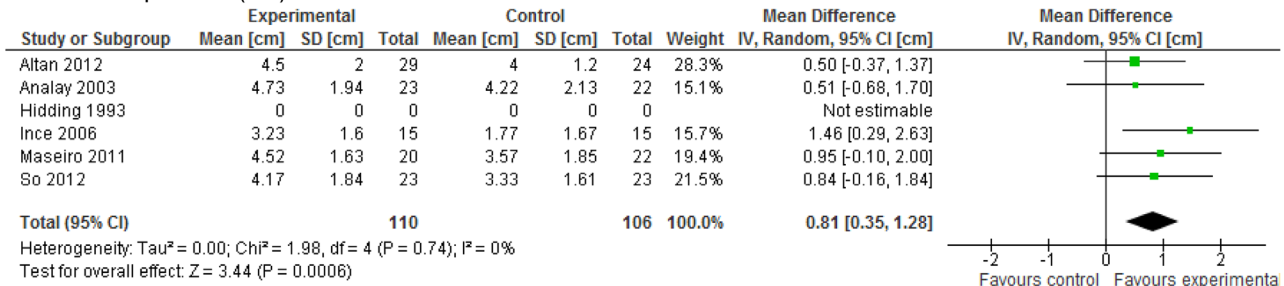


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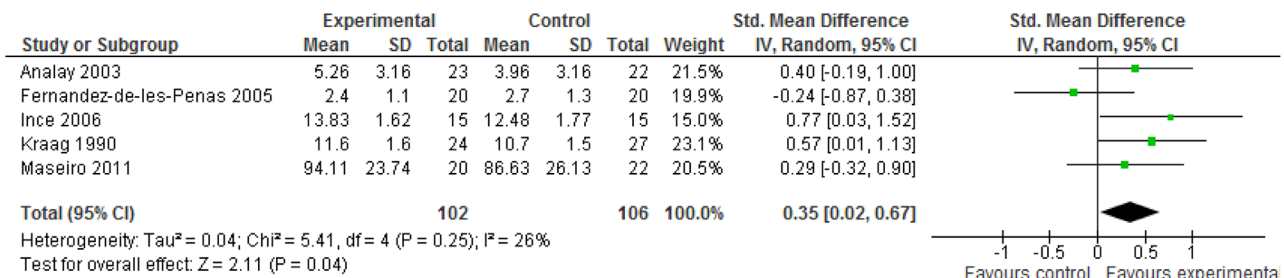
Fig. 2. Forest plots of meta-analyses; (A) Pain; (B) disease activity (BASDAI); (C) cervical mobility; (D) finger to floor distance (cm); (E) chest expansion; SD = standard deviation; CI = confidence interval.

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.

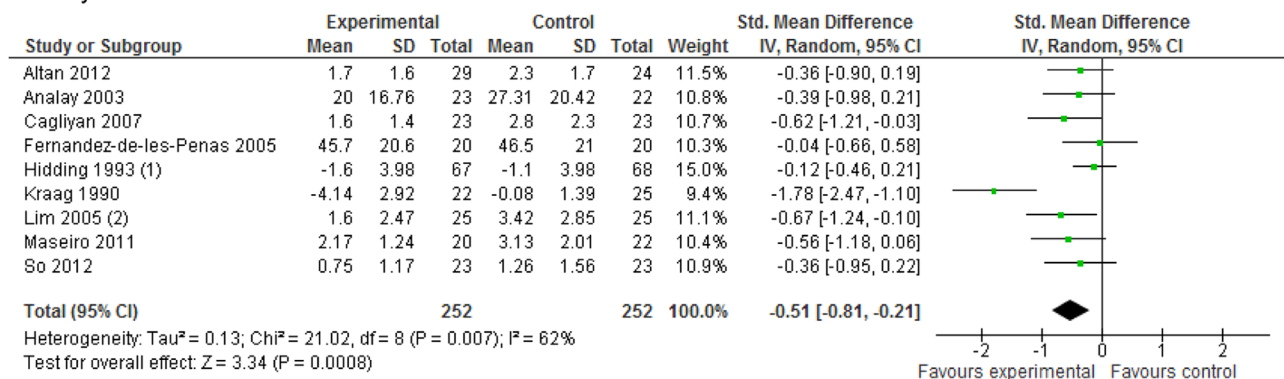
E Chest expansion (cm)



F Lumbar flexion



G Physical Function



- (1) Pre-post test change score used as outcome SD not available
(2) Data estimated from graphical presentation

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%; $\leq \times 1$ /week 18%; $\times 1-2$ /week but irregular 2%; $\geq \times 2$ /week 58%	n/a	n/a	Pool exs; walk; resistance exs; aerobic exs; cycle; floorball; golf; jogging; Nordic walk; tai chi	Higher exercise frequency ($> \times 2$ /week) predicted by long duration of symptoms, prior exercise habits, higher disease activity and living alone
Carter (2006) [69]	UK	131	Daily 35%; $\times 3-5$ /week 26%; $\times 1-2$ /week 27%; $< \times 1$ /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	$> \times 2$ /week 19%; $\times 1-2$ /week 36%; $< \times 1$ /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	$< \times 1$ /week 36%; $\times 1-3$ /week 46%; $> \times 3$ /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 ($\times 5-7$ /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 $\times 3$ /week 35%; stretch $\times 3$ /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%; $\times 3-6$ /week 15%; $\times 1-2$ /week 30%; $< \times 1$ /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 long-standing 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 Ruppap 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-TNF α 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 measurable 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.

Acknowledgements

The authors would like to sincerely thank Dr Hilton Francis, who conceptualised the exercise framework ([Fig. 1](#)), and all of the patients and health professionals who took the time to contribute to this article.

Janet Millner was a recipient of an Allied Health Postgraduate Scholarship (201383523) awarded under the Nursing and Allied Health Scholarship and Support Scheme (NAHSSS), administered by Services for Australian Rural and Remote Allied Health (SAR-RAH) and funded by the Commonwealth Department of Health (DoH), Australia.

The authors would like to thank AbbVie Pty Ltd for providing logistical support for a group meeting to develop these recommendations. AbbVie Pty Ltd funded Cutting Edge Services, Sydney, Australia who provided logistical services for this meeting, and AbbVie Pty Ltd reimbursed travel expenses for meeting attendees. AbbVie Pty Ltd was not involved in the development or review of this publication.

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>.

References

- [1] Khan M. Update on spondyloarthropathies. *Ann Intern Med* 2002;136:896–907.
- [2] Dougados M, Baeten D. Spondyloarthritis. *Lancet* 2011;377:2127–37.
- [3] Vander Cruyssen B, Ribbens C, Boonen A, Mielants H, De Vlam K, Lenaerts J, et al. The epidemiology of ankylosing spondylitis and the commencement of anti-TNF therapy in daily rheumatology practice. *Ann Rheum Dis* 2007;66(8):1072–7.
- [4] Maksymowych WP, Gladman D, Rahman P, Boonen A, Bykerk V, Choquette D, et al. The Canadian rheumatology association/spondyloarthritis research consortium of Canada treatment recommendations for the management of spondyloarthritis: a national multidisciplinary stakeholder project. *J Rheumatol* 2007;34:2273–84.
- [5] Ozgocmen S, Akgul O, Altay Z, Altindag O, Baysal O, Calis M, et al. Expert opinion and key recommendations for the physical therapy and rehabilitation of patients with ankylosing spondylitis. *Int J Rheum Dis* 2011;15(3):229–38.
- [6] van den Berg R, Baraliakos X, Braun J, van der Heijde D. First update of the current evidence for the management of ankylosing spondylitis with non-pharmacological treatment and non-biologic drugs: a systematic literature review for the ASAS/EULAR management recommendations in ankylosing spondylitis. *Rheumatology (Oxford)* 2012;51:1388–96.
- [7] Zochling J vdHD, Burgos-Vargas R, Collantes E, Davis JC, Dijkmans B, Dougados M, et al. ASAS/EULAR recommendations for the management of ankylosing spondylitis. *Ann Rheum Dis* 2006;65:442–52.
- [8] Dagfinrud H, Hagen KB, Kvien TK. Physiotherapy interventions for ankylosing spondylitis. *Cochrane Database of Systematic Reviews* 2008 Issue 1. Art. No.: CD002822. [10.1002/14651858.CD002822.pub3](http://dx.doi.org/10.1002/14651858.CD002822.pub3).
- [9] Dagfinrud H, Halvorsen S, Vollestad NK, Niedermann K, Kvien TK, Hagen KB. Exercise programs in trials for patients with ankylosing spondylitis: do they really have the potential for effectiveness? *Arthritis Care Res* 2011;63:597–603.
- [10] Zochling J, van der Heijde D, Dougados M, Braun J. Current evidence for the management of ankylosing spondylitis: a systematic literature review for the ASAS/EULAR management recommendations in ankylosing spondylitis. *Ann Rheum Dis* 2006;65:423–32.
- [11] Sahin N, Ozcan E, Baskent A, Karan A, Ekmeci O, Kasikcioglu E. Isokinetic evaluation of ankle muscle strength and fatigue in patients with ankylosing spondylitis. *Eur J Phys Rehabil Med* 2011;47:399–405.
- [12] Vergara ME, O'Shea FD, Inman RD, Gage WH. Postural control is altered in patients with ankylosing spondylitis. *Clin Biomech (Bristol, Avon)* 2012;27:334–40.
- [13] Berdal G, Halvorsen S, van der Heijde D, Mowe M, Dagfinrud H. Restrictive pulmonary function is more prevalent in patients with ankylosing spondylitis than in matched population controls and is associated with impaired spinal mobility: a comparative study. *Arthritis Res Ther* 2012;14:R19.
- [14] Altan L, Bingol U, Aslan M, Yurtkuran M. The effect of balneotherapy on patients with ankylosing spondylitis. *Scand J Rheumatol* 2006;35:283–9.
- [15] Lubrano E, D'Angelo S, Spadaro A, Palazzi C, Olivieri I. Rehabilitation for ankylosing spondylitis in the era of biologics: any room left for this treatment? *J Rheumatol* 2011;38:1228–30.
- [16] Merlin T, Weston A, Tooher R. Extending an evidence hierarchy to include topics other than treatment: revising the Australian' levels of evidence. *BMC Med Res Methodol* 2009;9:34.
- [17] Pescatello LS. American College of Sports Medicine's Guidelines for Exercise Testing and Prescription. 9th ed. Baltimore, MD, USA: ACSM; 2013.
- [18] Dalyan M, Guner A, Tuncer S, Bilgic A, Arasil T. Disability in ankylosing spondylitis. *Disabil Rehabil* 1999;21:74–9.
- [19] Falkenbach A, Franke A, van der Linden S. Factors associated with body function and disability in patients with ankylosing spondylitis: a cross-sectional study. *J Rheumatol* 2003;30:2186–92.
- [20] Martindale J, Smith J, Sutton CJ, Grennan D, Goodacre L, Goodacre J. Disease and psychological status in ankylosing spondylitis. *Rheumatology* 2006;45:1288–93.
- [21] Vesovic-Potic V, Mustur D, Stanisavljevic D, Ille T, Ille M. Relationship between spinal mobility measures and quality of life in patients with ankylosing spondylitis. *Rheumatol Int* 2009;29:879–84.
- [22] van Weely S, van Denderen J, Steultjens M, van der Leeden M, Nurmohamed MT, Dekker J, et al. Moving instead of asking? Performance-based tests and BASFI-questionnaire measure different aspects of physical function in ankylosing spondylitis. *Arthritis Res Ther* 2012;14(R52).
- [23] Porter SB, John GA, Lynne G, Jane S, Chandra C. Anthropometric measurement as a predictor of exercise behaviour in people with ankylosing spondylitis. *Rheumatology* 2005;44:277.
- [24] Mathieu S, Gossec L, Dougados M, Soubrier M. Cardiovascular profile in ankylosing spondylitis: a systematic review and meta-analysis. *Arthritis Care Res* 2011;63:557–63.
- [25] Halvorsen S, Vollestad NK, Fongen C, Provan SA, Semb AG, Hagen KB, et al. Physical fitness in patients with ankylosing spondylitis: comparison with population controls. *Phys Ther* 2012;92:298–309.
- [26] Kelman A, Lane NE. The management of secondary osteoporosis. *Best Pract Res Clin Rheumatol* 2005;19:1021–37.
- [27] Ghazali I, Ghazi M, Nouijai A, Mounach A, Rezqi A, Achemlal L, et al. Prevalence and risk factors of osteoporosis and vertebral fractures in patients with ankylosing spondylitis. *Bone* 2009;44:772–6.
- [28] Thumbikat P, Hariharan RP, Ravichandran G, McClelland MR, Mathew KM. Spinal cord injury in patients with ankylosing spondylitis: a 10-year review. *Spine* 2007;32:2989–95.
- [29] Kim KT, Lee SH, Suk KS, Lee JH, Im YJ. Spinal pseudarthrosis in advanced ankylosing spondylitis with sagittal plane deformity: clinical characteristics and outcome analysis. *Spine* 2007;32:1641–7.
- [30] Tang WM, Chiu KY. Primary total hip arthroplasty in patients with ankylosing spondylitis. *J Arthroplasty* 2000;15:52–8.
- [31] Ramos-Remus C, Gomez-Vargas A, Guzman-Guzman J, Jimenez-Gil F, Gamez-Nava J, Gonzalez-Lopez L, et al. Frequency of atlantoaxial subluxation and neurologic involvement in patients with ankylosing spondylitis. *J Rheumatol* 1995;22:2120–5.

- [32] Pedersen BK, Saltin B. Evidence for prescribing exercise as therapy in chronic disease. *Scand J Med Sci Sports* 2006;16:3–63.
- [33] Gleeson M, Bishop NC, Stensel DJ, Lindley MR, Mastana SS, Nimmo MA. The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. *Nat Rev Immunol* 2011;11:607–15.
- [34] Perandini LA, de Sa-Pinto AL, Roschel H, Benatti FB, Lima FR, Bonfa E, et al. Exercise as a therapeutic tool to counteract inflammation and clinical symptoms in autoimmune rheumatic diseases. *Autoimmun Rev* 2012;12:218–24.
- [35] Mathur N, Pedersen BK. Exercise as a mean to control low-grade systemic inflammation. *Mediators Inflamm* 2008;2008:1–6.
- [36] Thomas J. Helpful or harmful? Potential effects of exercise on select inflammatory conditions. *Phys Sportsmed* 2013;41:93–100.
- [37] Masiero SBL, Pigatto M, Lo Nigro A, Ramonda R, Punzi L. Rehabilitation treatment in patients with ankylosing spondylitis stabilized with tumour necrosis factor inhibitor therapy. a randomized controlled trial. *J Rheumatol* 2011;38(7):1325–42.
- [38] Lin ZM, Wei YL, Li L, Wu YQ, Ge L, Gu JR. Efficacy of exercise therapy combined with etanercept in patients with ankylosing spondylitis. *Int J Rheum Dis* 2010;13:155.
- [39] Colina M, Ciancio G, Garavini R, Conti M, Trotta F, Govoni M. Combination treatment with etanercept and an intensive spa rehabilitation program in active ankylosing spondylitis. *Int J Immunopathol Pharmacol* 2009;22:1125–9.
- [40] Yinullit S, Iahin Z, Demir S, Aytacnall DH. The effect of exercise therapy in patients with ankylosing spondylitis receiving anti-TNF. *Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi* 2011;57:329.
- [41] Lubrano E, D'Angelo S, Parsons WJ, Serino F, Tanzillo AT, Olivieri I, et al. Effects of a combination treatment of an intensive rehabilitation program and etanercept in patients with ankylosing spondylitis: a pilot study. *J Rheumatol* 2006;33:2029–34.
- [42] Jenkinson T, Mallorie P, Whitelock H, Kennedy G, Garret S, Calin A. Defining spinal mobility in ankylosing spondylitis (AS). *The Bath Metrology Index. J Rheumatol* 1994;21:1694–8.
- [43] O'hea J. Physiotherapy management of ankylosing spondylitis. In: Porter S, editor. *Tidy's Physiotherapy*. London: Butterworth-Heinemann; 2003. p. 273–90.
- [44] Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the pedro scale for rating quality of randomized controlled trials. *Phys Ther* 2003;83:713–21.
- [45] Ferreira ML, RJEEM Smeets, Kamper SJ, Ferreira PH, Machado LAC. Can we explain heterogeneity among randomized clinical trials of exercise for chronic back pain? A meta-regression analysis of randomized controlled trials. *Phys Ther* 2010;90(10):1–21.
- [46] Hoogboom TJ. Meta-analyses on therapeutic physical exercise: time for a new direction. *Phys Ther Rev* 2013;18:219–20.
- [47] Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee I-M, et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc* 2011;43:1334–59. <http://dx.doi.org/10.1249/MSS.0b013e318213f3fb>.
- [48] Brown WJ, Bauman AE, Bull FC, Burton NW. Development of evidence-based physical activity recommendations for adults (18–64 years). Report prepared for the Australian Government Department of Health. 2012.
- [49] Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007;39:1423–34.
- [50] Harris C, Jeffries C, Jones T, McCormick P, Goodenough L. The NASS guide to exercising effectively and safely for people with ankylosing spondylitis. *Back to Action*. Richmond, Surrey, UK: National Ankylosing Spondylitis Society (UK); 2010.
- [51] McGonagle D, Thomas RC, Schett G. Spondyloarthritis: may the force be with you? *Ann Rheum Dis* 2014;73:321–3.
- [52] Lee EN, Kim YH, Chung WT, Lee MS. Tai chi for disease activity and flexibility in patients with ankylosing spondylitis—a controlled clinical trial. *Evid Based Complement Alternat Med* 2008;5:457–62.
- [53] Karapolat H, Eyigor S, Zoghi M, Akkoc Y, Kirazli Y, Keser G. Are swimming or aerobic exercise better than conventional exercise in ankylosing spondylitis patients? A randomized controlled study. *Eur J Phys Rehabil Med* 2009;45:449–57.
- [54] Altan L, Korkmaz N, Dizdar M, Yurtkuran M. Effect of Pilates training on people with ankylosing spondylitis. *Rheumatol Int* 2012;32:2093–9.
- [55] Falkenbach A, Neger J, Tripathi R, Wigand R. Recreational exercises and mobility in young patients with ankylosing spondylitis (AS). *Sports Med Train Rehabil* 1999;9:101–6.
- [56] Sims J, Hill K, Hunt S, Haralambous B, Brown A, Engel L, et al. National physical activity recommendations for older Australians: discussion document. Canberra: Australian Government Department of Health and Ageing. 2006.
- [57] Lemmey B. Arthritis. In: Ehrman J, Gordon P, Visich P, Keteyian S, editors. *Clinical Exercise Physiology*. 3rd ed. Champaign, Illinois: Human Kinetics; 2013. p. 419–45.
- [58] Kraag G, Stokes B, Groh J, Helewa A, Goldsmith C. The effects of comprehensive home physiotherapy and supervision on patients with ankylosing spondylitis—a randomized controlled trial. *J Rheumatol* 1990;17:228–33.
- [59] Lim HJ, Moon YI, Lee MS. Effects of home-based daily exercise therapy on joint mobility, daily activity, pain, and depression in patients with ankylosing spondylitis. *Rheumatol Int* 2005;25:225–9.
- [60] So MW, Heo HM, Koo BS, Kim YG, Lee CK, Yoo B. Efficacy of incentive spirometer exercise on pulmonary functions of patients with ankylosing spondylitis stabilized by tumor necrosis factor inhibitor therapy. *J Rheumatol* 2012;39:1854–8.
- [61] Fernandez-de-las-Penas C, Alonso-Blanco C, Morales-Cabezas M, Miangolarra-Page JC. Two exercise interventions for the management of patients with ankylosing spondylitis—a randomized controlled trial. *Am J Phys Med Rehabil* 2005;84:407–19.
- [62] Arends S, Hofman M, Kamsma YPT, Van Der Veer E, Leijmsma MK, Houtman PM, et al. The relation between daily physical activity measured with the accelerometer and clinical assessments in patients with ankylosing spondylitis. *Arthritis Rheum* 2011;63(S10).
- [63] Santos H, Brophy S, Calin A. Exercise in ankylosing spondylitis: how much is optimum? *J Rheumatol* 1998;25:2156–60.
- [64] Ward MM. Predictors of the progression of functional disability in patients with ankylosing spondylitis. *J Rheumatol* 2002;29:1420–5.
- [65] Egger G, Donovan RJ, Giles-Corti B, Bull F, Swinburn B. Developing national physical activity guidelines for Australians. *Aust N Z J Public Health* 2001;25:561–3.
- [66] Boonen A, van der Linden SM. The burden of ankylosing spondylitis. *J Rheumatol* 2006;78:4–11.
- [67] Sabaté E. Adherence to long-term therapies: evidence for action. *World Health Organization* 2003.
- [68] Barlow JH. Understanding exercise in the context of chronic disease: an exploratory investigation of self-efficacy. *Percept Mot Skills* 1998;87:439–46.
- [69] Carter ND, Smith LV, Sutton PA, Walsh DA. Exercise habits among patients with ankylosing spondylitis: a questionnaire survey. *Rheumatology* 2006;45 [I64–I64].
- [70] Fitzpatrick M, FitzGerald O, Staines A, Hurley DA. Quality of life and exercise compliance in patients with ankylosing spondylitis: a cross-sectional survey. *Arthritis Rheum* 2006;54:S814–5.
- [71] Barlow JH, Barefoot J. Group education for people with arthritis. *Patient Educ Couns* 1996;27:257–67.
- [72] Sweeney S, Taylor G, Calin A. The effect of a home based exercise intervention package on outcome in ankylosing spondylitis: a randomized controlled trial. *J Rheumatol* 2002;29:763–6.
- [73] Jordan JL, Holden MA, Mason EEJ, Foster NE. Interventions to improve adherence to exercise for chronic musculoskeletal pain in adults *Cochrane Database of Systematic Reviews* 2010 Issue 1. Art. No.: CD005956. 10.1002/14651858.CD005956.pub2.
- [74] Conn VS, Hafdahl AR, Minor MA, Nielsen PJ. Physical activity interventions among adults with arthritis: meta-analysis of outcomes. *Semin Arthritis Rheum* 2008;37:307–16.
- [75] Conn VS, Hafdahl AR, Brown SA, Brown LM. Meta-analysis of patient education interventions to increase physical activity among chronically ill adults. *Patient Educ Couns* 2008;70:157–72.
- [76] Falagas ME, Zarkadoulia E, Rafailidis PI. The therapeutic effect of balneotherapy: evaluation of the evidence from randomised controlled trials. *Int J Clin Pract* 2009;63:1068–84.
- [77] Cagliyan A, Kotevoglou N, Onal T, Tekkus B, Kuran B. Does group exercise program add anything more to patients with ankylosing spondylitis? *J Back Musculoskelet Rehabil* 2007;20:79–85.
- [78] Machado P, Castrejon I, Katchamart W, Koevoets R, Kuriya B, Schoels M, et al. Multinational evidence-based recommendations on how to investigate and follow-up undifferentiated peripheral inflammatory arthritis: integrating systematic literature research and expert opinion of a broad international panel of rheumatologists in the 3E Initiative. *Ann Rheum Dis* 2011;70:15–24.
- [79] Widberg K, Karimi H, Hafstrom I. Self- and manual mobilization improves spine mobility in men with ankylosing spondylitis—a randomized study. *Clin Rehabil* 2009;23:599–608.
- [80] Giannotti E, Trainito S, Arioli G, Rucco V, Masiero S. Effects of physical therapy for the management of patients with ankylosing spondylitis in the biological era. *Clin Rheumatol* 2014;33:1217–30.
- [81] Liang H, Zhang H, Ji H, Wang C. Effects of home-based exercise intervention on health-related quality of life for patients with ankylosing spondylitis: a meta-analysis. *Clin Rheumatol* 2015;34(10):1737–44.
- [82] Lubrano E, Spadaro A, Amato G, Benucci M, Cavazzana I, Chimenti MS, et al. Tumour necrosis factor alpha inhibitor therapy and rehabilitation for the treatment of ankylosing spondylitis: a systematic review. *Semin Arthritis Rheum* 2015;44:542–50.
- [83] Martins NA, Furtado GE, Campos MJ, Leitao JC, Filaire E, Ferreira JP. Exercise and ankylosing spondylitis with New York modified criteria: a systematic review of controlled trials with meta-analysis. *Acta Reumatol Port* 2014;39:298–308.
- [84] O'Dwyer T, O'Shea F, Wilson F. Exercise therapy for spondyloarthritis: a systematic review. *Rheumatol Int* 2014;34:887–902.
- [85] Hsieh LF, Chuang CC, Tseng CS, Wei JC, Hsu WC, Lin YJ. Combined home exercise is more effective than range-of-motion home exercise in patients with ankylosing spondylitis: a randomized controlled trial. *Biomed Res Int* 2014;2014 [Article ID 398190].
- [86] O'Dwyer T, O'Shea F, Wilson F. Physical activity in spondyloarthritis: a systematic review. *Rheum Int* 2014;35:393–404.

- [87] Roşu M, Țopa I, Chiriac R, Ancuta C. Effects of Pilates, McKenzie and Heckscher training on disease activity, spinal motility and pulmonary function in patients with ankylosing spondylitis: a randomized controlled trial. *Rheum Int* 2014;34:367–72.
- [88] Niedermann K, Sidelnikov E, Muggli C, Dagfinrud H, Hermann M, Tamborini G, et al. Effect of cardiovascular training on fitness and perceived disease activity in people with ankylosing spondylitis. *Arthritis Care Res* 2013;65:1844–52.
- [89] Rosu OM, Ancuta CM. McKenzie training in patients with early stages of ankylosing spondylitis: results of a 24-week controlled study. *Eur J Phys Rehabil Med* 2014;51(3):261–8.
- [90] Dragoi RG, Amaricai E, Dragoi M, Popoviciu H, Avram C. Inspiratory muscle training improves aerobic capacity and pulmonary function in patients with ankylosing spondylitis: a randomized controlled study. *Clin Rehabil* 2015, 10.1177/0269215515578292.
- [91] Sveaas SH, Berg IJ, Provan SA, Semb AG, Hagen KB, Vollestad N, et al. Efficacy of high intensity exercise on disease activity and cardiovascular risk in active axial spondyloarthritis: a randomized controlled pilot study. *PLoS One* 2014;9:e108688.
- [92] Dundar U, Solak O, Toktas H, Demirdal US, Subasi V, Kavuncu V, et al. Effect of aquatic exercise on ankylosing spondylitis: a randomized controlled trial. *Rheumatol Int* 2014;34:1505–11.
- [93] Masiero S, Poli P, Bonaldo L, Pigatto M, Ramonda R, Lubrano E, et al. Supervised training and home-based rehabilitation in patients with stabilized ankylosing spondylitis on TNF inhibitor treatment: a controlled clinical trial with a 12-month follow-up. *Clin Rehabil* 2013;28:562–72.
- [94] Rodriguez-Lozano C, Juanola X, Cruz-Martinez J, Pena-Arrebola A, Mulero J, Gratacos J, et al. Outcome of an education and home-based exercise programme for patients with ankylosing spondylitis: a nationwide randomised study. *Clin Exp Rheumatol* 2013;31(5):739–48.
- [95] van der Heijde D, Deodhar A, Inman RD, Braun J, Hsu B, Mack M. Comparison of three methods for calculating the Bath Ankylosing Spondylitis Metrology Index in a randomized placebo-controlled study. *Arthritis Care Res* 2012;64:1919–22.
- [96] Akgul O, Kiliç E, Kiliç G, Ozgocmen S. Physiotherapy and rehabilitation in ankylosing spondylitis: is it still the mainstay of management in the era of biologics? *Int J Clin Rheum* 2013;8:579–84.
- [97] Schiotis RE, Calvo-Gutiérrez J, Salas A, Font-Ugalde P, MdC Castro-Villegas, Collantes-Estévez E. Recent updates on the recommendations for the management of ankylosing spondylitis: what and why? *Int J Clin Rheum* 2013;8:361–71.
- [98] Maksymowych WP, Mallon C, Richardson R, Conner-Spady B, Jauregui E, Chung C, et al. Development and validation of the Edmonton Ankylosing Spondylitis Metrology Index. *Arthritis Rheum* 2006;55:575–82.
- [99] Australian Government National Health and Medical Research Council (NHMRC): NHMRC additional levels of evidence and grades for recommendations for developers of guidelines. In., vol. 2009: NHMRC; 2009.
- [100] Ruppert TM, Conn VS. Interventions to promote physical activity in chronically ill adults. *Am J Nurs* 2010;110:30–7 [quiz 38–39].
- [101] Analay Y, Ozcan E, Karan A, Diracoglu D, Aydin R. The effectiveness of intensive group exercise on patients with ankylosing spondylitis. *Clinic Rehabil* 2003;17:631–6.
- [102] Hidding A, van der Linden S, Boers M, Gielen X, de Witte L, Kester A, et al. Is group physical therapy superior to individualized therapy in ankylosing spondylitis? A randomized controlled trial. *Arthritis Care Res* 1993;6:117–25.
- [103] Ince G, Sarpel T, Durgun B, Erdogan S. Effects of a multimodal exercise program for people with ankylosing spondylitis. *Physical Therapy* 2006;86:924–35.
- [104] Lee EN, Kim YH, Chung WT, Lee MS. Tai Chi for Disease Activity and Flexibility in Patients with Ankylosing Spondylitis A Controlled Clinical Trial. *Evid Based Complement Alternat Med* 2008;5:457–62.
- [105] Brodin N, Opava CH. Predicting general health perception and exercise habits in ankylosing spondylitis. *Advan Physiother* 2007;9:23–30.
- [106] Cooksey R, Davies H, Dennis MS, Siebert S, Brophy S. The effect of physical activity and motivation on function in ankylosing spondylitis. *Rheumatology (United Kingdom)* 2012;51:iii91.
- [107] Haglund E, Bergman S, Petersson IF, Jacobsson LT, Strombeck B, Bremander A. Differences in physical activity patterns in patients with spondylarthritis. *Arthritis Care Res (Hoboken)* 2012;64:1886–94.
- [108] O'Shea FD, Passalent LA, Soever LJ, Inman RD. Exercise in ankylosing spondylitis: Discrepancy between recommendations and reality. *Clinic Experiment Rheumatol* 2008;26:744.
- [109] Sundstrom B, Ekegard H, Sundelin G. Exercise habits among patients with ankylosing spondylitis. A questionnaire based survey in the County of Vasterbotten, Sweden. *Scand J Rheumatol* 2002;31:163–7.
- [110] Uhrin Z, Kuzis S, Ward MM. Exercise and changes in health status in patients with ankylosing spondylitis. *Arch Intern Med* 2000;160:2969–75.