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# Physical activity in spondyloarthritis: a systematic review

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**Abstract** Physical activity (PA) is associated with numerous health-related benefits among adults with chronic diseases and the general population. As the benefits are dose-dependent, this review aims to establish the PA levels of adults with spondyloarthritis and to compare these to the general population. Electronic databases (Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE/PubMed, PEDro, AMED, CINAHL) were systematically searched from inception to May 2014 using medical subject headings and keywords. This was supplemented by searching conference abstracts and hand-searching reference lists of included studies. Eligible studies were randomized controlled trials and observational studies of adults with SpA in which free-living PA or energy expenditure levels were measured. Subjects less than 18 years or with juvenile-onset SpA were excluded. Outcomes included objective and self-report measurements. Two reviewers independently screened studies for inclusion and assessed methodological quality using the Cochrane risk of bias tool and the RTI item bank. From the 2,431 records reviewed, nine studies involving 2,972 participants were included. This review focused on qualitative synthesis. Meta-analyses were not undertaken due to differences in study design, measurement tools, and participant characteristics. This heterogeneity, coupled with the risk of bias inherent in the included observational studies, limits the generalizability of findings. Objective measurements suggest PA levels may be lower among adults with spondyloarthritis than in healthy population controls. Self-reported PA and self-reported rates of adherence to PA recommendations varied largely across studies; higher disease activity was associated with lower self-reported PA levels. Physical activity levels may be lower in adults with axial spondyloarthritis, with higher disease activity associated with lower PA levels.

**Keywords** Physical activity · Exercise · Spondyloarthritis · Ankylosing spondylitis

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## Introduction

The spondyloarthropathies (SpA) are a heterogeneous group of inflammatory conditions that include ankylosing spondylitis (AS), reactive arthritis (ReA), enteropathic spondylitis, or arthritis associated with inflammatory bowel disease (IBD), psoriatic arthritis (PsA), and undifferentiated spondyloarthropathy (uSpA) [1]. Depending on the clinical features and imaging, SpA can be classified as predominantly axial or predominantly peripheral [2, 3]. They are associated with decreased physical function, decreased work productivity, and lower health-related quality of life (QoL) [4–6]. Elevated cardiovascular risk factors and increased cardiovascular morbidity and mortality have been associated with AS and PsA [7, 8].

A combination of pharmacological and non-pharmacological treatment modalities is advocated for optimal management of patients with AS and PsA [9, 10].

Exercise-based interventions have been found to be safe and to yield beneficial physical and psychological effects in adults with SpA [11]. In this context, exercise is a planned, structured, and repetitive activity, with an objective to improve or maintain the elements of physical fitness [12]. Exercise is just one component of physical activity (PA), which includes any bodily movement produced by skeletal muscles that results in energy expenditure [12]. PA occurring in all aspects of daily free living contributes toward energy expenditure; this is often subdivided into work, transport, leisure time, and domestic activities. Global recommendations for health enhancement and prevention of non-communicable diseases are based on PA rather than exercise, and the health-related benefits are numerous.

In the general population, PA has been found to reduce the risk of cardiovascular disease, obesity, colon and breast cancers, type 2 diabetes, and osteoporosis [13, 14]. It also improves musculoskeletal health and reduces the symptoms of depression [15]. The World Health Organization (WHO) recommendations on PA state that adults should perform ≥150 min/week of moderate intensity aerobic physical activity ($PA_{mod}$), or ≥75 min/week of vigorous intensity aerobic physical activity ($PA_{vig}$), or an equivalent weekly combination of $PA_{mod}$ and $PA_{vig}$. Furthermore, PA should be performed in bouts of at least 10 min and should be supplemented by muscle-strengthening activities on two or more days [15]. It is further recommended that older adults with medical conditions engage in PA in a manner that effectively and safely treats their condition and prevents the development of other chronic diseases [16].

Despite strong evidence that physical inactivity adversely affects many aspects of health, the recommendations for the management of SpA do not contain specific guidance on PA. Studies have traditionally focused specifically on flexibility-based interventions, with few investigating the effects of aerobic exercise. No study has systematically reviewed PA in adults with SpA. The aims of this systematic review were to (1) explore the PA levels of adults with SpA, (2) compare the PA levels of adults with SpA to healthy, equivalent controls, and (3) examine the effect of interventions on PA levels of adults with SpA.

## Materials and methods

A protocol outlining the planned search strategy and methods of analysis for this review was registered online with a registry of systematic reviews (available at http://www.crd.york.ac.uk/prospero/display_record.asp?ID=CRD42014007607#.Uy_r0vl_u0I). This review was guided by the recommendations for reporting of systematic review and meta-analysis of observational studies in epidemiology (MOOSE) [17].

### Eligibility criteria

Adults diagnosed by a rheumatologist as having AS, ReA, PsA, uSpA, or enteropathic spondylitis were included in this study. Participants under 18 years of age or with juvenile-onset SpA were excluded. Randomized controlled trials (RCTs) and observational studies with or without controls were considered for inclusion. Review articles, case reports, commentaries, and studies with ≤5 participants were excluded.

The primary outcomes of interest were free-living PA levels or energy expenditure levels collected over ≥24 h. These included both self-report methods (e.g., questionnaires) and objective measures (e.g., accelerometry). Depending on the measurement method employed, outputs were expressed as continuous variables (e.g., kJ/day, MET-minutes per week) or categorical variables (e.g., meeting/not meeting national guidelines, high/moderate/low PA level) (see Supplement 1).

### Information sources and study selection

Studies were retrieved by searching six electronic databases (MEDLINE/PubMed, EMBASE, PEDro, AMED, CINAHL, and The Cochrane Central Register of Controlled Trials) from their inception to May 2014. Search terms were adapted for use with each database. Common keywords and medical subject headings were related to two components: (1) the condition and (2) PA (see Supplement 2). No search restrictions were imposed. The electronic database search was supplemented by searching abstracts from the annual congresses of the World Confederation for Physical Therapy (2003–2011), the American College of Rheumatology (2006–2013), the European League Against Rheumatism (2002–2013), and the American Physical Therapy Association (2002–2013). When only abstracts were available in the published literature, authors were contacted seeking full-text manuscripts of relevant studies. Finally, a hand search of the reference lists of included studies was conducted.

Two reviewers (TOD and FW) independently screened titles and abstracts to identify studies that potentially met the eligibility criteria. Full-texts of these reports were retrieved and assessed for eligibility by the same two reviewers. Foreign-language articles were translated into English. Disagreements on inclusion were resolved by discussion to achieve consensus, and failing agreement, a third reviewer (FOS) was consulted.

### Data collection and analysis

A data extraction template based on Cochrane recommendations was piloted on five randomly selected studies and

modified accordingly for this review [18]. One reviewer (TOD) recorded (1) study characteristics, (2) participant characteristics, and (3) PA outcome data. In studies including a control group, the differences in group means (with 95 % confidence interval) were calculated at clinically relevant time points (i.e., baseline and post-intervention). In cases where elaboration on published material was needed or further data were required, study authors were contacted requesting the pertinent information. Meta-analyses were planned but ultimately deemed inappropriate due to the heterogeneity of study designs and interventions. Statistical analysis was conducted using SPSS version 21 (IBM, Armonk, NY, USA).

### Risk of bias and levels of evidence

A risk of bias appraisal of included studies was performed independently by two reviewers (TOD and FW). Disagreements between the reviewers were resolved through discussion to achieve consensus. Failing agreement, a third reviewer (FOS) arbitrated. For randomized and quasi-randomized controlled trials, the Cochrane Collaboration's risk of bias tool was used. This tool rated the risk of bias across six domains as low, high, or unclear (selection bias, performance bias, detection bias, attrition bias, reporting bias, and other sources of bias including confounding) [18]. For observational studies, the RTI item bank for assessing the risk of bias and confounding was used [19]. In accordance with the developers' instructions, this tool was adapted to cater to the review topic and the design types of the included observational studies. Eight validated items assessing selection bias, detection bias, reporting bias, confounding, and overall bias of each study were selected. For each item, criteria relevant to determining the risk of bias were indicated to assist reviewers.

## Results

### Study selection

A total of nine studies, reported across 11 articles published between 2012 and 2014, were included in this review. The search strategy is summarized in Fig. 1. The electronic database search returned 2,410 records (after removal of duplicates), and an additional 21 reports were identified from the conferences abstracts search. Of the 2,431 records screened for eligibility by title and abstract, 47 titles were considered for full-text review. Studies were excluded for not meeting study design criteria ($n = 1{,}454$), not investigating an SpA cohort ($n = 207$), and not reporting free-living PA over at least 24 h ($n = 723$). When multiple articles reported different data from the same study, results were pooled under a primary study. As such, data reported by van Genderen et al. [20] are included with the data from Plasqui et al. [21], and results from the study by Halvorsen et al. [22] are combined with those from Fongen et al. [23]. Upon request, the authors of two studies provided additional relevant data not included in the published full-texts [24, 25].

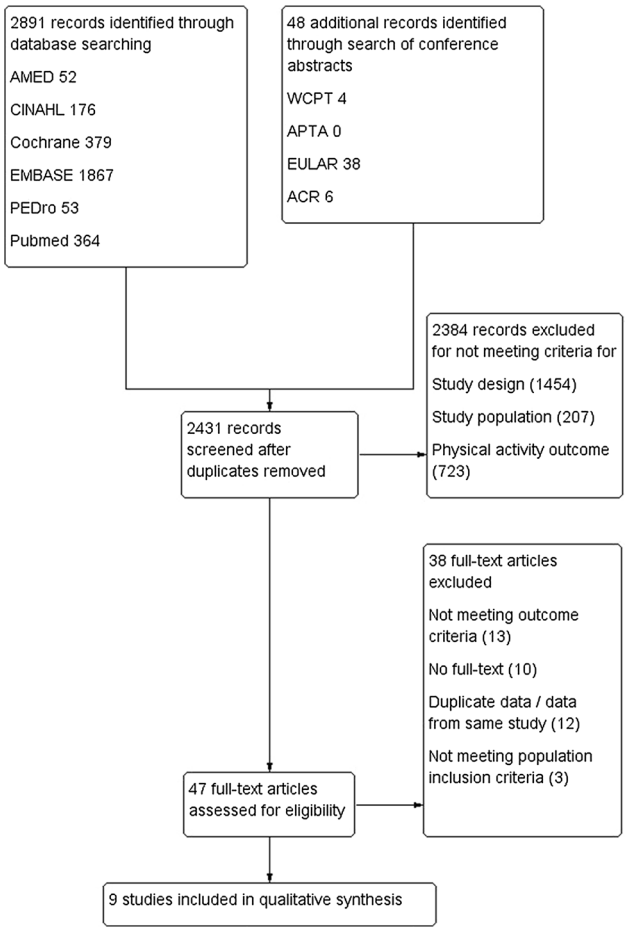


**Fig. 1** PRISMA flow diagram of study selection process

### Study characteristics

Seven of the included studies employed a cross-sectional design, while one RCT [26] and one validation/reliability study [27] were also included (baseline data are reported for RCT and reliability studies). Three studies included matched population controls [21, 23, 28], one study compared findings to existing normative data [29], and the RCT compared exercising and non-exercising groups of adults with AS [26].

Study characteristics are summarized in Table 1. A total of 2,972 participants with SpA were included (F/M; 1,373:1,585, 14 unspecified), and 198 population controls. The predominant

**Table 1** Study methodology

| Study | Location | Study design | Inclusion criteria | Exclusion criteria |
|---|---|---|---|---|
| Arends et al. [27] | The Netherlands | Validity (Group 1) and reliability (Group 2) study | AS according to mNYC<br>ASAS criteria for axial SpA including MRI<br>>18 years of age | Unable to read Dutch<br>Comorbidity restricting PA |
| Brophy et al. [30] | Wales | Cross-sectional | AS diagnosed by rheumatologist (Criteria not specified) | Incomplete questionnaires |
| Fongen et al. [23] | Norway | Cross-sectional | AS according to mNYC<br>resident <50 km from hospital<br>≤70 years of age | History of inflammatory arthritis (control group only) |
| Haglund et al. [29] | Sweden | Cross-sectional | ≥18 years of age<br>Diagnosis of SpA identified by ICD-10 code in health care register | None reported |
| Manning et al. [24] | England | Cross-sectional | ≥18 years of age<br>Attending rheumatology clinic | None reported |
| Niedermann et al. [26] | Switzerland | RCT | AS according to mNYC<br>>18 years of age<br>Sufficient German-language skills | Moderate-to-severe heart disease<br>Inability to cycle an ergometer |
| O'Dwyer et al. [25] | Ireland | Cross-sectional | ≥18 years of age<br>Attending rheumatology clinic | Unable to understand English questionnaire |
| Plasqui et al. [21] | The Netherlands | Cross-sectional | AS according to mNYC<br>Disease duration >5 years | On anti-TNFα therapy<br>Comorbidities affecting energy balance |
| Swinnen et al. [28] | Belgium | Cross-sectional | Axial SpA diagnosed by rheumatologist according to European Spondyloarthropathy Study Group criteria | History of spinal fracture, other fracture in last 12 months, lower-quadrant musculoskeletal injuries not related to SpA, discitis, pregnancy, spondylolisthesis, spondylolysis, severe health condition affecting PA assessment, unable to stand and walk without a mobility aid |

AS, ankylosing spondylitis; ASAS, Assessment of SpondyloArthritis international Society; ICD, International statistical classification of disease and related health problems; mNYC, modified New York criteria; PA, physical activity; RCT, randomized controlled trial; SpA, spondyloarthritis; TNF, tumor necrosis factor

subtype was AS. The median (IQR) study sample size was 106 (210). Subject characteristics varied in age, disease duration, disease severity, and medication use (Table 2).

Physical activity was measured by questionnaire in six studies [20, 23–25, 29, 30], by accelerometry in one study [28], and by both methods in three studies [21, 26, 27]. The diversity of measurement tools used to quantify PA generated a variety of outcome variables.

### Risk of bias within studies

The Cochrane risk of bias form was used to assess the RCT by Niedermann et al. [26], and the risk of bias was low. The remaining observational studies were appraised using the RTI item bank, and the results are summarized in Table 3; taking study limitations into consideration, individual study results were deemed credible. All studies included participants with a formal diagnosis of SpA, although the criteria used in the study by Brophy et al. [30] are unclear, and two studies used patient-reported doctor diagnoses to classify patients attending rheumatology clinics [24, 25]. Although no study protocols were reported, reporting bias appears low as no primary outcomes appeared missing. Confounding was accounted for in four studies by statistical adjustment [29], or control matching for age and gender. Additionally, studies also matched controls for residential area [23], body mass index [21], and data collection period [28].

### Synthesis of results

A meta-analysis was not undertaken due to the heterogeneity of study designs, participant characteristics, PA measurement tools, and outcome variables. Consequently, this review focused on a qualitative synthesis of the studies.

### Accelerometry

Four studies objectively measured PA using accelerometry (Table 4). Niedermann et al. [26] used an ActiGraph to monitor PA before and after a 12-week aerobic exercise intervention. The waist-mounted monitor was worn for 7 days, including two weekend days. The authors reported mean (SD) output of 336.3 (184.9) counts/min prior to the intervention; this was comparable to baseline PA of a control group with AS who attended group discussions on coping strategies and mindfulness-based stress reduction (mean difference [95 % CI]; 34.2 counts/min [−29.1 to 97.5]). Post-intervention PA scores were not significantly changed in either group (MD [95 % CI]; 2.9 counts/min [−53.0 to 47.2]).

Arends et al. [27] explored the construct validity of two PA self-report questionnaires by comparing agreement with output from uniaxial ActiGraph accelerometers in an AS cohort. The devices were worn for a minimum of 10 waking hours (except during water-based activities) for 5–7 days (including two weekend days). Mean (SD) ActiGraph output of 236 (106) kilocounts/day was reported.

Swinnen et al. [28] used the SenseWear Pro3 Armband to measure PA. The device combines a two-axial accelerometer with thermal sensors and estimates minute-by-minute energy expenditure and PA intensity. The device was worn for 5–7 consecutive days, for a minimum of 90 % of each 24-h day. In a group of patients with axial SpA, the authors reported physical activity levels (PAL), energy expenditure, and moderate/vigorous physical activity (MVPA). These outcomes were significantly lower than healthy matched controls ($p < 0.048$, $p < 0.045$ and $p < 0.029$, respectively).

Plasqui et al. [21] used the triaxial Tracmor accelerometer to measure PA of adults with AS and matched controls. The device was worn around the waist during waking hours for seven consecutive days. Unlike Swinnen et al. [28], this was not statistically different to PA levels of the healthy control group.

### Self-report questionnaires

Eight studies used self-report questionnaires to measure PA (Table 5). In their validation and reliability study, Arends et al. [27] assessed PA using both the long form of the International Physical Activity Questionnaire (IPAQ-LF) and the Short Questionnaire to Assess Health (SQUASH). Participants were divided into validity and reliability arms, and the authors reported median (IQR) group PA measured with the IPAQ-LF of 3,849 (1,470–8,132) MET-minutes per week and 5,937 (2,126–11,601) MET-minutes per week, respectively. Total activity scores on the SQUASH were 7,267 (3,453) [mean (SD)] and 5,760 (3,360–6,890) [median (IQR)], respectively.

Fongen et al. [23] compared PA of participants with low disease activity and those with high disease activity (high disease activity: $ASDAS_{CRP} > 2.1$ units), and compared both to healthy controls. The IPAQ-LF was used to measure PA. Participants with high disease activity reported significantly less weekly PA compared to participants with low disease activity and controls ($p < 0.02$ and $p < 0.01$, respectively).

In a questionnaire circulated to an AS cohort, Brophy et al. [30] measured PA on the short form of the IPAQ (IPAQ-SF) and reported a median (IQR) PA of 1,719 MET-minutes per week (396–3,892). The authors also reported that participants with a high level of disease activity (BASDAI > 60; scale 0–100) had lower PA levels than those with milder disease activity ($p = 0.0028$).

In the study by Manning et al. [24], 508 patients attending a rheumatology clinic completed the IPAQ-SF. Fourteen respondents had a diagnosis of AS and reported a mean score of 1,862 MET-minutes per week (95 % CI 873.0–2,851.9).

**Table 2** Participant characteristics

| Study | Participants (*n*) | Age | Sex ratio F/M | Disease activity | Disease duration (years) | Medication use [*n* (%)] |
|---|---|---|---|---|---|---|
| Arends et al. [27] | AS (115) split into Group 1 (63) and Group 2 (52) | 44.6 (12.1) | 44:71 | BASDAI: 3.7 (0.0–9.0)*<br>ESR: 11 (2–60)*<br>CRP: 3 (2–46)*<br>$ASDAS_{crp}$: 2.3 (0.7–4.4)* | Symptoms: 16 (0–54)*<br>Time since Dx: 10 (0–42)* | Anti-TNFα: 78 (70 %)<br>NSAID: 44 (40 %)<br>DMARD: 17 (15 %) |
| Brophy et al. [30] | AS (326) | 55 (14) | 79 % male | BASDAI: 41 (24) | Symptoms: 30 (15)<br>Time since Dx: 22 (15) | Anti-TNFα: 58 (16 %)<br>NSAIDS: 299 (83 %) |
| Fongen et al. [23] | AS(149)[‡] split into | 49.4 (11.0)[‡] | 92 men (62 %)[‡] | $ASDAS_{crp}$: 2.3 (1.0)[‡] | Symptoms: 23 (7–55)*[‡] | Anti-TNFα: 32 (22 %)[‡] |
| | High disease activity; ASDAScrp >2.1 (81) | 51.4 (11) | 43 men (54 %) | $ASDAS_{crp}$: 3.0 (0.6) | Not reported | Anti-TNFα: 14 (17 %) |
| | Low disease activity (67) | 46.9 (11) | 47 men (70 %) | $ASDAS_{crp}$: 1.4 (0.5) | Not reported | Anti-TNFα: 18 (27 %) |
| | Controls (133) | 52.9 (11) | 75 men (57 %) | N/A | N/A | N/A |
| Haglund et al. [29] | AS (571)<br>PsA (1,185)<br>uSpA (370)<br>IBD-related (41) | 55 (14)<br>58 (13)<br>49 (14)<br>57 (12) | 197:374<br>681:504<br>216:154<br>28:13 | BASDAI: 3.9 (2.2)<br>BASDAI: 4.8 (2.1)<br>BASDAI: 4.2 (2.2)<br>BASDAI: 5.1 (1.9) | Symptoms: 20 (14)<br>Symptoms: 13 (11)<br>Symptoms: 10 (10)<br>Symptoms: 11 (90) | Not reported |
| Manning et al. [24] | AS (14) | <35 = 2<br>35–44 = 3<br>45–54 = 6<br>55–69 = 3 | 7:7 | Not assessed | Symptoms: 10.2 (95 % CI 3.3–17.1) | Not assessed |
| Niedermann et al. [26] | AS exercise group (53) | 50.1 (11.9) | 19:34 | BASDAI: 3.3 (1.9)<br>$ASDAS_{crp}$: 2.2 (0.8)<br>CRP: 7.5 (9.8) | Symptoms: 9 (0.5–45)* | Anti-TNFα: 15 (28 %) |
| | AS control group (53) | 47.6 (12.4) | 19:34 | BASDAI: 3.6 (2.1)<br>$ASDAS_{crp}$: 2.3 (1.0)<br>CRP: 6.4 (8.7) | Symptoms: 8 (0.5–39)* | Anti-TNFα: 16 (30 %) |
| O'Dwyer et al. [25] | aSpA 30/0 | 46.0 (15.6) | 16:14 | Not assessed | Time since Dx: 9.3 (11.4) | Not assessed |
| Plasqui et al. [21][¥] | AS (25) | 48 (11) | 10:15 | BASDAI: 4.3 (2.2)<br>CRP: 3.1 (0.6–8.6)*<br>TNFα: 1.4 (1.0–2.7) * | Time since Dx: 19 (12) | NSAIDS: 16 (76 %)<br>DMARDs: 3 (14 %) |
| | Controls (25) | 48 (12) | 10:15 | CRP: 1.8 (0.3–2.7)*<br>TNFα: 1.3 (0.8–1.7)* | N/A | N/A |
| Swinnen et al. [28] | AS (40) | 44.4 (11.3) | 16:24 | BASDAI: 3.69 (2.59) | Symptoms: 11.4 (9.5) | NSAIDS: 21 (52.5 %)<br>Biologics: 19 (47.5 %)<br>Analgesics: 14 (35 %)<br>DMARDS: 8 (20 %)<br>Corticosteroids: 0 |
| | Controls (40) | 44.3 (10.6) | 16:24 | N/A | N/A | N/A |

Mean (standard deviation) unless otherwise indicated

*AS* ankylosing spondylitis, *ASDAS* ankylosing spondylitis disease activity index, *aSpA* axial spondyloarthritis, *BASDAI* bath ankylosing spondylitis disease activity index, *CRP* C-reactive protein, *DMARD* disease-modifying antirheumatic drug, *Dx* diagnosis, *ESR* erythrocyte sedimentation rate, *IBD* inflammatory bowel disease, *N/A* not applicable, *NSAID* nonsteroidal anti-inflammatory drug, *PsA* psoriatic arthritis, *TNF* tumor necrosis factor, *uSpA* undifferentiated spondyloarthritis

* Median (interquartile range)

[‡] Additional data from Halvorsen et al. [22]

[¥] Additional data from van Genderen et al. [20]

**Table 3** Risk of bias appraisal using RTI item bank

| Study | 1 | 2 | 3 | 6 | 9 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|
| Arends et al. [27] | N | N | N/A | Y | N | Y | N/A | U |
| Brophy et al. [30] | N | N | N/A | U | N | Y | N/A | U |
| Fongen et al. [23] | N | N | N | Y | N | Y | Y | P |
| Haglund et al. [29] | U | N | N | U | N | Y | Y | N |
| Manning et al. [24] | N | N | N/A | U | N | Y | N/A | N |
| Niedermann et al. [26] | Cochrane Collaboration risk of bias tool used. Overall risk of bias low | | | | | | | |
| O'Dwyer et al. [25] | N | N | N/A | U | N | Y | N/A | N/A |
| Plasqui et al. [21] | P | Y | N | Y | N | Y | Y | N |
| Swinnen et al. [28] | U | Y | N | Y | N | Y | Y | N |

N: No; Y: Yes; N/A: not applicable; U: unclear; P: partially

| | | |
|---|---|---|
| 1. | Do the inclusion/exclusion criteria vary across the comparison groups of the study? | Selection bias |
| 2. | Does the strategy for recruiting participants into the study differ across groups? | Selection bias, confounding |
| 3. | Is the selection of the comparison group inappropriate? | Selection bias, confounding |
| 6. | Were valid and reliable measures implemented consistently across all study participants to assess inclusion/exclusion criteria, physical activity outcomes, and potential confounders? | Detection bias, confounding |
| 9. | Are any important primary outcomes missing from the results? | Reporting bias |
| 11. | Are results believable taking study limitations into consideration? | Overall assessment |
| 12. | Were there any attempts to balance the allocation between the groups or match groups? | Confounding |
| 13. | Were important confounding variables not taken into account in the design and/or analysis? | Confounding |

In addition to measuring PA by accelerometry, Niedermann et al. [26] employed the Office in Motion Questionnaire (OIMQ) and assigned METs to each reported activity. Mean baseline OIMQ in the intervention group was 71.8 (39.1) METs per week, which was comparable to controls (MD [95 % CI]; −6.6 MET per week [−25.5 to 12.3]). Post-intervention, there were no significant between-group differences reported. In keeping with these findings, Van Genderen et al. [20] found no significant differences between an AS group and matched controls in self-reported PA measured on the Baecke Physical Activity questionnaire [median (IQR); 8.4 (1.4) vs. 8.4 (1.6), respectively].

### Comparisons to physical activity guidelines

Four studies examined compliance with PA guidelines. Fongen et al. [23] determined whether or not participants were meeting health-enhancing physical activity (HEPA) requirements based on IPAQ-LF results. They defined meeting HEPA as engaging in 30-min $PA_{mod}$ on ≥5 days/week, or engaging in 20-min $PA_{vig}$ on ≥3 days/week achieving ≥600 MET-minutes per week. Participants with low disease activity met the criteria more frequently than respondents with high disease activity (61 vs. 41 %, $p < 0.02$). Neither group was significantly different compared to the control group (49 % meeting HEPA criteria, $p < 0.1$ and $p < 0.28$, respectively).

Based on the results from the IPAQ-SF, Manning et al. [24] reported that 71 % of adults with AS exceeded weekly PA recommendations of >500MET-minutes per week; 21 % were classified as inactive. O'Dwyer et al. [25] administered a single-item measure to determine self-reported PA in a population attending rheumatology clinics. Of the SpA subset, 17.2 % met national guidelines of participating in ≥30 min of PA on ≥5 days per week (41 % reported no PA).

Haglund et al. [29] gathered information on PA in a large SpA cohort through a questionnaire enquiring about weekly PA frequency, duration, and intensity. They reported that 68 % of respondents with SpA met the WHO recommendation for PA, a rate slightly higher than that observed in the general Swedish population (RR 1.09, 95 % CI 1.04–1.15).

## Discussion

### Main findings

This is the first systematic review of PA in adults with SpA. The evidence from two studies comparing objectively measured PA levels of adults with axial SpA to

**Table 4** Physical activity measured by accelerometry

| Study | Accelerometer | Output | Results | |
|---|---|---|---|---|
| Arends et al. [27] | ActiGraph (uniaxial) | Kilocounts per day | 236 (106) | |
| Niedermann et al. [26] | ActiGraph (model unspecified) | | AS exercise group | AS control group |
| | | Counts per minute | 336.3 (184.9) | 370.5 (145.0) |
| | | $PA_{mod}$ minutes per day | 145.9 (54.2) | 170.4 (64.5) |
| | | $PA_{vig}$ (units of ≥20 min per week) | 11.1 (9.4) | 13.6 (12.9) |
| | | | No significant between-group differences in PA at baseline | |
| Plasqui et al. [21] | Tracmor (triaxial accelerometer) | | AS | Controls |
| | | PAL (MET) | 1.73 (0.15) | 1.74 (0.09) |
| | | Kilocounts per day | 319 (105) | 326 (66) |
| | | Kilocounts per minute | 0.30 (0.09)*¥ | 0.33 (0.09)*¥ |
| | | | No significant between-group differences in PA | |
| Swinnen et al. [28] | SenseWear Pro 3 Armband Multisensor device (2-axial with thermal sensors) | | aSpA | Controls |
| | | Energy expenditure METs.h/day | 34.55 (31.08–39.41)* | 36.40 (33.43–41.01)* |
| | | PAL (MET) | 1.45 (1.31–1.67)* | 1.54 (1.41–1.73)* |
| | | MVPA min/day | 98.19 (71.93–169.26)* | 144.71 (96.98–208.05)* |
| | | | Energy expenditure, PAL and MVPA significantly lower in patients with aSpA than controls ($p < 0.045$, $p < 0.048$, $p < 0.029$ respectively) | |

Mean (standard deviation) unless otherwise indicated

*AS* ankylosing spondylitis, *aSpA* axial spondyloarthritis, *MET* metabolic equivalent, *MVPA* moderate–vigorous intensity physical activity, *PA* physical activity, *PAL* physical activity level, $PA_{mod}$ moderate intensity physical activity, $PA_{vig}$ vigorous intensity physical activity

* Median (interquartile range)

¥ Additional data from van Genderen et al. [20]

matched population controls is conflicting; PA may be decreased [28] or no different [21]. In the AS subtype, participants with high disease activity reported engaging in significantly less PA than respondents with low disease activity [23, 30]. Arends et al. [27] also found PA scores to be related to disease activity, physical function, and quality of life; however, causality has not been established due to the cross-sectional design of these studies.

Estimates of compliance with PA recommendations to achieve health-related benefits vary across studies from 17 % [25] to 71 % [24]. Comparisons with healthy population controls are mixed. The large disparity may be in part due to differences in outcome measures, criteria for meeting recommendations, participant characteristics, and condition-related factors (e.g., disease duration, medications usage, and disease severity).

## Interventions

Just one study measured the effect of an aerobic exercise intervention on PA [26]. Although the volume of PA performed by the exercise group during the intervention phase was substantial, at the conclusion, participants reverted to baseline PA levels and no follow-up period was performed to examine long-term effect on PA behavior. This is not surprising as increasing free-living PA was not the primary aim of this aerobic exercise and flexibility intervention. Interventions specifically targeting PA beliefs and motivation to engage in PA have shown efficacy in improving PA participation in adults with arthritis [31, 32].

## Methodological considerations

Accurate measurement of PA is essential for the study of the relationship between PA and health in adults with rheumatic conditions. The practical benefits of using self-reported PA questionnaires include the low cost, low participant burden, and general acceptance among patient groups. However, they possess several limitations in reliability and validity [33]. Arends et al. [27] found only modest construct validity for the IPAQ-LF and SQUASH questionnaires compared to the ActiGraph accelerometer. The validity and reliability of the remaining questionnaires included in the review has not been established in an SpA population.

Direct measurement by accelerometry allows objective PA data to be gathered, although this method is not without limitations. Certain types of activities, such as upper body work or strengthening exercises, may be underestimated,

**Table 5** Physical activity measured by self-report questionnaire

| Study | PA measurement tool | PA variable | Results | | | |
|---|---|---|---|---|---|---|
| | | | Group 1 | | Group 2 | |
| Arends et al. [27] | IPAQ-LF | MET-minutes per week | 5,937 (2,126–11,601)* | | 3,849 (1,470–8,132)* | |
| | SQUASH | Total activity score | 7,267 (3,453) | | 5,760 (3,360–6,890)* | |
| Brophy et al. [30] | IPAQ-SF | MET-minutes per week | 1,719 (396–3,892) | | | |
| Fongen et al. [23] | IPAQ-LF | MET-minutes per week | High activity | Low activity | AS | Controls |
| | | | 3,073 (22,788)* | 4,290 (18,084)* | 3,738 (22,788)*‡ | 4,300 (18,366)* |
| | | | High versus low $p < 0.02$; no significant differences between control and AS subgroups | | | |
| | HEPA criteria | Met/not met criteria | Met 33 (41 %) | Met 41 (61 %) | Not reported | Met 64 (49 %) |
| | | | High versus low $p < 0.02$; no significant differences between control and AS groups | | | |
| Haglund et al. [29] | Questionnaire relating to intensity, duration and frequency of weekly PA | Met/not met WHO recommendations for PA | Met PA: 1,470 (68 %)<br>Met $PA_{mod}$: 1,237 (57 %)<br>Met $PA_{vig}$: 697 (32 %)<br>RR 1.09 (95 % CI 1.04–1.15) compared to Swedish population | | | |
| Manning et al. [24] | IPAQ-SF | MET-minutes per week<br>Met/not met recommendations >500 MET-minutes per week | 1,862.4 (95 % CI 873.0–2,851.9)<br>10 (71 %) | | | |
| Niedermann et al. [26] | OIMQ | METs per week | AS exercise group<br>71.8 (39.1) | | AS control group<br>78.4 (58.5) | |
| O'Dwyer et al. [25] | Single-item PA measure | Met/not met criteria WHO recommendations for PA | 5 (17.2 %) | | | |
| Plasqui et al. [21] | Baecke Questionnaire | Total score | AS 8.4 (1.4)*¥ | | Controls 8.4 (1.6)*¥ | |

Mean (standard deviation) and number (%) unless otherwise indicated

AS, ankylosing spondylitis; CI, confidence interval; HEPA, health-enhancing physical activity; IPAQ-LF, long-form international physical activity questionnaire; IPAQ-SF, short-form international physical activity questionnaire; MET, metabolic equivalent; OIMQ, office in motion questionnaire; PA, physical activity; $PA_{mod}$, moderate intensity physical activity; $PA_{vig}$, vigorous intensity physical activity; RR, relative risk; SQUASH, short questionnaire to assess health; WHO, world health organization

* Median (IQR)

‡ Additional data from Halvorsen et al. [22]

¥ Additional data from van Genderen et al. [20]

while many devices cannot monitor water-based activities [34]. Self-reported PA measures can both under- and overestimate PA compared to accelerometry [35], with no clear trends in the degree to which PA estimates diverge across measures. For these reasons, direct comparison and pooling has been avoided in this review.

A priori sample size calculations were reported in the studies by Niedermann [26] and Halvorsen [22]; however, neither were calculated for PA outcomes. The remaining studies may also have been underpowered and at risk of type 2 error, or overestimating effect sizes. The lack of healthy population controls in some studies limits conclusions that may be drawn. Sampling methods varied, and there is a possibility of selection bias.

### Clinical implications

Current practice guidelines advocate exercise as a key component of the management of axial SpA, but lack guidance on the amount of PA needed to derive condition-specific and general health benefits [9]. This is particularly pertinent as SpA have a higher incidence of comorbidities, such as cardiovascular disease and osteoporosis, that may be favorably impacted by increasing PA [7, 8, 36]. Although evidence of a higher prevalence among the SpA population of other chronic conditions such as obesity and diabetes is conflicting, PA could potentially also ameliorate these.

Advice on PA would be welcomed by the majority of patients attending rheumatology clinics, though in approximately half the cases, this is never discussed [24, 37]; adults with rheumatic conditions are largely unaware that PA guidelines exist [25]. There is a strong case for recommendations on PA among adults with SpA; however, it is yet to be determined whether PA guidelines for the general population are optimal for adults with rheumatic conditions.

### Limitations of the study

The diversity of design and the inherent biases of observational studies make reviewing the methodological quality challenging. Numerous appraisal tools are described in the literature, yet no gold standard exists for evaluating risk of bias [38, 39]. In this review, a decision to use either the RTI item bank or the Cochrane Collaboration's risk of bias tool was made on the basis of the methodological design of individual studies. Neither tool ascribes a score, as quality scoring of observational studies remains controversial; key components of design rather than aggregate scores were considered more important [17].

The heterogeneous nature and methodological limitations of the included studies prevent firm conclusions being drawn and restrict the generalizability of findings. The included studies included participants classified as predominantly axial-SpA; consequently, no inference can be made about predominantly peripheral-SpA, in which PA may be differently affected due to peripheral joint involvement [2, 3].

### Areas for future research

Larger epidemiological studies objectively measuring free-living PA would build on existing studies that utilized self-report questionnaires. Longitudinal studies would allow investigation of cause–effect relationships between sociodemographic and condition-related factors and PA behavior. Studies exploring the effect of current management strategies on long-term PA habits are needed, as are studies investigating strategies to positively influence PA behavior in adults with SpA. Finally, working toward including specific PA recommendations in SpA practice guidelines would add clarity for patients and healthcare practitioners.

## Conclusions

Higher disease activity was associated with lower self-reported PA levels compared to lower disease activity and controls. Objective measurement suggests PA levels may be lower among adults with SpA than among the general population. However, the heterogeneity of study designs and measurement tools, coupled with the inherent risk of bias of observational studies, limits the conclusions that may be drawn regarding the PA levels of adults with SpA.

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