Physical activity and sedentary behaviour and their associations with clinical measures in axial spondyloarthritis

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Abstract
Engaging in physical activity (PA) is a key aspect in the management of axial spondyloarthritis (axial SpA), however, its relationship with clinical measures is unknown. Previous research has mainly focused on subjective methods of measuring PA and sedentary behaviour (SB). The aim of this study was to explore the associations between objectively measured PA and SB with clinical measures in people with established axial SpA. Fifty participants were recruited from secondary-care rheumatology outpatient services in Glasgow, UK. Clinical measures collected included; Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), Bath Ankylosing Spondylitis Functional Index (BASFI), Bath Ankylosing Spondylitis Metrology Index (BASMI), Ankylosing Spondylitis Quality of Life (ASQOL) and the Six Minute Walk Test (6MWT). PA and SB were measured using the activPAL3 tri-axial accelerometer. Data from forty-five participants were included (23 males, average age 49 ± 12 years). Participants accumulated an average of 93.2 ± 41.5 min/day walking with an average of 7200 ± 3397 steps/day. The majority of the day (65%) was spent sitting, accumulated in prolonged bouts. Walking time and steps taken/day were associated with better BASFI ($r = -0.395, p = 0.007$ and $r = -0.404, p = 0.006$), ASQOL ($r = -0.375, p = 0.015$) and 6MWT ($r = 0.396, p = 0.007$ and $r = 0.421, p = 0.004$); while longer walking events were associated with better BASMI ($\rho = -0.352, p = 0.018$), BASFI ($\rho = -0.316, p = 0.034$) and 6MWT ($\rho = 0.404, p = 0.006$). SB was associated with worse ASQOL ($r = 0.380, p = 0.010$) and 6MWT (6MWT, $r = -0.357, p = 0.016$). In people with axial SpA PA is associated with better function, exercise capacity and spinal mobility, while SB is associated with lower exercise capacity and poor quality of life. These findings support the promotion of PA and reduction of SB in people with axial SpA.

Keywords Axial spondyloarthritis · Physical activity · Sedentary behaviour · Rheumatology

Introduction
Axial spondyloarthritis (axial SpA), including ankylosing spondylitis and non-radiographic axial SpA, is a chronic inflammatory arthritis characterised by reduced spinal mobility and function and an increased risk of cardiovascular events [1, 2]. A combination of pharmacological and non-pharmacological management is essential for good clinical outcomes in axial SpA. Physical activity (PA) and exercise, a subcategory of PA, are key aspects in the management of people with axial SpA [3, 4]. People with axial SpA are at increased risk of cardiovascular disease [5]. A lack of PA...
and predominance of sedentary behaviour (SB), are independent risk factors for co-morbidities, such as cardiovascular disease, in the general population [6] and, therefore, should be considered in axial SpA symptom and co-morbidity management.

Recently, disease activity was found to be associated with time spent sedentary while no association was found with moderate-vigorous physical activity (MVPA) in people with axial SpA [7]. In addition, physical fitness components (aerobic capacity, strength and body fat percentage) were associated with functional ability [8, 9] and disease activity [10]. Yet, the relationship between PA and/or SB with clinical measures such as spinal mobility, functional ability and exercise capacity in people with axial SpA is unknown. It is widely considered that people with axial SpA are less active and more sedentary than their healthy counterparts [11]. However, previous research has mainly focused on subjective methods of measuring PA and SB [11] and so may not be an accurate reflection [12]. While self-report measures are convenient and inexpensive, they are subject to issues such as recall bias and social desirability. Agreement between commonly used questionnaires to measure PA and SB has been found to be poor [12, 13]. For instance, the International Physical Activity Questionnaire (IPAQ) underestimated sitting time by up to 4.6 h per day [12]. Therefore, the effects of PA and SB variables on health-related outcomes may be diminished when using inaccurate measurement tools [14]. The aim of this study was to explore the associations between objectively measured PA and SB with axial SpA clinical measures.

**Methods**

**Study design and participants**

This study utilises baseline data from a prospective cohort study on web-based physiotherapy exercise, which recruited 50 people with axial SpA with low self-reported exercise levels (ClinicalTrials.gov ref: NCT02666313) [15]. The participants were recruited from the secondary-care rheumatology outpatient service of NHS Greater Glasgow & Clyde, UK. Participants were included if they had a confirmed diagnosis, by a rheumatology consultant, according to the Assessment of Spondyloarthritis International Society criteria [16], for more than one year, were over 18 years and had access to the internet at home. Participants were excluded if they self-reported participating in structured exercise regularly (three or more times per week), had a joint replacement within the last six months, had any significant comorbidities that would preclude them from taking part in a regular exercise programme or if they were currently participating in another clinical trial [15]. All participants gave informed, written consent and the study was approved by the West of Scotland Research Ethics Committee (Ref: 15/WS/0229).

**Measurement of physical activity and sedentary behaviour**

PA, defined as any bodily movement produced by skeletal muscle that requires energy expenditure [17], and SB, defined as any waking behaviour characterised by an energy expenditure of ≤ 1.5 metabolic equivalents while in a sitting, reclining or lying position [18], were objectively measured using the activPAL3 activity monitor (PAL Technologies Ltd, Glasgow, UK). The activPAL3 device is a small, lightweight (55 × 35 × 7 mm, 15 g) tri-axial accelerometer worn on the anterior thigh of the dominant leg and attached using a Tegaderm waterproof dressing. The activPAL3 has been found to be a valid measure of steps, walking and sedentary time in healthy adults [19-21]. Participants were asked to wear the monitor continuously for one week and undertake their usual activities. A day was considered valid if it contained 24 h of wear time. For each participant the time spent standing, walking, number of steps and time spent sedentary per day were measured. Participants were asked to record their sleep time each night using a sleep diary, and sleep time was removed from the analysis [22].

**Demographic variables and outcome measures**

Demographic characteristics including age, gender, work status and medication history were collected. Clinical measures included the following, described in full in Paul et al. [15]: Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), a six item questionnaire measuring disease activity with higher scores indicating greater activity [23], Bath Ankylosing Spondylitis Functional Index (BASFI), a 10 item questionnaire measuring functional ability with higher scores indicating worse function [24], Bath Ankylosing Spondylitis Metrology Index (BASMI), a five item index measuring spinal mobility with higher scores indicating greater limitations in movement [25], Ankylosing Spondylitis Quality of Life (ASQOL), a questionnaire with higher scores indicating poorer quality of life [26], and the Six Minute Walk Test (6MWT), a walking test conducted over six minutes with a greater distance walked indicating better exercise capacity [27].

**Statistical analysis**

PA and SB data were extracted from the activPAL3 monitors using proprietary software (version 7.24, PAL Technologies, Glasgow, UK). Data were visually inspected hour by hour and compared to completed sleep diaries to ensure accuracy of completed diaries. Additional data processing.
was spent sitting (10.8 ± 2.3 h/day). The majority of the total (> 100 steps/min). The majority of the waking day (65%) in prolonged bouts (defined as sitting events ≥ 30 min) with sitting time (40% ± 18% of the waking day) was accumulated in MVPA was associated with better functional ability (BASFI, r = −0.404, p = 0.006, respectively) and exercise capacity (r = −0.395, p = 0.016) and exercise capacity

Results

Fifty participants were recruited between December 2016 and December 2017. PA and SB data were missing for five participants [allergy to Tegaderm dressing (n = 1), instrument error (n = 3) and researcher error (n = 1)]; therefore, complete data were available for 45 participants. Complete activPAL3 data for seven (n = 1), six (n = 42), five (n = 1) and four days (n = 1) was available. Participants, 23 male and 22 female, had an average age of 49 ± 12 years and an average axial SpA disease duration of 16 ± 11 years (Table 1). The majority of participants (69%) were in paid employment with only 8% currently receiving physiotherapy treatment or attending an exercise class. Participants had an average BASDAI score of 4.5 ± 2.3, of which 28 participants had a BASDAI of ≥ 4, indicating active disease activity [33] (Table 1). Distance walked during the 6MWT was 414 ± 106 m (range 121–622), substantially lower than the reference standard for healthy adults (571 ± 90 m [range 380–782 m]) [34] (Table 1).

Participants walked on average for 93.2 ± 41.5 min/day with an average of 7200 ± 3397 steps/day and average cadence of 69.6 ± 4.6 steps/min (Table 2). Approximately 20 ± 4 min/day were spent stepping at a moderate intensity (> 100 steps/min). The majority of the waking day (65%) was spent sitting (10.8 ± 2.3 h/day). The majority of the total sitting time (40% ± 18% of the waking day) was accumulated in prolonged bouts (defined as sitting events ≥ 30 min) with an average of 6.7 ± 2.9 h/day of prolonged sitting bouts. On average, participants accumulated 121 ± 97 min/week of PA at a moderate intensity, with one third (n = 15) of participants achieving the PA guidelines of 150 min/week of moderate intensity PA [35]. While there were no statistically significant differences between those with low and active disease activity (BASDAI), there was a trend for those with active disease activity to be less physically active and more sedentary (Table 2). There were no correlations of age and gender with any PA and SB outcomes.

There were small significant correlations for walking time and steps taken/day with the BASFI, indicating that both time spent walking and steps taken were associated with better function ability (BASFI, r = −0.395, p = 0.007 and r = −0.404, p = 0.006, respectively). Similar significant correlations were found for exercise capacity (r = −0.395, p = 0.007 and r = 0.421, p = 0.004, respectively) and quality of life (ASQOL, r = −0.375, p = 0.011 and r = −0.361, p = 0.015, respectively) (Table 3). In addition, time spent in MVPA was associated with better functional ability (BASFI, rho = −0.358, p = 0.016) and exercise capacity...
Longer walking events were associated with better spinal mobility (BASMI, \(\rho = -0.352, p = 0.018\)), functional ability (BASFI, \(\rho = -0.316, p = 0.034\)) and exercise capacity (6MWT, \(\rho = 0.404, p = 0.006\)) (Table 3). Furthermore, greater total time spent sitting was associated with poorer quality of life (ASQOL, \(r = 0.380, p = 0.010\)) and prolonged sitting was associated with reduced exercise capacity (6MWT, \(r = -0.357, p = 0.016\)) (Table 3).
Discussion

The results of this study indicate that, in people with axial SpA, higher levels of objectively measured PA (walking time, steps taken, MVPA, duration of walking events) is associated with better functional ability (BASFI), exercise capacity (6MWT) and spinal mobility (BASMI); while higher levels of objectively measured SB (greater total sitting time and prolonged sitting) is associated with reduced exercise capacity (6MWT) and quality of life (ASQoL). While there was no association between SB or PA with disease activity (BASDAI). In this study, monitors were worn continuously which allowed for 24-h assessment which minimised data loss due to compliance or issues in identifying wear time [36]. Furthermore, the activPAL3 is recognised as the gold standard measurement device for postural SB [20, 21], with sleep time, identified using diaries, removed from analysis. This method was of particular benefit as it avoided issues with differentiating between sleep, SB or non-wear time that may occur with other devices [36].

Participants with axial SpA in the current study engaged in a greater amount of SB (10.8 ± 2.3 h/day) than reported in previous research (7.5 ± 1.97 h/day) [7]. Swinnen et al. reported that people with axial SpA were sedentary for 17.99 h/day including sleep time. If we assume sleep time of approximately 8 h/day then sedentary time in the current study may be comparable. Participants in the current study spent less time spent in MVPA, 20.3 ± 16.0 min/day, compared to 59.1 ± 29.6 min/day [7] and 98 min/day [37]. These differences are likely due to differences in recruitment (participants in the current study were excluded if they self-reported as exercising ≥ 3 times/week), while differences in measurement device and their position on the body or classification of MVPA may further play a role. For instance, O’Dwyer et al. [7] utilised the RT3 tri-axial accelerometer, worn at the hip for at least 10 h per day, removed during sleep and washing/bathing activities, providing an output expressed as activity counts and converted to minutes. This could have led to a systematic error in which SB was not consistently measured. Comparisons with other research [38-40], which only reported activity counts, cannot be made since they are arbitrary units which require calibration [40].

Participants in the current study undertook 7200 ± 3397 steps/day with only 33% of participants meeting the current UK and USA PA guidelines (150 mins MVPA/week) [35, 41]. This is similar to previous objectively measured findings (27–39%) [7, 42], yet lower compared to studies which measured PA participation using questionnaires (41–71%) [43-45], suggesting participants may overestimate their PA levels when assessed by self-report. This rate of attainment is based upon PA guidelines for healthy adults (18–65 years old) since no disease-specific guidelines exist.

Engaging in regular PA and reducing prolonged SB is important to maintain and improve health [46]. This study adds to the current literature on PA and SB levels of people with axial SpA using accurate objectively measured PA and SB in people with axial SpA who self-report as not adhering to PA guidelines. The low adherence to the PA guidelines are concerning given the findings of the current study, risk of developing co-morbidities [5] and the beneficial effects of exercise [3]. The management of people with axial SpA should focus on interventions to improve PA to optimise the health benefit, and consider interventions to reduce SB.

This study has a number of limitations. First, selection bias may be present since studies investigating exercise and PA are likely to recruit participants who are interested in PA/exercise; while, potential participants recruited in the current study were excluded if they were exercising three or more times per week [15]. As such, the PA and SB levels presented may not be representative of the overall axial SpA population. Finally, the results presented are cross-sectional, therefore, prevent determination of causality with multiple comparisons conducted on a small sample with no statistical corrections employed.

Conclusion

The results demonstrate objective PA outcomes are associated with better function (BASFI), exercise capacity (6MWT) and spinal mobility (BASMI), while SB outcomes are associated with exercise capacity (6MWT) and quality of life (ASQoL) in people with axial SpA. These findings appear to support the promotion of PA and reduction of SB in this population, as well as the use of objective measurement devices for PA and SB in axial SpA. Future research is required to explore if interventions which improve PA and/or SB result in improvements in clinical measures.

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Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Marie Therese McDonald, Sara Cameron, and Elaine Coulter. The first draft of the manuscript was written by Elaine Coulter and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest Dr Coulter, Ms McDonald, Dr Siebert and Professor Paul received a research grant from Versus Arthritis (formerly Arthritis Research UK) during the conduct of the study. Ms Cameron declares no conflicts of interest.

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