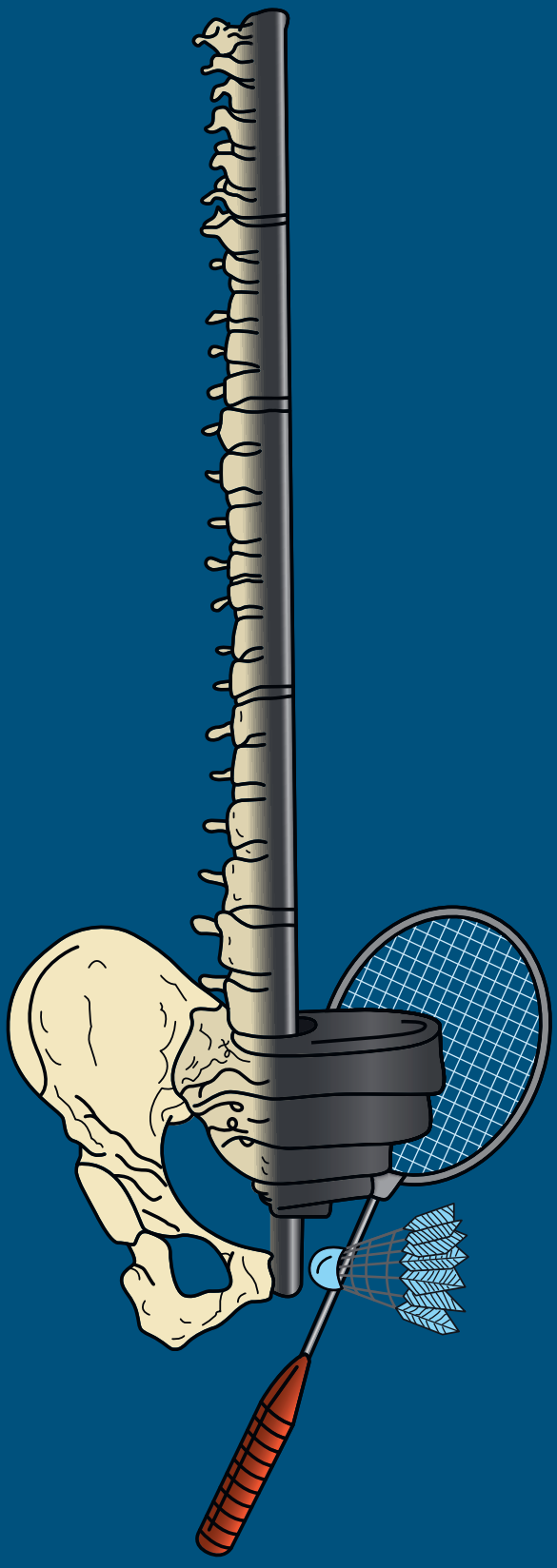
Optimizing physical activity and exercise in people with axial spondyloarthritis

Hilberdink, S.



Chapter 3

Differences in characteristics, health status and fulfilment of exercise recommendations between axial spondyloarthritis patients with and without supervised group exercise

Bas Hilberdink
Marlies Carbo
Davy Paap
Suzanne Arends
Thea Vliet Vlieland
Florus van der Giesen
Anneke Spoorenberg
Salima van Weely

Seminars in Arthritis and Rheumatism 2022;55:152035.

Abstract

Objective

Since decades, supervised group exercise (SGE) is recommended for people with axial spondyloarthritis (axSpA). This study examines if weekly SGE contributes to fulfillment of exercise recommendations in axSpA patients.

Methods

Cross-sectional data from three studies with axSpA patients in the Netherlands, including two with outpatient populations (n=196 and n=153) and one with SGE participants (n=128), were analyzed. Sociodemographic and disease characteristics, SGE participation, health status (ASAS Health Index), spinal mobility and fulfillment of the recommendations for leisure-time aerobic (≥150 min/week moderate-intensity or ≥75 min/week vigorous-intensity) and strength and mobility (≥2 sessions/week) exercise (measured with SQUASH-questionnaire) were assessed. Differences between patients with and without SGE were analyzed.

Results

In the two outpatient populations (n=349), 17 patients (5%) used SGE. The SGE participants (n=145) were significantly older, had longer disease duration, were less frequently employed, used less medication and had worse spinal mobility than patients without SGE (n=332). There were no significant differences in health status. Patients with SGE fulfilled the moderate-intensity aerobic (89% vs. 69%) and strength and mobility (44% vs. 29%) exercise recommendations more often than patients without SGE, but the aerobic exercise recommendation was less often fulfilled with vigorous-intensity exercise (5% vs. 12%).

Conclusion

SGE is used by just few, especially older, axSpA patients and contributes to fulfilling recommendations for moderate-intensity, mobility and strength exercise. Both in patients with and without SGE, only a minority fulfilled the recommendations for vigorous-intensity, strength and mobility exercises. Therefore, future promotion of exercise should focus on implementing these types of exercise.

Introduction

Axial spondyloarthritis (axSpA) is a chronic inflammatory rheumatic disease primarily affecting the spine (1, 2). Patients with axSpA are recommended to engage in aerobic, strength and mobility exercises, dosed according to public health recommendations, to positively influence symptoms, cardiorespiratory fitness, functioning and quality of life (3-7). Supervised group exercise (SGE) in particular has been recommended for many years for axSpA patients (7-9), as it was found to have a better effect on symptoms, fitness and functioning than home exercise (7, 8, 10, 11). In some countries, including the Netherlands and Switzerland, local patient associations organize SGE specifically for axSpA patients: these exercise groups typically combine land-based and aquatic exercises and sports activities and are often supervised by a physical therapist (12-14). However, although axSpA patients are recommended to engage in aerobic, strength and mobility exercises at least twice a week (3, 5), current SGE in the Netherlands focuses primarily on mobility and strength exercise and takes place just once a week (5, 12, 13). To improve the quality of exercise in SGE participants, recent studies sought to implement SGE enhancements, including greater focus on (high-intensity) aerobic exercises and educating patient about additional (home) exercises (14, 15). Therefore, it is important to know how many and which axSpA patients engage in SGE and to what extent they currently engage in exercise according to public health exercise recommendations, also compared to patients without SGE.

It is not entirely clear which axSpA patients participate in SGE, although this is useful information for future exercise promotion. Findings from previous studies suggest that only a small minority of axSpA patients engages in axSpA-specific SGE (12, 16, 17) and that this concerns relatively old axSpA patients (12, 13). This should be taken into account when providing personal exercise advice, as older axSpA patients, on average, have worse spinal mobility (18), slightly worse health status (19, 20) and a higher risk of comorbidities (21).

While many studies have examined engagement in physical activity among axSpA patients, few studies focused specifically on leisure time exercise and no study looked at the differences between axSpA patients with and without SGE. Exercise is a subcategory of physical activity and concerns planned, structured and repetitive activities performed in leisure time and specifically aimed at gaining health benefits (22). Previous studies showed that in axSpA patients the amount of moderate-intensity physical activity was comparable to the general population, while engagement in vigorous-intensity physical activity was lower (16, 23-28), despite the particularly promising effects in axSpA patients (29). The engagement of axSpA patients in mobility (approx. 30%) and strength (approx. 10%) exercises appears to be lacking (6, 23, 30), but the evidence for this is limited. Given the current content of axSpA-specific SGE (12, 13), SGE contributes to engagement in mobility and

strength exercises. However, SGE may prevent patients from participating in other exercise activities, because they already engage in SGE, resulting in not meeting the recommended exercise frequency (≥2 sessions/week (3)).

Thus, it is important to know how many and which axSpA patients participate in SGE and whether SGE contributes to meeting the exercise recommendations. Therefore, this study aims to compare axSpA patients with and without SGE regarding sociodemographic and disease characteristics, health status and engagement in leisure time exercise.

Material and Methods

In this cross-sectional study, data from three cohorts of axSpA patients in the Netherlands were used:

1. Cohort 1 (n=196) concerns data from a cross-sectional study of the Leiden University Medical Center (LUMC), including patients with an axSpA diagnosis confirmed by a rheumatologist from registries of three hospitals in the southwest of the Netherlands (LUMC in Leiden, Haga Hospital in The Hague and Reinier de Graaf Gasthuis in Delft). Eligible patients who had ever visited the rheumatology outpatient clinics from these hospitals were invited for this study in 2015. There was a 45% response rate and the participants´ sex ratio and proportion using physical therapy was comparable to other axSpA studies (16). The study used a survey to examine physical therapy use and physical activity (16).
2. Cohort 2 (n=153) concerns data from the Groningen Leeuwarden Axial Spondyloarthritis (GLAS) cohort, an ongoing prospective longitudinal observational cohort study of two hospitals in the north of the Netherlands (University Medical Center Groningen (UMCG) and Medical Center Leeuwarden (MCL)), with standardized follow-up of axSpA patients fulfilling the modified New York criteria (31) or the ASAS classification criteria for axSpA (32). As part of a validation study, an axSpA-specific physical activity questionnaire, the (m)SQUASH, was added to the GLAS assessment protocol and presented to all consecutive patients participating in GLAS in 2018 (33). These data were used for the present analysis.
3. Cohort 3 (n=128) concerns data from an SGE cohort, with axSpA patients from four regions geographically spread across the Netherlands (Leiden, Mid Limburg, the Gooi and the Hague) where local patient associations affiliated to the Dutch Arthritis Society organize axSpA-specific SGE. The four regions in this cohort participated in a pilot project to implement proposed SGE enhancements (13), which was conducted between 2015 and 2018. Of the 130

SGE participants, almost all patients agreed to participate (n=128). Only baseline data was used for the current study.

The necessary amendments to analyze the data for the present study were approved by the local ethics committees of the LUMC, Haga and RdGG (METC-LDD P14.326/DJ/dj) and UMCG and MCL (GLAS RTPO 364/604).

Assessments

From the three cohorts, data on sociodemographic and disease characteristics, health status and leisure time exercise were gathered.

- Sociodemographic and disease characteristics: Data on age, sex, time since diagnosis (disease duration) and use of medication related to axSpA, i.e. analgesics (acetaminophen or opioids, not available in Cohort 2), Non-Steroidal Anti-Inflammatory Drugs (NSAIDs), biologicals and Disease-Modifying Antirheumatic Drugs (DMARDs), were included. Additionally, employment status was derived from the physical activity questionnaire described below. In Cohort 1 and Cohort 3, data on individual physical therapy use (yes/no) and duration of SGE engagement (years) were also available.
- Disease-related health status: Patients completed questionnaires, including the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), which measures disease activity (34), the Bath Ankylosing Spondylitis Functional Index (BASFI), which measures physical functioning (35), the Ankylosing Spondylitis Quality of Life (ASQoL) questionnaire, which measures quality of life (36), and the ASAS Health Index (ASAS HI), which measures participants' health status (19). Spinal mobility was assessed with lateral spinal flexion, chest expansion, cervical rotation (from seated position) and the modified Schober's test (37). ASAS HI data were available for Cohorts 1 and 3 and for a subset of Cohort 2. In Cohort 1, no other data on disease-related outcomes were available and ASQoL data were only available in Cohort 2.
- Leisure time exercise: The Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) (38) was used in Cohort 1 and Cohort 3 to assess exercise engagement. The modified (m)SQUASH, an axSpA-specific adaptation of the SQUASH (33), was used in Cohort 2. Both the SQUASH and mSQUASH measure all physical activity during an average week in the past month. This study focuses only on leisure time exercise and, therefore, only extracted frequency and duration of recreational walking, cycling and other exercise activities that patients reported to engage in from these questionnaires. Both questionnaires also allowed to identify which patients from Cohorts 1 and 2 engaged in SGE. All exercise activities were assigned the corresponding MET-value using Ainsworth's compendium (39); this was done identically for both the SQUASH and the mSQUASH. Duration (minutes/week) and frequency

(sessions/week) of all aerobic exercise activities were calculated, as well as engagement in vigorous-intensity exercise (yes/no) and fulfillment of the World Health Organisation (WHO) recommendations for aerobic exercise (moderate-intensity exercise, defined as ≥3 MET, for ≥150 min/week and/or vigorous-intensity exercise, defined as ≥6 MET, for ≥75 min/week and/or an equivalent combination) (40). In addition, the frequency of engagement in exercise types with strength and mobility components was calculated, i.e. gym, aquatic and home exercise, SGE, competitive sports, climbing and body and mind exercise (yoga, Pilates or tai chi). It was then assessed whether the recommended frequency for these strength and mobility exercises (≥2 sessions/week) was fulfilled (yes/no).

Statistical analyzes

For Cohorts 1 and 2, SGE engagement was extracted from the physical activity questionnaires. The SGE participants from Cohorts 1 and 2 were combined with SGE participants from Cohort 3 after assessing if the data from the three cohorts could be combined. Descriptive statistics were used to report sociodemographic and disease characteristics, health status and exercise engagement, for patients with and without SGE separately. Results were reported as means and standard deviations (SD) or medians and interquartile range (IQR) for normally and non-normally distributed continuous variables, respectively. Numbers and percentages were reported for categorical variables. To examine whether the data from the three cohorts could be combined, characteristics of patients with and without SGE were compared between the three different cohorts using the Mann-Whitney U test for non-normally distributed continuous variables and the Chi-Square test for categorical variables.

A 'cross-walk' procedure of ASQoL data into ´expected ASAS HI´ scores was performed for patients in Cohort 2 with no available ASAS HI data. For this 'cross-walk', the models of Pike at al. (41) were applied and validated using data of 34 participants of the current study who had both ASAS HI and ASQoL data available. A Bland-Altman plot (Figure A1 in Appendix A) showed no proportional bias in these data.

To examine the differences between patients with and without SGE, Chi-square tests and Mann-Whitney U tests were used where appropriate. In addition, univariate and multivariate regression models were performed to examine the associations of SGE with fulfillment of the aerobic, strength and mobility exercise recommendations and to correct for potential covariates, i.e. age, sex, employment and ASAS HI (42, 43). For the associations with aerobic exercise recommendations, multinomial regression models were used, because the dependent variable consisted of three categories: not fulfilling any aerobic exercise recommendation

(reference category), fulfilling only the moderate-intensity exercise recommendations (≥ 150 minutes per week) and fulfilling the vigorous-intensity exercise recommendation (≥ 75 minutes per week). For the strength and mobility exercise recommendation (≥2 sessions/week), logistic regression models were used. Exploratory analyzes were performed to examine the associations of duration of SGE participation with ASAS HI and exercise engagement, using Spearman's correlation. All statistical analyzes were performed with IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, N.Y., USA).

Results

Patient characteristics

Among the three cohorts (n=477), 145 axSpA patients participated in SGE: in addition to the 128 SGE participants from Cohort 3, also 17 of 349 patients (5%) in the outpatient populations of Cohort 1 (n=13/196) and Cohort 2 (n=4/153). In these 145 patients, the median duration of SGE participation was 22 years (IQR 9-25). Before comparing patients with and without SGE, it was assessed if the data from the three cohorts could be combined by comparing the 17 SGE participants from Cohorts 1 and 2 with the 128 from Cohort 3 as well as the patients without SGE from Cohorts 1 and 2. The subgroups in the different cohorts proved to be sufficiently comparable: between SGE participants from Cohorts 1 and 2 and Cohort 3, only the difference in employment status reached statistical significance and in the patients without SGE from Cohorts 1 and 2, only age and disease duration were significantly different (see Supplementary Table S1). Therefore, the data were combined.

The differences in characteristics between patients with (n=145) and without (n=332) SGE are presented in Table 1. AxSpA patients with SGE were significantly older ($p < 0.001$), had longer disease duration ($p < 0.001$) and were less likely to use biologicals ($p < 0.001$) and analgesics ($p < 0.05$). Furthermore, a lower proportion of SGE participants were employed ($p < 0.05$), but this difference was not significant when stratifying subgroups for being younger or older than 65 years. Additional analysis showed that although not using NSAIDs, biologicals or DMARDS was associated with engaging in SGE, these patients did not report a higher use of analgesics or individual physical therapy (data not shown).

Table 1. Differences between axSpA patients with and without SGE in patient characteristics.

	Patients with SGE (n=145)	Patients without SGE (n=332)	*P* [a]
Age, years, Med (IQR)	61 (52-70)	53 (41-63)	**<0.001**
Sex, male, n (%)	92/139 (66)	214/331 (65)	0.750
Disease duration, years, Med (IQR)	27 (15-36)	15 (6-30)	**<0.001**
Individual physical therapy use [b], n (%)	41/97 (42)	81/182 (45)	0.720
Medication use, n (%)			
No NSAID, biological or DMARD	36/125 (29)	35/314 (11)	**<0.001**
NSAID	70/125 (56)	199/303 (66)	0.060
Biological	23/125 (18)	129/316 (41)	**<0.001**
DMARD	15/125 (12)	50/316 (16)	0.307
Analgesics [b]	32/121 (26)	69/183 (38)	**0.041**
Being employed, n (%)	64/135 (47)	186/320 (58)	**0.036**
Employment among under 65s	58/87 (67)	180/254 (71)	0.462
Employment among over 65s	6/48 (13)	8/67 (12)	0.928

[a] P-value of Mann Whitney U Test (continuous variables) or Chi Square Test (categorical variables).

[b] Not assessed in Cohort 2 (only in Cohorts 1 and 3)

AxSpA = axial spondyloarthritis; SGE = supervised group exercise; NSAID = nonsteroidal anti-inflammatory drug; DMARD = disease-modifying antirheumatic drug.

Disease-related health-status

The ASAS HI was available for 353 participants. In addition, 'cross-walking' of ASQoL data was applied in 59 participants to calculate the expected ASAS HI (see Supplementary Figure S1). This resulted in a total of 412 ASAS HI scores. The other health-status variables were available in fewer participants, because these were not measured in Cohort 1. As shown in Table 2, there were no significant differences in ASAS HI, BASFI or BASDAI between patients with and without SGE. AxSpA patients with SGE had significantly worse lateral spinal flexion ($p = 0.01$) and cervical rotation ($p < 0.001$), but not when adjusting for age ($p = 0.321$ and 0.064, respectively). Duration of SGE participation was not significantly associated with ASAS HI scores (data not shown).

Table 2. Differences between axSpA patients with and without SGE in different disease-related outcomes.

	Patients with SGE		Patients without SGE		*P* [a]
	N	Med (IQR)	N	Med (IQR)	
ASAS Health Index [b]	133	5.0 (3.0-7.0)	279	5.0 (2.0-8.3)	0.678
BASFI [c]	56	4.0 (1.9-5.5)	110	2.8 (1.0-5.7)	0.156
BASDAI [c]	80	3.8 (2.3-4.8)	141	3.4 (1.7-6.0)	0.591
Spinal mobility [c]					
Lateral spinal flexion	85	9.5 (5.4-14.7)	137	12.3 (8.3-16.3)	**0.010**
Chest expansion	86	2.5 (1.7-4.0)	137	3.0 (1.0-5.0)	0.369
Cervical rotation	44	52 (40-70)	137	70 (60-80)	**<0.001**
Modified Schober's test	44	3.5 (2.4-4.8)	137	4.0 (3.0-5.0)	0.542

[a] P-value of Mann Whitney U Test. When adjusting for age, there was no significant difference between axSpA patients with and without SGE.
[b] Original ASAS Health Index: n=353. Expected ASAS Health by 'cross-walking' the Ankylosing Spondylitis Quality of Life (ASQoL) scores (Pike et al., 2021): n=59.
[c] Not assessed in Cohort 1 (only in most in Cohort 2 and partially in Cohort 3)
AxSpA = axial spondyloarthritis; SGE = supervised group exercise; Med = median; IQR = interquartile range; BASFI = Bath Ankylosing Spondylitis Functional Index; BASDAI = Bath Ankylosing Spondylitis Disease Activity Index.

Leisure time exercise

Table 3 and Figure 1 show the differences in weekly exercise engagement between axSpA patients with and without SGE. Compared to axSpA patients without SGE, patients with SGE were significantly more likely to fulfill the moderate-intensity (89% vs. 69%) and the combined WHO aerobic exercise recommendations (90% vs. 74%), while they were less likely to fulfill the aerobic exercise recommendation with vigorous-intensity exercise (5% vs. 12%). In both patients with and without SGE, only a small minority engaged in any vigorous-intensity exercise (7% vs. 16%, respectively).

Table 3. Difference between axSpA patients with and without SGE in weekly exercise engagement.

	Patients with SGE (n=135)	Patients without SGE (n=320)	*P* [a]
WHO aerobic exercise recommendations, n (%)	121 (90)	236 (74)	**<0.001**
Moderate-intensity exercise ≥150 min/wk	120 (89)	222 (69)	**<0.001**
Vigorous-intensity exercise ≥75 min/wk	7 (5)	38 (12)	**0.029**
Aerobic exercise [b] duration, minutes, Med (IQR)	420 (285-660)	283 (120-540)	**<0.001**
Aerobic exercise [b] frequency, sessions, Med (IQR)	6 (4-9)	5 (2-9)	**0.035**
Strength/mobility exercise [c] ≥2 sessions, n (%)	59 (44)	92 (29)	**0.002**
Exercise types, n (%)			
Recreational walking	92 (68)	222 (69)	0.796
Recreational cycling	84 (62)	179 (56)	0.215
Aquatic exercise (besides SGE)	33 (24)	41 (13)	**0.002**
Gym exercise	17 (13)	69 (22)	**0.026**
Home exercise	9 (7)	23 (7)	0.843
Running	3 (2)	26 (8)	**0.019**
(Competitive) sports	10 (7)	25 (8)	0.882
Body and mind exercise	5 (4)	10 (3)	0.752
Other sports	2 (2)	8 (3)	0.498

[a] P-value of Mann Whitney U Test (continuous variables) or Chi Square Test (categorical variables).

[b] This includes all exercise with at least moderate-intensity (≥3 MET), including SGE.

[c] This includes exercise types with potential strength and mobility components, including SGE.

AxSpA = axial spondyloarthritis; SGE = supervised group exercise; min/wk = minutes per week; Med = median; IQR = interquartile range.

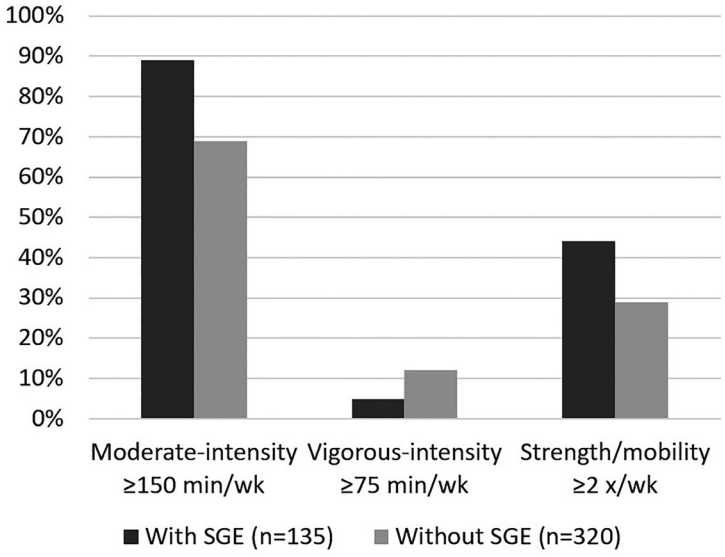


Figure 1. Differences in fulfillment of exercise recommendations between axial spondyloarthritis patients with and without supervised group exercise (SGE). Min/wk = minutes per week; x/wk = sessions per week.

Furthermore, the recommendation for strength and mobility exercise (≥2 sessions/week) was fulfilled by 44% of patients with SGE (including the weekly SGE engagement) and by 29% of patients without SGE ($p < 0.01$). SGE participants engaged in aquatic exercise significantly more often ($p < 0.01$) and in running and gym exercise less often (both $p < 0.01$) than patients without SGE. Walking and cycling were the most popular forms of exercise in both groups.

Tables 4 and 5 present the results of the multinominal and logistic regression analyzes. After adjusting for age, sex, being employed and ASAS HI scores, SGE participation was significantly associated with fulfilling the aerobic recommendation with only moderate-intensity exercise as well as the strength and mobility exercise recommendation.

Finally, exploratory analyzes showed that duration of SGE participation was not significantly associated with exercise engagement (data not shown).

Table 4. Multinomial regression analyzes exploring factors associated with fulfilling aerobic exercise recommendations in axSpA patients (n=402).

	Univariable			Multivariable		
	Exp(*B*)	95% CI	*P*	Exp(*B*)	95% CI	*P*
Fulfilling recommendation with only moderate-intensity						
SGE engagement (no)	0.28	0.15-0.51	**<0.001**	0.35	0.18-0.67	**0.002**
Age (years)	1.03	1.01-1.04	**0.003**	1.01	0.99-1.03	0.602
Sex (male)	1.08	0.68-1.71	0.756	1.09	0.63-1.87	0.765
Being employed (no)	2.00	1.25-3.19	**0.004**	2.36	1.29-4.34	**0.006**
ASAS Health Index (0-17)	0.97	0.90-1.03	0.306	0.94	0.87-1.01	0.080
Fulfilling recommendation with vigorous-intensity						
SGE engagement (no)	0.87	0.33-2.34	0.788	0.96	0.33-2.78	0.945
Age (years)	1.00	0.98-1.03	0.957	1.01	0.98-1.05	0.553
Sex (male)	3.98	1.54-10.30	**0.004**	2.31	0.83-6.41	0.108
Being employed (no)	0.61	0.28-1.35	0.222	1.04	0.36-2.98	0.948
ASAS Health Index (0-17)	0.71	0.61-0.82	**<0.001**	0.73	0.63-0.85	**<0.001**

Reference category = not fulfilling aerobic exercise recommendations.
AxSpA = axial spondyloarthritis; SGE = supervised group exercise.

Table 5. Logistic regression analyzes exploring factors associated with fulfilling strength/mobility exercise recommendation in axSpA patients (n=402).

	Univariable			Multivariable		
	Exp(*B*)	95% CI	*P*	Exp(*B*)	95% CI	*P*
SGE engagement (yes)	1.92	1.27-2.92	**0.002**	1.82	1.16-2.88	**0.010**
Age (years)	1.01	0.99-1.02	0.455	1.00	0.98-1.01	0.603
Sex (female)	0.88	0.58-1.33	0.547	0.88	0.55-1.39	0.568
Being employed (yes)	0.85	0.58-1.26	0.427	0.70	0.43-1.14	0.155
ASAS Health Index (0-17)	0.94	0.88-0.99	**0.027**	0.93	0.87-0.99	**0.016**

Dependent variable = fulfilling the strength and mobility exercise recommendation (≥2 sessions per week).
AxSpA = axial spondyloarthritis; SGE = supervised group exercise.

Discussion

This study showed that just a small minority of axSpA patients participated in SGE; only 5% of two outpatient cohorts in different regions in the Netherlands. After combining the data of these two outpatient populations with that of a cohort of SGE participants, it was found that patients engaging in SGE were older, had longer disease duration, were less frequently employed, used less medication and had worse spinal mobility, yet fulfilled the recommendations for (moderate-intensity) aerobic and strength and mobility exercise more often than patients without SGE. Both among patients with and without SGE, the vast majority fulfilled the aerobic exercise recommendation with moderate-intensity exercise (89% and 69%, respectively), mainly through (brisk) walking and cycling, and only a minority fulfilled it with vigorous-intensity exercise (5% and 12%) or fulfilled the recommendation for strength and mobility exercise (44% and 29%). These findings were in line with previous studies (6, 16, 23-28, 30), showing that although most axSpA patients engage in sufficient moderate-intensity exercise, just a minority engages in vigorous-intensity, mobility and strength exercise. These results demonstrate that SGE contributes to fulfilling the recommendations for aerobic, mobility and strength exercise. Apparently, SGE participation does not prevent engagement in other exercise activities, but comes as an addition to it.

The observed differences in age, disease duration, employment and spinal mobility between patients with and without SGE were in line with indications from previous studies (12, 13, 18). However, both the lower medication use in patients with SGE and the comparable health status between patients with and without SGE were surprising, as health status and physical functioning may deteriorate with age in axSpA patients, similar to spinal mobility (18-20). It can be speculated that SGE participation prevented deterioration of health status and the need for analgesics, since previous studies have shown positive effects of SGE on symptoms, fitness and functioning (7, 8, 10, 11). However, another possibility is that patients with better health status and a more active coping choose to participate in SGE.

The findings of this study could guide future exercise promotion, which should likely have different aims for axSpA patients with and without SGE, as SGE participants are apparently an aging subgroup within the axSpA population. For patients with SGE, the current findings support previously proposed SGE enhancements advocating for higher intensity aerobic exercise during SGE and for patient education about more frequent exercise to meet mobility and strength exercise recommendations (12, 13). For patients without SGE, it seems justified to encourage more weekly exercise engagement, either by promoting SGE or other appropriate exercise activities. Physical therapists are in a good position to provide such exercise promotion, as the vast majority of axSpA patients uses physical therapy over the course of their disease (16, 17).

Since there are many differences in personal exercise preferences and in SGE availability between regions (12), future studies could explore which exercise activities are suitable and equally effective alternatives to SGE. Cycling and (brisk) walking proved to be the most popular exercise activities: while they may be suitable for aerobic exercise, they are not suitable for mobility and strength and are rarely performed at high-intensity. Therefore, patients should be educated about other appropriate exercise activities that may include high-intensity, strength and mobility components, such as a home, gym or aquatic exercise program. Such education requires a personalized approach, taking into account key barriers and facilitators, including personal motivation and self-efficacy (6, 44). Furthermore, to support maintenance of exercise over time, it might help to promote group exercise activities for some patients (6).

Some study limitations should be noted. First, while combining data of three cohorts resulted in a larger, more generalizable study population with more statistical power for analysis, it also resulted in missing data and in variation in the assessments used. This was partially resolved by 'cross-walking' ASQoL data to expected ASAS HI scores and by using only the leisure time exercise questions of the SQUASH and the mSQUASH, which were identical. Another limitation is that both the SQUASH and mSQUASH are known to overestimate the intensity of physical activity (33, 45). The proportion engaging in mobility and strength exercise may also have been overestimated, as it is uncertain what types of exercise participants actually performed when reporting to exercise at home or in the gym, for example. Finally, a relatively low explained variance was found in the regression models. This may have been caused by not measuring motivation and self-efficacy, both important determinants of exercise behavior (6).

In conclusion, SGE contributes to fulfilling the exercise recommendations in axSpA patients, but only few, especially older patients, seem to participate in it. Furthermore, future exercise promotion should focus on more engagement in exercise activities with vigorous-intensity and with strength and mobility components, as only a minority is sufficiently engaged in this. These types of exercise should be implemented both within SGE and among the general axSpA population.

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Supplementary data

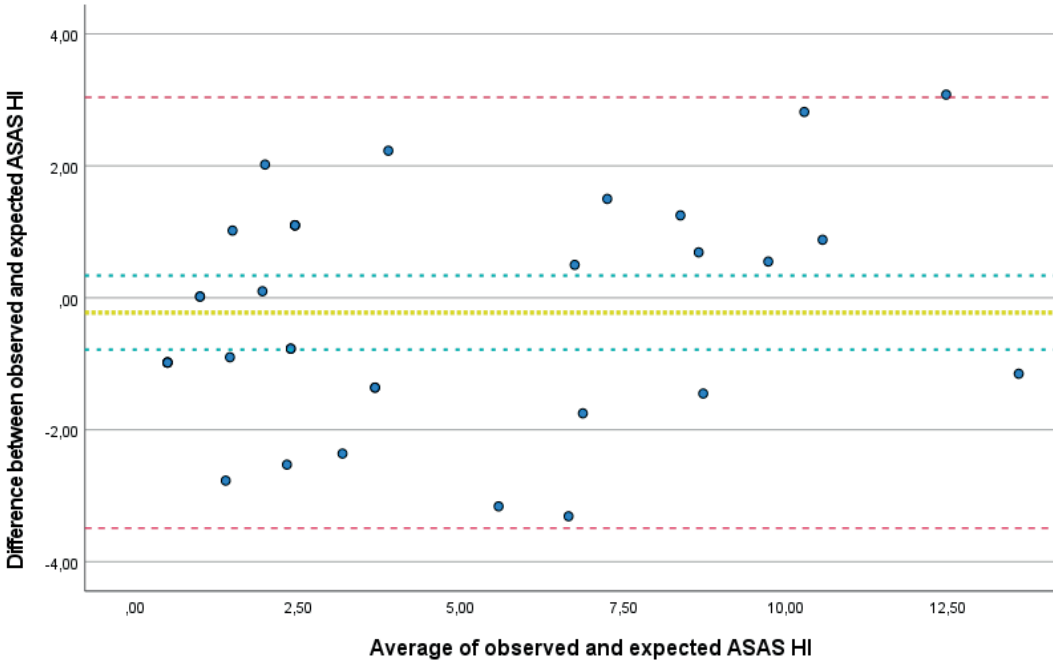

Figure S1. Bland-Altman plot to analyse agreement between observed and expected (from ASQoL) ASAS HI scores (N=34).
*Yellow line = Mean; Blue lines = 95% confidence interval (1,96 * SE Mean); red lines = limits of agreement (1,96 * SD). ASAS HI = ASAS Health Index; ASQoL = Ankylosing Spondylitis Quality of Life.*

The Bland-Altman plot shows there is no proportional bias in the data, as the observed ASAS HI scores agree equally through the range of measurements with the ASAS HI scores expected from the ASQoL data. The absence of proportional bias was confirmed by a univariate regression analysis and a one-sample t-test.

Table S1. Comparison of characteristics of axSpA patients with and without SGE among three different cohorts.

	With SGE			Without SGE		
	Cohort 1&2 (n=17)	Cohort 3 (n=128)	*P* [a]	Cohort 1 (n=183)	Cohort 2 (n=149)	*P* [a]
Age, years, Med (IQR)	62 (51-73)	60 (52-69)	0.686	57 (45-67)	50 (37-57)	**<0.001**
Sex, male	13/17 (77)	79/122 (64)	0.339	126/182 (69)	88/149 (59)	0.054
Disease duration, years, Med (IQR)	29 (17-37)	27 (15-36)	0.683	23 (9-35)	11 (5-19)	**<0.001**
Individual physical therapy use [b]	4/13 (31)	37/84 (44)	0.367	81/182 (44)	n/a	n/a
Medication use						
No NSAID, biological or DMARD	3/17 (18)	33/108 (31)	0.275	24/183 (13)	11/131 (8)	0.190
NSAID	12/17 (71)	58/108 (54)	0.192	113/183 (62)	86/120 (72)	0.075
Biological	6/17 (35)	17/108 (16)	0.053	70/183 (38)	59/133 (44)	0.275
DMARD	3/17 (18)	12/108 (11)	0.441	23/183 (13)	27/133 (20)	0.063
Analgesics [b]	6/13 (46)	26/108 (24)	0.088	69/183 (38)	n/a	n/a
Being employed	4/17 (24)	60/118 (51)	**0.035**	100/177 (57)	90/147 (61)	0.390

Reporting frequency (and percentage) unless stated otherwise.

[a] P-value of Mann Whitney U Test (continuous variables) or Chi Square Test (categorical variables).

[b] Not assessed in Cohort 2 (only in Cohorts 1 and 3)

AxSpA = axial spondyloarthritis; SGE = supervised group exercise; Med = median; IQR = interquartile range; NSAID = nonsteroidal anti-inflammatory drug; DMARD = disease-modifying antirheumatic drug; Cohort 1 = LUMC-study (among outpatient clinic population); Cohort 2 = GLAS cohort (among outpatient clinic population); Cohort 3 = SGE Cohort (among SGE participants).