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ORIGINAL RESEARCH

Spondyloarthritis and Sarcopenia: Prevalence of Probable Sarcopenia and its Impact on Disease Burden: The Saspar Study

Blandine Merle[1] · Marie Cottard[2] · Elisabeth Sornay-Rendu[1] · Pawel Szulc[1] · Roland Chapurlat[1,2]

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Abstract

To evaluate the prevalence of probable, confirmed, and severe sarcopenia in spondyloarthritis (SpA), according to the *European Working Group on Sarcopenia in Older People 2019* (EWGSOP2) definition. A total of 103 patients (51% women) with SpA, mean age 47.1 ± 13.7 years, were included and compared to 103 age- and sex-matched controls. Grip strength was measured by dynamometry. Body composition was assessed by whole-body densitometry. In SpA patients gait speed was measured by the 4-m-distance walk test and quality of life was evaluated with a specific health-related questionnaire for sarcopenia (SaRQoL®). Twenty-two SpA patients (21%) versus 7 controls (7%) had a low grip strength, i.e., probable sarcopenia ($p < 0.01$), 15 SpA (15%) patients and 7 controls (7%) had low Skeletal Muscle mass Index (SMI) (ns), respectively, and 5 and 2% of SpA patients and controls had low grip strength and low SMI, i.e., confirmed sarcopenia (ns). All the sarcopenic SpA patients had a low gait speed, i.e., severe sarcopenia. Finally, probable sarcopenic SpA patients had significantly higher C-Reactive Protein (CRP, $p < 0.001$) and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI score, $p < 0.01$), lower gait speed ($p < 0.001$), and SarQoL® score ($p < 0.001$) than SpA patients with normal grip strength. According to EWGSOP2 definition, the prevalence of probable sarcopenia was significantly higher in SpA patients compared to controls. Probable sarcopenia was associated with higher inflammation and disease activity, impaired muscle performance, and quality of life. These results suggest that muscle strength may be a salient hallmark in SpA.

Keywords Spondyloarthritis · Probable sarcopenia · Sarcopenia · Muscle strength · Muscle mass · SarQoL®

Introduction

Sarcopenia is defined as a progressive and generalized loss of muscle mass, decline in muscle function and physical performance leading to frailty, disability, and increased mortality [1, 2]. Originally considered as an age-related syndrome, it is now recognized that disease-related sarcopenia may be associated with chronic inflammatory diseases or physical inactivity and categorized as secondary sarcopenia in opposition to the primary age-related sarcopenia [3, 4]. However, different diagnostic criteria of sarcopenia have been established worldwide including low muscle mass, low muscle strength, and poor physical function with varying outcome thresholds [2, 4–6]. A consensus definition was nevertheless lacking. This may explain that even if sarcopenia is now formally recognized as a muscle disease by the World Health Organization and received an International Classification of Diseases code, sarcopenia remains under-diagnosed and under-managed despite its clinical importance [7]. Recently, the *European Working Group on Sarcopenia in Older People* (EWGSOP) proposed an updated definition (EWGSOP2) with clear cut-offs where low muscle strength is an obligatory criterion for probable sarcopenia, and the association of low muscle strength and low muscle quantity or quality defines sarcopenia. When low muscle strength, low muscle quantity/quality, and low physical performance are all detected, sarcopenia is considered severe [8].

Spondyloarthritis (SpA) is a family of chronic inflammatory rheumatisms that share some of their clinical manifestations as well as a common genetic background [9, 10]. Few studies explored secondary sarcopenia in rheumatic diseases and those on sarcopenia in SpA are rare and displayed inconsistent results because of the use of different diagnostic

✉ Blandine Merle
blandine.merle@inserm.fr

[1] INSERM UMR 1033—Université de Lyon, 5 Place d'Arsonval, 69437 Lyon, France

[2] Service de Rhumatologie, Hôpital Edouard Herriot, Hospices Civils de Lyon, 5 Place d'Arsonval, 69437 Lyon, France

criteria [11–14]. Several of these studies have measured the skeletal muscle mass index (SMI), without considering muscle strength and/or physical performance [11–14]. In this context, there is a need for studies exploring jointly muscle strength, muscle mass, and muscle function with standardized outcome measures in patients with SpA [10].

The purpose of the present study was to assess the prevalence of low muscle strength, low muscle mass, and poor physical function in a group of French SpA patients and their age- and sex-matched controls, in accordance with the EWGSOP2 standardized criteria [8].

Materials and Methods

Study Design—Participants

The SASPAR study (SArcopenia in SPondyloARthritis), is a single-center cross-sectional study. Consecutive patients with axial and/or peripheral SpA (according to ASAS: *Assessment of SpondyloArthritis international Society* or CASPAR: *ClASsification for Psoriatic ARthritis criteria*), aged 18 to 85 years, admitted to the rheumatology division of the Edouard Herriot Hospital (Lyon, France) between November 2017 and July 2018 in consultation and conventional or day hospitalization, were included. Exclusion criteria were immobilization for a period of more than 15 days during the last 3 months, decline to consent, psychiatric condition-precluding consent, or difficulty to understand oral French. Women of childbearing potential age underwent measurement of β-HCG hormone before bone densitometry.

Control participants (CT) were healthy individuals matched for age and sex selected from the OFELY, MoDaM, and STRAMBO population-based cohorts recruited and followed at the INSERM UMR1033 unit (Lyon, France). OFELY (Os des Femmes de Lyon) is an ongoing prospective cohort study of skeletal fragility in women [15]. MoDaM (Mother Daughter microarchitecture) is a cross-sectional study exploring the familial resemblance of bone microarchitecture parameters between postmenopausal mothers and their premenopausal daughters [16]. STRAMBO (Structure of the Aging Men's Bones) is a prospective cohort exploring the determinants of skeletal fragility in men [17]. All controls were ambulatory without any malignant disease and without disease or drugs known to affect bone metabolism.

Our study was approved by the local ethics committee (ID-RCB: 2017-A02391-52) and the national French data protection authority (CNIL). It was conducted in accordance with the French national ethical directives and ethical standards of the Helsinki Declaration (1983) and registered at ClinicalTrials.gov (NCT03319264). Eligible patients received oral and written information and signed a written consent before being enrolled in the study.

Measurements

Body weight (kg) and standing height (cm) were measured and body mass index (BMI) was expressed in kg/m^2. Grip strength was assessed by dynamometry with a pre-calibrated Jamar Plus + digital hand dynamometer (Patterson Medical®, Bolingbrook, IL, USA) and expressed in kg in the SpA group: two measurements were performed on each hand, the highest value being used [18]. In the control group, Grip strength was assessed using Martin vigorimeter and obtained in bars. Grip strength in kg was extrapolated from the association between both methods performed successively in 57 women of the OFELY cohort (coefficient of correlation $r = 0.84$) as reported [19]. Applying the criteria of the EWGSOP2, a grip strength value < 16 kg for women or < 27 kg for men was the criteria to define probable sarcopenia [8].

Whole body composition was evaluated by dual-energy x-ray absorptiometry (DXA, Hologic Discovery A, Hologic Inc., Bedford, MA, USA), [20]. The long-term stability was assessed by daily measurements of the Hologic lumbar spine phantom. The long-term coefficient of variation (CV) was 0.35%. Appendicular skeletal muscle mass (kg) was calculated as the sum of the lean mass of arms and legs. The Skeletal Muscle Mass Index (SMI) in kg/m^2 was obtained by dividing appendicular lean mass by height square. A measure of muscle mass < 5.5 kg/m^2 in women and < 7 kg/m^2 in men using the EWGSOP2 definition confirmed sarcopenia [8]. Fat Mass Index (FMI) in kg/m^2 was calculated by dividing whole-body fat mass obtained by DXA by height square.

Gait speed (marker of physical performance) was assessed in the SpA group only: patients were asked to walk at their usual pace over 4 m. The faster of 2 trials was kept in analysis. A walking speed ≤ 0.8 m/s was a criterion for severe sarcopenia [8].

Questionnaires

Patients and controls completed a lifestyle questionnaire. The SarQol® (Sarcopenia Quality of Life) questionnaire was also completed by patients. SarQol® is a validated specific patient-reported outcome measure designed to assess quality of life in patients with muscle function impairment and sarcopenia, including 22 questions on 7 domains relative to quality of life. Each domain is scored from 0 to 100 and an overall score is calculated, with a higher score reflecting a better quality of life [21].

Disease- and patient-related characteristics were also recovered from patient's computerized medical record: age, C-Reactive Protein (CRP), disease duration, Bath Ankylosing Spondylitis Disease Activity Index

(BASDAI), Human Leukocyte Antigen B27 (HLAB27), and treatment with biologics.

Statistics

Based on previous studies [11–13] and considering a power of 80% and an alpha risk of 5%, we assumed that the inclusion of 200 patients (100/arm) would allow to demonstrate a significant difference in the prevalence of probable and confirmed sarcopenia in SpA patients compared to controls.

Demographic and clinical characteristics of patients were described using frequencies and percentages for categorical variables and means and standard deviations for continuous variables. The differences between patients and controls were tested using the Wilcoxon signed-rank test for quantitative variables and the Fischer exact two-sided test for qualitative variables. All analyses were performed using R software, version 3.3.3 (©2017; R Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org/).

Results

Participants Characteristics

From November 2017 to July 2018, 103 consecutive SpA patients (50 men and 53 women) aged 20 to 85 years were enrolled in the study (among the SpA consecutive patients, four others were not included due to non-inclusion criteria). Patients' characteristics according to sex and type of SpA are described in Table 1. No significant differences were found between men and women. Mean age was 47.2 ± 13.7 years and 47% of patients were HLA B27 +. Mean disease duration was 12.2 ± 9.0 years and 50% of the patients presented a high active disease evaluated by a BASDAI score > 4 (Table 1). Fifty-three patients (51%) had axial SpA (AxSpA) and fifty (49%) presented peripheral SpA (PerSpA). Among PerSpA, 13 patients (12%) had psoriatic arthritis.

AxSpA patients were significantly younger than PerSpA (43.6 ± 12.2 versus 50.9 ± 14.3 years, $p < 0.01$) (Table 1). As expected, more AxSpA were HLA B27 + compared to PerSpA (60% vs 32%, $p < 0.01$); current smoking concerned 52% of AxSpA versus 24% of PerSpA ($p < 0.01$) (Table 1);

Table 1 SpA patients' characteristics according to sex and type of SpA: axial, or peripheral SpA.

Characteristics	All patients ($n = 103$)	Men ($n = 50$)	Women ($n = 53$)	Axial SpA ($n = 53$)	peripheral SpA ($n = 50$)	P
Sex: women, *n* (%)	53 (51)	–	–	25 (47)	28 (56)	ns
Age (years)	47.2 ± 13.7	47.0 ± 13.6	47.3 ± 13.9	43.6 ± 12.2	50.9 ± 14.3	**
BMI (kg/m^2)	26.0 ± 5.0	25.8 ± 4.8	26.2 ± 5.2	25.8 ± 5.5	26.3 ± 4.5	ns
Diagnosis, *n* (%)				–	–	
- axial SpA (AxSpA)	53 (51)	28 (56)	25 (47)	–	–	ns
- peripheral SpA (PerSpA)	50 (49)	22 (43)	28 (53)	–	–	ns
BASDAI [&]	4.09 ± 2.21	3.99 ± 2.35	4.20 ± 2.08	4.04 ± 2.24	4.16 ± 2.21	ns
BASDAI > 4 [&]	33 (50)	16 (46)	17 (55)	20 (48)	14 (56)	ns
Disease duration. (years)	12.2 ± 9.0	11.9 ± 10.4	12.6 ± 7.6	12.9 ± 9.8	11.5 ± 8.2	ns
HLA B27positive, *n* (%)	48 (47)	25 (50)	23 (43)	32 (60)	16 (32)	**
Treatment with biologics, *n* (%)	73 (71)	35 (70)	38 (72)	39 (74)	34 (68)	ns
CRP (mg/l)	6.6 ± 11.2	6.8 ± 11.3	6.2 ± 11.4	5.3 ± 6.8	7.8 ± 14.6	ns
Professional activity & student, *n* (%)	46 (45)	26 (52)	20 (38)	26 (49)	26 (40)	ns
Alcohol consumption ≥ 14 drinks/ Week, *n* (%)	1 (1)	1 (2)	0	0 (0)	1 (2)	ns
Current smoking, *n* (%)	40 (39)	24 (48)	16 (30)	28 (52)	12 (24)	**
Regular Sport (> 2 h/week), *n* (%)	21 (20)	10 (20)	11 (21)	12 (23)	9 (18)	ns
Falls during last year, *n* (%)	27 (26)	14 (28)	13 (25)	17 (32)	10 (20)	ns
Walking aid, *n* (%)	16 (16)	7 (14)	9 (17)	11 (21)	5 (10)	ns

Values are Mean±sd or *n* (%) as indicated.

BMI body mass index, *CRP* C-reactive protein. [&]: *BASDAI* (Bath Ankylosing Spondylitis Disease Activity Index) was available for 66 patients only; BASDAI > 4 indicates an active disease.

Comparison betwenn Axial and peripheral SpA: p:***: < 0.001; **: < 0.01; *: < 0.05, ns: non-significant; age, HLA B27, and current smoking were significantly different between axial and peripheral SpA

Table 2 Comparison of SpA patients and controls according to EWGSOP2 definition.

	Controls ($n=103$)	SpA patients ($n=103$)	p
Age (years)	47.02 ± 13.46	47.07 ± 13.66	ns
BMI (kg/m^2)—all	**24.1 ± 3.3**	**26.0 ± 5.0**	**
- men	25.4 ± 3.3	25.8 ± 4.8	ns
- women	**23.0 ± 2.8**	**26.2 ± 5.2**	***
Current smoking, *n* (%)	**15 (15)**	**40 (39)**	***
Regular Sport (> 2 h/week), *n* (%)	**65 (64)**	**21 (20)**	***
Grip strength (kg)—all	31.5 ± 6.6	28.8 ± 13.1	*
- men	34.7 ± 7.2	37.1 ± 12.9	ns
- women	**28.5 ± 4.2**	**20.8 ± 6.9**	***
Probable sarcopenia *n*(%)—all	**7 (7)**	**22 (21)**	**
- men	7 (14)	10 (20)	ns
- women	**0 (0)**	**12 (23)**	***
SMI (kg/m^2).—all	7.4 ± 1.2	7.4 ± 1.3	ns
- men	8.3 ± 1.0	8.0 ± 1.2	ns
- women	6.4 ± 0.7	6.6 ± 1.0	ns
Low SMI *n*(%)—all	7 (7)	15 (15)	ns
- men	5 (10)	10 (20)	ns
- women	2 (4)	5 (9)	ns
Sarcopenia (*n* (%)—all	2 (2)	5 (5)	ns
- men	2 (4)	3 (6)	ns
- women	0 (0)	2 (4)	ns
Gait speed (m/sec).—all	nd	0.88 ± 0.36	–
- men	nd	0.90 ± 0.35	–
- women	nd	0.86 ± 0.36	–
Low Gait speed *n*(%)—all	nd	43 (42)	–
- men	nd	20 (40)	–
- women	nd	23 (43)	–
Severe Sarcopenia *n*(%)—all	nd	5 (5)	–
- men	nd	3 (6)	–
- women	nd	2 (4)	–
FMI (kg/m^2).—all	**6.4 ± 2.2**	**8.2 ± 3.6**	***
- men	**5.3 ± 1.8**	**6.4 ± 2.3**	*
- women	**7.4 ± 2.1**	**9.9 ± 3.8**	***
Ratio SMI/FMI.—all	1.34 ± 0.66	1.06 ± 0.51	***
- men	1.75 ± 0.68	1.38 ± 0.48	***
- women	0.95 ± 0.33	0.76 ± 0.31	***

Bold values are statistically significant ($p < 0.05$)

Values are Mean ± sd or *n* (%) as indicated. Patients were analyzed according to sex. A low grip strength was defined as < 16 kg in women or < 27 kg in men, a low SMI as < 5.5 kg/m^2 in women and < 7 kg/m^2 in men, and a low gait speed as ≤ 0.8 m/s for men and women, according to EWGSOP2 definition. Probable sarcopenia was defined as the presence of low grip strength, confirmed sarcopenia as the combination of low grip strength and low SMI and severe sarcopenia as the presence of low grip strength, low SMI, and low gait speed.

BMI body mass index, *FMI* fat mass index, *SMI* skeletal muscle mass index. *Ns* non-significant. *Nd* not determined.

p: ***: < 0.001; **: < 0.01; *: < 0.05

no other significant differences were found between AxSpA and PerSpA.

Comparison of SpA Patients with Age- and Sex-Matched Controls According to EWGSOP2 Criteria

Grip strength was significantly lower in SpA compared to

age-matched controls ($p < 0.05$) particularly for women ($p < 0.001$), whereas no significative difference could be detected in men (Table 2). According to EWGSOP2 cut-off points, a significantly higher proportion of SpA patients (21%, $n = 22$) had low grip strength, i.e., probable sarcopenia, compared to controls (7%, $n = 7$) ($p < 0.01$) (Table 2). This difference was highly significant only for women, with 23% ($n = 12$) of women having a low grip strength in the SpA group versus 0% in the control group ($p < 0.001$) (Table 2). No significant difference was found in men with SpA (20%, $n = 10$) versus controls (14%, $n = 7$,). Among patients, no significant correlation was found between grip strength and disease duration (data not shown).

Skeletal muscle mass evaluated by SMI (kg/m^2) was similar for patients and controls for either sex (Table 2). Although not significant, the proportion of patients with a low SMI was higher in SpA (15%, $n = 15$) than in controls (7%, $n = 7$), according to EWGSOP2. No significant correlation was found between SMI and disease duration (data not shown). Sarcopenia, defined as the presence of low grip strength and low SMI, concerned only 5% of SpA patients ($n = 5$) and 2% of controls ($n = 2$, ns).

According to EWGSOP2, 42% of SpA patients ($n = 43$) had a low gait speed without significant differences according to sex (Table 2). All the sarcopenic SpA patients had a low gait speed characterizing severe sarcopenia ($n = 5$, 5%) (Table 2).

Compared to their age- and sex-matched controls, SpA patients had significantly higher FMI ($p < 0.001$) and BMI ($p < 0.01$), particularly for women ($p < 0.001$ for FMI and BMI) compared to men ($p < 0.05$ for FMI, ns for BMI), (Table 2). The ratio SMI/FMI was significantly lower in SpA patients compared to controls ($p < 0.001$).

Finally, no significant differences were found between AxSpA and PerSpA patients for grip strength (30.6 ± 13.5 vs 26.8 ± 12.4), or SMI (7.4 ± 1.4 vs 7.2 ± 1.3), respectively. Gait speed was slightly higher in AxSpA versus PerSpA (0.96 ± 0.36 vs 0.80 ± 0.33, $p < 0.05$) but the difference was no longer significant after adjustment for age (data not shown).

Comparison of SpA Patients According to Grip Strength

According to EWGSOP2 grip strength cut-offs, SpA patients were classified into two groups: 22 patients (21%) having a low grip strength (mean ± sd: 13.6 ± 5.4 kg), i.e., probable sarcopenia, and 81 patients (79%) having a normal grip strength (32.8 ± 11.4 kg, $p < 0.001$, Table 3). As the prevalence of probable sarcopenia was not significantly different between AxSpA and PerSpA, all SpA patients were analyzed as one group. Age, sex distribution, BMI, FMI, and SMI were not significantly different between both groups, as well as physical activity, HLAB27, disease duration, current smoking, and falls during last year. However, CRP level (12.2 ± 15.0 vs 5.0 ± 9.6, $p < 0.001$) and disease activity measured with BASDAI score (5.55 ± 1.94 vs 3.69 ± 2.13, $p < 0.01$) were significantly higher in patients with probable sarcopenia than in controls, respectively (Table 3).

Physical performance assessed by gait speed was significantly lower (0.59 ± 0.24 vs 0.96 ± 0.34 m/sec, $p < 0.001$) and the prevalence of patients with a low gait speed was significantly higher (86.4% vs 29.6%, $p < 0.001$) in probable sarcopenic compared to normal grip strength patients according to EWGSOP2 definition (Table 3).

SarQoL® assesses patient's perception of physical, psychological, and social aspects of life; in our study, SarQoL overall score was significantly lower in low grip strength compared to normal grip strength patients (44.3 ± 11.6 vs 61.0 ± 15.8, $p < 0.001$). Furthermore, SarQol overall score correlated with grip strength ($r = 0.55$, $p < 0.001$) and gait speed ($r = 0.39$, $p < 0.001$) in SpA patients (data not shown). Finally, a significantly greater proportion of patients with probable sarcopenia needed a walking aid compared to those with normal grip strength. Treatment with biologics tended to be less frequent in SpA patients with a low grip strength compared to normal grip strength patients (54.5% versus 75.3%. ns, Table 3).

Discussion

Our study evaluated probable sarcopenia and confirmed sarcopenia in SpA patients with assessment of muscle strength, muscle mass, and muscle performance as recommended by EWGSOP2 [8]. Early diagnosis of sarcopenia is important to allow the implementation of adapted interventions to prevent muscle wasting and adverse outcomes such as disability and poor health quality in SpA patients. We showed that, according to the EWGSOP2 definition, the prevalence of low grip strength, i.e., probable sarcopenia, was higher in SpA patients compared to age- and sex-matched controls, whereas the prevalence of confirmed sarcopenia assessed by grip strength and SMI was low and not different between SpA patients and controls. Additionally, all the SpA patients defined as sarcopenic had a lower gait speed, i.e., a sign of severe sarcopenia [8]. As proposed in EWGSOP2 definition, our results indicate that, at least in SpA, muscle strength may be a salient hallmark for an early diagnosis of probable sarcopenia.

We observed a higher prevalence of low grip strength, i.e., probable sarcopenia, in SpA compared to control participants, which was highly significant for women only. Even if studies on grip strength are scarce and conducted in small numbers of patients and mostly men, a limitation of grip strength has already been demonstrated in SpA [12, 13]. Marcora et al. found a reduced upper and lower body

Table 3 Comparison of SpA patients according to normal or low grip strength.

	Normal grip strength ($n=81$)	Low grip strength ($n=22$)	p
Grip Strength (kg)	32.8 ± 11.4	13.6 ± 5.4	***
Age (years)	46.7 ± 13.3	48.9 ± 15.4	ns
Sex: women, *n* (%)	41 (50.6)	12 (54.6)	ns
AxSpA/PerSpA *n* (%)	43 (53) /38 (47)	10 (45) /12 (54)	ns
Disease duration (years)	11.9 ± 9.3	13.4 ± 7.9	ns
BMI (kg/ m^2)	25.7 ± 4.3	27.1 ± 7.0	ns
BASDAI [&]	**3.69 ± 2.13**	**5.55 ± 1.94**	**
BASDAI > 4 [&], *n* (%)	23 (44.2)	10 (71.4)	ns
HLA B27 +, *n* (%)	37 (45.7)	11 (50.0)	ns
CRP mg/l	**5.0 ± 9.6**	**12.2 ± 15.0**	***
Biologic treatment *n* (%)	61 (75.3)	12 (54.5)	ns
SMI (kg/m^2)	7.3 ± 1.2	7.3 ± 1.7	ns
Low SMI, *n* (%)	10 (12.3)	5 (22.7)	ns
FMI (kg/m^2)	8.0 ± 3.4	9.2 ± 4.4	ns
SMI/FMI	1.13 ± 0.46	1.01 ± 0.56	ns
Gait speed (m/s)	**0.96 ± 0.34**	**0.59 ± 0.24**	***
Low gait speed, n (%)	**24 (29.6)**	**19 (86.4)**	***
Current smoking, *n* (%)	31 (38.3)	9 (40.9)	ns
Regular Sport (> 2 h/week), *n* (%)	18 (22.2)	3 (13.6)	ns
Falls during last year, *n* (%)	18 (22.5)	9 (40.9)	ns
SaRQoL Overall score	**61.0 ± 15.8**	**44.3 ± 11.6**	***
Walking aid, *n* (%)	**8 (10.0)**	**8 (36.4)**	**

Bold values are statistically significant ($p < 0.05$)

Values are mean ± sd or *n* (%) as indicated. SpA patients were classified into normal grip strength or low grip strength defined as < 16 kg in women or < 27 kg in men, according to the EWGSOP2 definition. A low SMI was defined as < 5.5 kg/m^2 in women and < 7 kg/m^2 in men and a low gait speed as ≤ 0.8 m/s for men and women, according to the EWGSOP2 definition. Probable sarcopenia was defined as the presence of a low grip strength; confirmed sarcopenia as the combination of low grip strength and low SMI; and severe sarcopenia as the presence of low grip strength, low SMI and low gait speed. [&]: BASDAI was available for 66 patients only (52 with normal grip strength and 14 with low grip strength); BASDAI > 4 indicates an active disease.

BMI body mass index, *FMI* fat mass index, *SMI* skeletal muscle mass index, *CRP* C-reactive protein, *SarQoL score* Sarcopenia quality of life score. *ns* non-significant

p: ***:< 0.001; ** :<0.01; *:<0.05

strength measured with functional strength tests in male SpA patients [22]. A similar decrease in muscle strength has also been described in other rheumatic diseases, such as rheumatoid arthritis (RA) or psoriatic arthritis (PsA) [13, 14, 23]. Herein, probable sarcopenia concerned both AxSpA and PerSpA: even though AxSpA patients first show limitations in mobility of the axial skeleton, their grip strength is impaired.

It has been hypothesized that chronic inflammation and limitation of physical activity due to joint pain and stiffness may contribute to accelerated muscle loss; however, results are still conflicting and to date, a consensus for the reduction of muscle mass in SpA patients has not been established [22, 24]. Herein, we did not find a reduction of SMI in SpA patients, the prevalence of a low SMI being somewhat higher but not significantly different in SpA compared to controls. These results are consistent with two studies on SpA [25, 26], but other studies reported a reduction in total muscle mass in SpA as well as in RA and PsA [11–13, 22]. Discordant results may be related to the diverse methods of evaluation of muscle mass, diverse range of age, inclusion criteria, and treatment options across studies. Toussirot and Dos Santos studies, for instance, included only patients with early disease, whereas patients from the Marcora study had long-lasting disease [22, 25, 26]. The present study included patients with a broad range of age and disease severity, but it is likely that patients herein had a more severe disease as they were followed in a tertiary care hospital. A substantial proportion of patients, however, are typical of secondary care due to the hospital location, which probably mitigates this selection bias. Finally, as in the Moroccan and Italian studies, 2/3 of our SpA patients were treated by biologic

therapy which may also improve muscle mass and muscle strength [12, 13]. However, if biological therapies have a beneficial effect on systemic inflammation and disease activity, their effects on body composition and strength are still controversial in SpA [27]. Barone et al. reported an effect in less than half of the patients while El Maghraoui et al did not report any effect on muscle mass [12, 13]. Herein, we cannot exclude that, as the majority of our patients are treated, there is a positive effect of the treatment on muscle mass and strength. Indeed, treated patients had a higher grip strength (30.5 ± 13.1 vs 24.4 ± 12.0, $p < 0.05$) than non-treated patients. However, the ratio of probable sarcopenia (16% vs 33%) and sarcopenia (3% vs 10%) was not significantly different in both groups. Also, treatment by biologics was more frequent, even no significant, in normal compared to low grip strength patients; but due to potential differences in duration and type of treatment and limited sample size, we did not conduct extensive sub-group analyses.

The prevalence of confirmed sarcopenia in our SpA patients, i.e., low muscle strength and low muscle mass, appears to be lower than the odds in the Moroccan (34.3%) and Italian (20.8%) studies [12, 13]. However, the use of different definitions of probable sarcopenia and sarcopenia (EWGSOP1 vs EWGSOP2) and difference in design of the studies limits direct comparisons between studies. Handgrip strength and gait speed are dependent on stature and morphological variations within different populations. The significantly higher proportion of SpA patients with a lower grip strength but a similar SMI compared to controls indicates that muscle strength is impaired as an earlier consequence of disuse due to pain, joint inflammation, stiffness or enthesitis, limiting physical activity.

In EWGSOP2, the decrease in muscle strength is the determining parameter which makes the diagnosis of sarcopenia probable, then confirmed by low muscle mass; if low gait speed is also detected, sarcopenia is considered severe. In EWGSOP1, a decrease in muscle mass was the criterion of entry for probable sarcopenia, then confirmed by a decrease in muscle strength or performance [2, 8, 28]. Few studies compared the prevalence of sarcopenia according to EWGSOP1 or EWGSOP2; some found that fewer patients were classified as sarcopenic using EWGSOP2 versus EWGSOP1 [28–31]. They found significant discordance when applying both EWGSOP definitions [29, 31], while others reported good agreement [30, 32]. More research is needed to understand the predictive value of sarcopenia parameters according to sex, age, and health status of patients.

All our patients classified as sarcopenic with EWGSOP2 criteria are defined as severely sarcopenic, which makes the distinction between less and more severe cases questionable. This is consistent with the results of Reiss et al. who found a prevalence of more than 80% of severe sarcopenia among those classified as sarcopenic using EWGSOP2 criteria [28]. Noteworthy, 42% of all our patients had low gait speed, while only 21% had low grip strength, reflecting the fact that lower limbs are affected more intensely than upper limbs, but perhaps also due to back pain and/or stiffness associated with the disease. Similarly, 30% of SpA patients with normal grip strength have a low gait speed, corroborating impairment in physical activity.

In our study, SpA patients had higher fat mass (FMI) compared to controls, the differences being highly significant only for women as already described [33]. A higher prevalence of increased body fat mass, BMI, and obesity have already been described in patients with rheumatic diseases, particularly in women [34, 35]. Herein, women with SpA had significantly higher BMI, higher FMI, and lower grip strength which may reflect the different disease courses in women compared to men as previously proposed [36]. Additionally, a part of our patients is treated with biologics which may induce a fat and weight gain which in turn may influence the response to treatment although the link between anti-inflammatory treatments, muscle, and body composition requires further investigation [12, 27, 37, 38].

Analyzing SpA patients according to their grip strength, we observed that 21% of patients with a low grip strength displayed a worse inflammatory condition than patients with normal grip strength; they had a higher CRP, a more active disease measured with a higher BASDAI score. Eighty-six percent of these patients had a low gait speed reflecting general impaired muscle functions concerning upper and lower limbs and explaining the low level of sports practice. Finally, impaired muscle strength is associated with a significantly reduced SarQoL® score and a more frequent use of a walking aid. Originally designed for old people, the SarQoL® score reflects the disease burden of sarcopenia on quality of life, i.e., altered physical function and psychological impacts and correlates with the health survey SF36 questionnaire [8, 39, 40]. We showed here that SarQol® positively correlates with grip strength in young SpA patients and may complement quality of life evaluation in SpA. All these data showed that altered muscle functions and physical performance are significantly associated with a higher disease activity, joint damage, and disability but also with a poor quality of life.

Indeed, each criterion of EWGSOP definition, i.e., muscle strength, muscle mass, or muscle performance, may be a proxy reflecting a particular health status or disease [41]. A decreased muscle strength is a sign of physical limitations and a strong predictor of adverse health outcomes including an increased risk of falls, fractures, osteoporosis, stroke, and mortality, while SMI alone or other sarcopenia components are not [41, 42]. Gait speed and low muscle mass are associated with dependence for everyday activities, while mortality is related to low gait speed [32]. Our data showed that decreased muscle strength, considered as the key point of

sarcopenia in EWGSOP2 is, at least in SpA, a surrogate of a high disease burden and poor long-term disease outcome resulting in a faster degradation in the quality of life.

Comparing AxSpA and PerSpA patients, both groups showed similar range in BMI, muscle mass, fat mass, and grip strength and similar prevalence of low grip strength, low SMI, or low gait speed. This confirms that peripheral and axial symptoms often coincide in both types of SpA [43].

The present study has strengths and limitations. To our knowledge, it is the first study evaluating sarcopenia in SpA patients using the criteria of muscle strength, muscle mass, and physical performance as recommended by EWGSOP2 [8, 10]. Grip strength test measured with a Jamar hand dynamometer is considered a reliable surrogate marker for measures of limb muscle strength [44]. The use of a Martin Vigorimeter to measure grip strength in controls may introduce a bias. However, confirming literature, we showed that grip strength assessed with both devices demonstrated a strong correlation [19]. Fat-free mass and fat mass were measured by DXA, considered as the reference clinical method [8]. Physical performance was evaluated by gait speed, a highly reproducible test for sarcopenia [8]. The main limitations of the study were the absence of physical performance assessment in controls and the small number of sarcopenic patients, not allowing analysis in sub-groups of age and treatment, limiting the strength of the study. Finally, for the oldest participants of our study, sarcopenia may be disease- but also age related.

Conclusion

A sizeable proportion of SpA patients had low muscle strength, defining probable sarcopenia according to EWGSOP2, a condition associated with altered physical performance and higher disease burden contributing to deterioration of the quality of life. This suggests that muscle strength could be a salient hallmark of probable disease-related sarcopenia and may be considered in the management of spondyloarthritis. Evaluating grip strength is easily available in clinical settings allowing to identify at-risk patients and implement interventions. Our results point to the importance of muscle strengthening to prevent disability and subsequent loss of the quality of life in this population.

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Declarations

Conflicts of interest Blandine Merle, Marie Cottard, Elisabeth Sornay-Rendu, Pawel Szulc, and Roland Chapurlat declare no conflict of interest.

Human and Animal Rights and Informed Consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

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