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Original Article

Sex-specific muscle and fat mass alterations in Vietnamese patients with spondyloarthritis

[Alteraciones de la masa muscular y grasa específicas del sexo en pacientes vietnamitas con espondiloartritis]

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Abstract

Context: Alterations in body composition, including decreased muscle mass and increased adiposity, are common in spondyloarthritis (SpA) and are hypothesized to result from inflammatory cytokines.

Aims: To assess muscle-fat mass parameters and associated factors among SpA patients.

Methods: A case-control study was performed involving 43 SpA patients and 71 matched controls. Dual-energy X-ray absorptiometry (DEXA) was used to evaluate muscle and fat indices. Multivariable logistic regression determined associations with reduced appendicular skeleton muscle index and overfat status.

Results: Male patients exhibited significantly reduced muscle indices and A/G ratio, while females presented increased fat parameters. Correlations with anthropometric and clinical factors were noted.

Conclusions: These findings underscore the importance of sex-specific monitoring and tailored intervention strategies, including rehabilitation, dietary modification, and structured exercise programs.

Keywords: dual-energy X-ray absorptiometry; muscle-fat mass; spondyloarthritis; Vietnam.

Resumen

Contexto: Las alteraciones en la composición corporal, incluyendo la disminución de la masa muscular y el aumento de la adiposidad, son comunes en la espondiloartritis (EspA) y se ha hipotetizado que se deben a las citocinas inflamatorias.

Objetivos: Evaluar los parámetros de masa muscular y grasa y los factores asociados en pacientes con EspA.

Métodos: Se realizó un estudio de casos y controles con 43 pacientes con EspA y 71 controles emparejados. Se utilizó la absorciometría dual de rayos X (DEXA) para evaluar los índices musculares y de grasa. La regresión logística multivariable determinó las asociaciones con la reducción del índice muscular del esqueleto apendicular y el sobrepeso.

Resultados: Los pacientes varones presentaron índices musculares y una relación A/G significativamente reducidos, mientras que las mujeres presentaron un aumento de los parámetros de grasa. Se observaron correlaciones con factores antropométricos y clínicos.

Conclusiones: Estos hallazgos subrayan la importancia del seguimiento específico para cada sexo y de estrategias de intervención personalizadas, que incluyan rehabilitación, modificación de la dieta y programas de ejercicio estructurados.

Palabras Clave: absorciometría de rayos X de energía dual; masa músculo-grasa; espondiloartritis; Vietnam.

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Abbreviations: A/G ratio: Android/gynoid ratio; ASM: Appendicular skeleton muscle; ASMI: Appendicular skeleton muscle index; BF%: Body fat percentage; BMD: Bone mineral density; BMI: Body mass index; CRP: C reactive protein; DEXA: Dual energy X-ray absorptiometry; DMARDs: Disease-modifying antirheumatic drugs; ERS: Erythrocyte Sediment Rate; PsA: Psoriatic arthritis; FDR: Fat distribution ratio; FMI: Fat mass index; FN: Femoral neck; MMI: Muscle mass index; SpA: Spondyloarthritis; VATA: Visceral adipose tissue area; VATM: Visceral adipose tissue mass; WC: Waist circumference; and WHR: Waist to hip ratio.

INTRODUCTION

Spondyloarthritis (SpA) is a group of chronic inflammatory diseases that includes ankylosing spondylitis, psoriatic arthritis (PsA), reactive arthritis, arthritis associated with inflammatory bowel disease, and undifferentiated SpA. These conditions are classified according to the European Spondyloarthropathy Study Group criteria (Sharip and Kunz, 2020). The pathogenesis of SpA involves pro-inflammatory cytokines such as interleukin (IL)-1, IL-6, and tumor necrosis factor-alpha (TNF-α), which contribute to alterations in muscle and fat mass composition (Hu et al., 2024).

These inflammatory mediators impair muscle regeneration and promote sarcopenia, characterized by progressive loss of skeletal muscle mass and strength. Contributing factors may include aging, malnutrition, low physical activity, and chronic inflammation (Cruz-Jentoft et al., 2019). While TNF-α inhibitor therapies have shown efficacy in increasing muscle mass, they may simultaneously promote visceral fat accumulation (Toussirot, 2020).

Recent studies have reported variable prevalence rates of sarcopenia in SpA, ranging from 15% to 30%, depending on the population and diagnostic criteria employed (Hu et al., 2024). Multiple investigations have demonstrated that SpA patients exhibit reduced muscle assessment parameters, including total muscle mass, muscle mass index (MMI), appendicular muscle mass (ASM), and appendicular skeletal muscle mass index (ASMI), when evaluated against control groups (Aguiar et al., 2014; El Maghraoui et al., 2016; Marcora et al., 2006). Additionally, weight management concerns frequently accompany this condition, with studies by Bindesbøll et al. (2020) and Hu et al. (2021) revealing that over 40% of SpA patients experience overweight or obesity. Asian studies have identified a prevalence of sarcopenia ranging from 15.0% in Korea to 22.1% in Thailand (Kanjanavaikoon et al., 2023; Song et al., 2017). In Vietnam, pre-sarcopenia, sarcopenia, and severe sarcopenia were found in 53.9%, 30.8%, and 11.5% of SpA patients, respectively (Dam Duc and Pham, 2024).

Given the limited literature exploring both muscle and fat mass in Vietnamese SpA populations, this study was conducted to assess body composition using dual-energy X-ray absorptiometry and to identify clinical factors associated with sarcopenia and adiposity in SpA patients.

MATERIAL AND METHODS

Study design and participants

A case-control study was performed between February 2023 and September 2024 at the Hue University of Medicine and Pharmacy Hospital, Department of Internal Medicine. Participants included 43 patients with SpA and 71 healthy controls.

Patients were diagnosed according to the Assessment of SpA International Society 2009 criteria and were aged 17–50 years (Raychaudhuri and Deodhar, 2014). Exclusion criteria included the presence of comorbidities influencing body composition (e.g., endocrine, hepatic, nutritional, or pulmonary diseases), prior radiological contrast use, pregnancy, implanted devices, or inability to undergo DEXA.

Healthy controls were recruited from individuals undergoing routine health check-ups at Hue University of Medicine and Pharmacy Hospital. Control was matched to patients for age (± 5 years) and BMI (± 2 kg/m^2) to minimize confounding effects of these variables on body composition parameters. Controls were free from chronic spine diseases, lower back pain, and had no family history of SpA or other autoimmune conditions. All controls underwent screening questionnaires to exclude inflammatory joint symptoms, psoriasis, inflammatory bowel disease, and recent acute infections. Controls also met the same exclusion criteria as patients regarding comorbidities affecting body composition.

Ethics

All procedures were conducted in compliance with the Declaration of Helsinki. Informed consent was obtained from all participants. The study received ethical approval from the Hue University Ethical Review Committee (No. H2023/226).

Body composition assessment

DEXA scanning (Medix DR, MEDILINK) was employed to quantify body composition. Participants lay in a supine position during scanning with arms and legs extended. Total muscle and fat mass were assessed using standardized parameters.

Muscle mass indices included:

- Total body muscle mass (kg)

• Muscle mass index (MMI = muscle mass/height², kg/m²)

• Appendicular skeletal muscle mass (ASM)

• Appendicular skeletal muscle mass index (ASMI = ASM/height², kg/m²)

Fat mass indices included:

• Body fat percentage (BF%)

• Fat mass index (FMI = fat mass/height², kg/m²)

• Fat distribution ratio (FDR = trunk fat/appendicular fat)

• Android/gynoid (A/G) ratio

• Visceral adipose tissue area (VATA, cm²)

• Visceral adipose tissue mass (VATM, g)

Reduced ASMI cut-offs followed the Asian Working Group for Sarcopenia 2019 guidelines (≤7.0 kg/m² for men; ≤5.4 kg/m² for women) (Chen et al., 2020). Overfat status was defined per NHANES 2009 (FMI >6.0 kg/m² for men; >9.0 kg/m² for women) (Kelly et al., 2009).

Covariates and statistical analysis

Variables included age, sex, BMI, waist circumference (WC), waist-to-hip ratio (WHR), disease duration, disease activity, treatment status (e.g., DMARDs), femoral neck bone mineral density (BMD), and inflammatory markers (CRP, ESR). Disease activity was assessed by ASDAS-CRP, with inactive disease defined as ASDAS-CRP <1.3 (Wiąk-Walerowicz and Wielosz, 2024).

Comparisons between groups employed t-tests, Mann-Whitney U tests, and chi-square tests. Multivariable logistic regression was used to identify factors associated with reduced ASMI and overfat status. Statistical significance was set at $p<0.05$.

RESULTS

Table 1 presents the demographic and clinical characteristics of study participants. Most demographic characteristics were similar between groups, including age, sex distribution, BMI, and FN BMD. However, WC and WHR were significantly elevated in the SpA patients. Within the patient cohort, notable characteristics included a high prevalence of active disease (88.4%), limited disease-modifying antirheumatic drug (DMARD) use (65.1% had not used them), and a median disease duration of 4 years.

Notable sex-specific differences in muscle and fat mass measurements were indicated between SpA patients and controls in this study (Table 2). In male patients compared to controls, there were significantly lower muscle mass measurements across all metrics (total muscle mass, MMI, and AMS), while fat-related measurements showed no significant differences except for the A/G ratio. Female patients, on the other hand, showed higher BF% (39.09% vs 34.51%) and significantly higher FMI and VAT measurements, but no significant differences in muscle mass measurements.

Tables 3 and 4 demonstrate the correlations between muscle-fat mass measurements and various clinical parameters in SpA patients. BMI demonstrates strong positive correlations ($p<0.01$) with multiple indices, including muscle mass, fat mass, and visceral adipose tissue measurements. Both WC and WHR show significant positive correlations with most muscle mass parameters. Age correlates positively with fat distribution measures, with the A/G ratio showing a particularly moderate correlation ($r=0.42$, $p<0.01$). While disease duration generally shows very weak correlations across most measurements, it maintains notable weak correlations with fat distribution ratio ($r=0.35$, $p=0.02$) and A/G ratio ($r=0.36$, $p=0.02$). Notably, femoral neck BMD correlates significantly only with ASM and ASMI measurements.

Table 5 shows that patients with SpA had a 4.62-fold higher risk of reduced ASMI and a 2.41-fold higher risk of overfat compared to the control group ($p<0.05$).

Multivariable logistic regression showed that factors associated with an increased odds of reduced ASMI were being male (adjusted OR=24.48; 95% CI: 2.80-213.92; $p<0.01$) and having lower BMI (adjusted OR=0.56; 95% CI: 0.36-0.88; $p=0.01$). Furthermore, a significant association with overfat was indicated by the study for higher WC (adjusted OR=1.20; 95% CI: 1.06-1.36; $p<0.01$). Neither disease duration nor disease activity showed statistically significant associations with either condition in the analysis (Table 6).

DISCUSSION

Distinct sex-specific body composition patterns were observed in SpA patients. Males demonstrated significantly lower muscle mass, whereas females exhibited increased adiposity. These differences are consistent with previous literature and underscore the importance of personalized therapeutic approaches. The observed muscle mass alterations align with previous research (Aguiar et al., 2014; El Maghraoui et al., 2016; Marcora et al., 2006; Paccou et al., 2022). However, concerning fat mass measurements, only the study of Paccou et al. (2022) documented increased fat mass in SpA patients.

Table 1. Comparison of characteristics between the patients and the controls.

Variables		Patients (n=43)	Controls (n=71)	p-value
Sex, n (%)	Male	24 (55.81)	27 (38.00)	0.06
	Female	19 (44.19)	44 (62.00)	
Age (years)		29 (22-36)	30 (21-37)	0.70
Age group, n (%)	≤ 30	24 (55.81)	36 (50.70)	0.60
	>30	19 (44.19)	35 (49.30)	
BMI (kg/m2)		21.26 (19.38-22.68)	21.45 (19.56-23.05)	0.56
WC (cm)		78 (70-83)	71 (65-74)	<0.001
WHR, mean (SD)		0.86 (0.05)	0.82 (0.05)	<0.001
FN BMD (g/cm2), mean (SD)		0.90 (0.15)	0.95 (0.14)	0.08
CRP (mg/l)		11.73 (2.29-41.08)	-	
ERS (mm/h)		20.00 (10.00-35.00)	-	
Disease duration (years)		4.00 (2.00-7.00)	-	
Disease activity assessed by ASDAS-CRP, n (%)	Inactive	5 (11.63)	-	
	Active	38 (88.37)	-	
Used DMARD, n (%)	No	28 (65.12)	-	
	Yes	15 (34.88)	-	

Data are expressed as the median (Q1-Q3), unless otherwise indicated. Abbreviations: BMD: Bone mineral density; BMI: Body mass index; CRP: C-Reactive protein; DMARD: Disease-modifying antirheumatic drugs; ESR: Erythrocyte sedimentation rate; FN: Femoral neck; SD: Standard deviation; WC: Waist circumference; WHR: Waist-to-hip ratio.

Table 2. Comparison of muscle–fat mass in the patients and the controls.

Muscle – fat mass	Male			Female		
	Patients (n=24)	Controls (n=27)	p-value	Patients (n=19)	Controls (n=44)	p-value
Total muscle mass (kg)	37.71 (36.24-40.20)	39.60 (36.62-44.25)	0.03	30.75 ± 2.98	31.14 ± 3.96	0.67
MMI (kg/m2)	13.96 ± 1.52	15.06 ± 1.73	0.02	12.49 ± 1.03	12.99 ± 1.56	0.15
ASM (kg)	17.28 ± 2.27	19.73 ± 2.21	<0.01	14.01 ± 1.59	14.52 ± 2.28	0.31
ASMI (kg/m2)	6.39 ± 0.81	7.23 ± 0.91	0.01	5.69 ± 0.55	6.06 ± 0.93	0.06
BF% (%)	27.69 ± 4.62	27.28 ± 4.08	0.74	39.09 ± 4.57	34.51 ± 4.15	<0.001
FMI (kg/m2)	5.80 ± 1.77	6.00 ± 1.86	0.69	8.84 ± 1.75	7.19 ± 1.97	0.002
FDR	0.85 (0.77-1.06)	0.94 (0.82-1.02)	0.54	0.85 (0.79-0.97)	0.81 (0.76-0.94)	0.12
A/G ratio	0.99 ± 0.12	1.07 ± 0.10	0.02	0.96 ± 0.05	0.90 ± 0.10	0.003
VATA (cm2)	78.75 (51.75-93.95)	70.90 (54.00-99.50)	0.76	100.40 (72.00-114.80)	65.45 (45.70-96.68)	0.002
VATM (g)	391.25 (130.20-490.08)	314.70 (211.20-531.80)	0.91	485.30 (258.70-597.60)	215.60 (72.40-478.28)	0.006

Data are expressed as mean ± SD or median (Q1-Q3). Abbreviations: ASM: Appendicular skeleton muscle mass; ASMI: Appendicular skeleton muscle mass index; A/G ratio: Android fat mass percentage/gynoid fat mass percentage; BF%: Body fat percentage; FDR: Fat distribution ratio; FMI: Fat mass index; MMI: Muscle mass index; VATA: Visceral adipose tissue area; VATM: Visceral adipose tissue mass.

Table 3. Correlation between muscle mass and some factors in SpA patients (n=43).

Muscle mass	Total muscle mass (ρ)	MMI (ρ)	ASM (p)	ASMI (ρ)
Age	-0.24 (0.12)	-0.15 (0.34)	-0.29 (0.06)	-0.22 (0.17)
BMI	0.26 (0.09)	0.55 (<0.001)	0.28 (0.07)	0.54 (<0.001)
WC	0.34 (0.03)	0.51 (<0.001)	0.40 (0.007)	0.55 (<0.001)
WHR	0.36 (0.02)	0.45 (0.002)	0.37 (0.02)	0.44 (0.003)
Disease duration	-0.17 (0.29)	-0.00 (0.99)	-0.17 (0.26)	-0.10 (0.52)
FN BMD	0.22 (0.15)	0.20 (0.20)	0.30 (0.04)	0.32 (0.04)

Abbreviations: ASM: Appendicular skeleton muscle mass; ASMI: Appendicular skeleton muscle mass index; BMD: Bone mineral density; BMI: Body mass index; FN: Femoral neck; MMI: Muscle mass index; ρ (rho): Spearman correlation coefficient; WC: Waist circumference; WHR: Waist-to-hip ratio.

Table 4. Correlation between fat mass and some factors in SpA patients (n=43).

Fat mass	BF% (ρ)	FMI (ρ)	FDR (ρ)	A/G ratio (ρ)	VATA (ρ)	VATM (ρ)
Age	0.13 (0.41)	0.13 (0.40)	0.38 (0.011)	0.42 (0.006)	0.27 (0.08)	0.25 (0.10)
BMI	0.55 (<0.001)	0.74 (<0.001)	0.23 (0.13)	0.50 (<0.001)	0.71 (<0.001)	0.68 (<0.001)
WC	0.38 (0.011)	0.48 (<0.001)	0.18 (0.26)	0.49 (<0.001)	0.63 (<0.001)	0.63 (<0.001)
WHR	0.18 (0.26)	0.26 (0.09)	0.20 (0.19)	0.39 (0.009)	0.48 (0.001)	0.49 (<0.001)
Disease duration	0.07 (0.67)	0.09 (0.56)	0.35 (0.02)	0.36 (0.02)	0.19 (0.23)	0.18 (0.25)
FN BMD	-0.02 (0.90)	0.03 (0.83)	-0.03 (0.83)	0.15 (0.34)	0.11 (0.46)	0.09 (0.56)

Abbreviations: A/G ratio: Android fat mass percentage/gynoid fat mass percentage; BF%: Body fat percentage; BMI: Body mass index; BMD: Bone mineral density; FDR: Fat distribution ratio; FN: Femoral neck; FMI: Fat mass index; ρ (rho): Spearman correlation coefficient; VATA: Visceral adipose tissue area; VATM: Visceral adipose tissue mass; WC: Waist circumference; WHR: Waist-to-hip ratio.

Table 5. Prevalence of reduced ASMI and overfat of subjects.

Variable	n (%)	OR (95% CI)	p-value
Reduced ASMI			
Control	19 (26.76)	1	
Patients	27 (62.79)	4.62 (2.05-10.40)	<0.001
Overfat			
Controls	14 (19.72)	1	
Patients	16 (37.21)	2.41 (1.03-5.65)	0.04

Abbreviations: ASMI: Appendicular skeletal muscle mass index; CI: Confidence interval; OR: Odds ratio.

In contrast, studies conducted by others reported no significant variations in fat mass indices between SpA patients and control subjects (El Maghraoui et al., 2016; Marcora et al., 2006; Røren Nordén et al., 2016; Toussirot et al., 2001). These discrepancies may be explained by the fact that the research of Paccou et al. (2022) was centered on PsA patients, whereas other studies examined ankylosing spondylitis patients or a combination of both axial and peripheral SpA.

Multivariate analysis indicated that male sex and low BMI were independently associated with reduced ASMI, while increased WC was linked to overfat status. The role of testosterone deficiency in male patients with chronic inflammatory conditions may partially explain these associations, given testosterone's crucial role in muscle development (Mohamad et al., 2019; Vingren et al., 2010). Research has demonstrated an inverse relationship between testosterone and inflammatory markers, including CRP

Table 6. Factors associated with low appendicular muscle mass index and overfat in SpA patients (n=43).

Variable	Reduced ASMI				Overfat			
	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Gender								
Female	1		1		1		1	
Male	15.17 (3.22-71.38)	<0.001	22.82 (2.11-247.38)	0.01	1.03 (0.30-3.58)	0.97	1.04 (0.19-5.73)	0.96
Disease duration								
≤ 4 years	1		1		1		1	
> 4 years	0.72 (0.21-2.50)	0.61	1.02 (0.16-6.68)	0.98	1.39 (0.40-4.80)	0.61	0.88 (0.20-3.96)	0.87
BMI (kg/m2)	0.63 (0.46-0.87)	0.005	0.56 (0.36-0.88)	0.01	-	-	-	-
Disease activity					-		-	
Inactive	1		1		1		1	
Active	8.67 (0.87-86.06)	0.07	5.17 (0.16-164.45)	0.35	2.61 (0.27-25.65)	0.41	3.71 (0.25-55.69)	0.34
WC	-	-	-	-	1.19 (1.06-1.35)	0.005	1.20 (1.06-1.37)	0.004
Used DMARD								
Yes	1		1		1		1	
No	0.77 (0.21-2.88)	0.70	0.86 (0.09-8.60)	0.90	0.83 (0.23-3.03)	0.78	1.32 (0.23-7.59)	0.76

Abbreviations: ASMI: Appendicular skeletal muscle mass index; BMI: Body mass index; CI: Confidence interval; DMARD: Disease-modifying antirheumatic drugs; OR: Odds ratio; WC: Waist circumference.

levels, IL-6, and TNF-α (Bianchi, 2019), potentially explaining the more substantial muscle mass reduction in male SpA patients. While various lifestyle factors, including physical activity and dietary habits, influence muscle mass, our analysis also identified low BMI as a significant associated factor, aligning with previous research (Kanjanavaikoon et al., 2023; El Maghraoui et al., 2016). Furthermore, this study demonstrated a robust correlation between elevated WC and increased VAT across both univariate and multivariate analyses, consistent with established relationships between WC and VAT (Seagle et al., 2013).

The higher prevalence of reduced ASMI and overfat status in the patient cohort highlights the need for early detection and intervention. These findings support prior research suggesting that chronic inflammation and TNF-α may contribute to muscle degradation and fat redistribution (Hu et al., 2024; Marouen et al., 2017). Significant positive correlations were revealed between anthropometric measurements (BMI, WC, and WHR) and various body composition parameters, including MMI, ASMI, BF%, FMI, A/G ratio, and VAT measurements ($p<0.05$) in this study. While BMI provides a general assessment of body composition, WC and WHR serve as more specific indicators of fat distribution patterns and are established markers for metabolic syndrome risk (Gadekar et al., 2020; Seagle et al., 2013). Additionally, both age and disease duration exhibited positive correlations with FDR and A/G ratio. However, neither age nor disease status showed any significant association with muscle mass indices. These observations align with the findings previously reported in studies (Barone et al., 2018; Kaffel et al., 2022).

Notably, no significant association was observed between disease activity markers (ERS, CRP) and body composition, a finding consistent with previous studies (Aguiar et al., 2014; Kanjanavaikoon et al., 2023). Higher CRP values in patients with sarcopenia compared to those without were revealed in another study in Vietnam (Dam Duc and Pham, 2024). Similarly, significantly elevated CRP was also found in probable sarcopenic SpA patients compared to SpA

patients with normal grip strength, and a negative correlation between CRP and fat-free mass index was observed (Merle et al., 2023; Plasqui et al., 2012). Conversely, another study showed a positive correlation between CRP and muscle mass (Kaffel et al., 2022). Regarding disease activity assessed by ASDAS-CRP, findings of this study are aligned with previous studies, with no significant difference being shown between SpA patients with and without sarcopenia (Kanjanavaikoon et al., 2023). The study of Aguiar et al. (2014) also showed no correlation between muscle mass index and BASDAI or BASFI. Variations in treatment status and physical activity may have confounded these relationships in this study.

Analysis of the treated patient group revealed significantly higher ASM compared to the untreated group, although other indices showed no significant differences. Previous research has demonstrated that TNF-α inhibitor treatment leads to both enhanced muscle mass and increased fat mass accumulation (Barros et al., 2012; Hmamouchi et al., 2014). However, the history of DMARDs use was not associated with reduced ASMI or overfat in SpA patients in both univariate and multivariate logistic regression models. The discrepancy between these findings and existing literature may be attributed to our study's methodological limitations, specifically the restricted sample size and cross-sectional design. Future longitudinal investigations are warranted to elucidate these relationships more comprehensively, with the ultimate aim of enhancing therapeutic outcomes.

A key strength of this study was its comprehensive evaluation of both muscle mass and fat mass alterations in Vietnamese patients with SpA. The use of DEXA allowed precise quantification of both lean and fat mass (Chaves et al., 2022). However, a significant limitation of this study was the small sample size, which may be attributable to the relatively low prevalence of SpA in Southeast Asia (approximately 0.2%) (Stolwijk et al., 2016). Additionally, other limitations include the inability to assess participants' physical activity and nutritional status, which could have confounded the analysis results. Further longitudinal studies with larger cohorts and detailed assessments of lifestyle factors are recommended to better understand the dynamic changes in body composition among SpA patients and their response to treatment.

CONCLUSION

Significant sex-specific differences in muscle and fat mass were observed among Vietnamese SpA patients. These findings advocated for tailored rehabilitation and nutritional interventions targeting muscle preservation in males and fat reduction in females. Future longitudinal studies are warranted to evaluate therapeutic effects on body composition and to develop comprehensive care models for SpA patients.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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AUTHOR CONTRIBUTION:

Contribution	Nguyen HD	Nguyen VHT
Concepts or ideas	x	x
Design	x	x
Definition of intellectual content	x	x
Literature search	x	x
Clinical trial	x	x
Experimental studies	x	x
Data acquisition	x	x
Data analysis	x	x
Statistical analysis	x	x
Manuscript preparation	x	x
Manuscript editing	x	x
Manuscript review	x	x

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