

Relationships Among Clinical, Biomechanical, and Psychological Parameters in Individuals with Subacromial Impingement Syndrome

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Abstract

BACKGROUND/AIMS: This study aimed to investigate the relationships among acromio-humeral distance (AHD), ultrasonographic tendon thicknesses, pain intensity, kinesiophobia, functional status, and postural parameters in individuals with subacromial impingement syndrome (SAPS).

MATERIALS AND METHODS: Forty-four individuals diagnosed with SAPS were included in this cross-sectional study. AHD and rotator cuff tendon thicknesses were assessed using ultrasonography. Pain intensity was evaluated using the visual analog scale and the McGill Pain Questionnaire. Upper extremity disability was assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) scale, while kinesiophobia levels were evaluated using the Fear-Avoidance Beliefs Questionnaire (FABQ). Postural alignment was analyzed with the AI-based Posture Evaluation and Correction System® (APECS®) system. Associations among the study variables were analysed using Pearson correlation analysis.

RESULTS: No significant relationships were found between AHD and pain intensity, disability, or tendon thickness ($p>0.05$). However, a weak negative correlation was observed between AHD and the kyphotic posture parameter [APECS- lateral body alignment (LBA)]. Pain intensity and higher FABQ scores were positively associated with greater upper extremity disability (DASH). FABQ showed a moderate-to-strong positive correlation with DASH scores. Among postural parameters, LBA was associated with AHD and with the thicknesses of supraspinatus tendon, infraspinatus tendon, and long head of biceps tendon. Additionally, anterior knee alignment and head tilt were positively correlated with tendon thickness measurements.

CONCLUSION: Our findings suggest that postural deviations may be associated with tendon characteristics and subacromial space parameters in individuals with SAPS. Additionally, the observed relationships between kinesiophobia, pain, and disability may highlight the importance of psychosocial factors. However, these findings should be interpreted with caution due to the cross-sectional design, and further longitudinal studies are needed.

Keywords: Subacromial impingement syndrome, posture, ultrasonography, acromio-humeral distance, rotator cuff tendon thickness

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INTRODUCTION

Shoulder pathologies are a common complaint in musculoskeletal injuries, with subacromial impingement syndrome (SAPS) accounting for a significant proportion of these pathologies.¹ SAPS is characterised by increased mechanical stress, impingement, and inflammation of the rotator cuff structures located between the acromion and the humeral head during arm elevation.^{1,2}

Both internal and external causes related to the shoulder complex are assumed to play a role in the emergence of this pathology by causing narrowing of the acromio-humeral distance (AHD).³ Additionally, disorders affecting upper-extremity posture, such as shoulder protraction, anterior head tilt (ANHT), and thoracic kyphosis, may adversely impair the biomechanics of the shoulder complex.³ Impaired shoulder architecture may increase the risk of impingement by affecting scapular movement and the subacromial space.⁴ Ultrasonographic (US) studies have shown that during shoulder elevation, the AHD narrows within normal physiological limits.^{4,5} Kalra et al.⁵ demonstrated in their study that upright posture preserves the AHD by approximately 1.2 mm more than kyphotic posture during 45°C shoulder elevation. This finding is important in explaining the effect of postural changes on the AHD.

Although various studies exist on pain, shoulder function, disability, and kinesiophobia in patients with SAPS,⁶⁻⁸ evidence regarding the effects of posture on AHD and tendon loading is both limited and inconsistent. Therefore, a comprehensive clinical examination of the relationships among posture, AHD, tendon thickness, pain, kinesiophobia, and disability parameters will contribute to a better understanding of SAPS pathomechanics and the development of appropriate treatment strategies. In particular, the examination of the relationship among postural factors, AHD, and tendon thickness may enable clinical assessments to provide simple, non-imaging-based information about these parameters. Furthermore, to our knowledge, few studies have investigated the combined relationships among tendon thickness, AHD, and the aforementioned clinical and postural factors. This study was designed to examine the effects of posture on SAPS development and to assess the relationship between function, disability, kinesiophobia, and tendon thickness, as a complementary component of a previously published investigation.

Therefore, the aim of this study was to investigate the relationships among AHD, US tendon thicknesses, pain intensity, kinesiophobia, functional status, and postural parameters in individuals with SAPS. It was hypothesized that postural alignment and psychosocial factors would be associated with both structural and clinical parameters.

MATERIALS AND METHODS

Participants

Though this cross-sectional study was conducted as part of a doctoral thesis project, it included all 44 eligible individuals aged 18-65 years who presented with shoulder pain between June 2023 and September 2023 and were diagnosed with SAPS based on clinical, radiological, and US examinations. Although derived from the same research framework, the present study differs from previous work in terms of its specific research objectives, an expanded sample, and the inclusion of additional postural assessments. Volunteers who had a shoulder pain complaint lasting more than one month, who had limited passive

movement compared to the opposite shoulder, who had positive Neer, Hawkins, and Jobe supraspinatus (SSp) tests for impingement, and who were able to communicate were eligible for inclusion. Individuals presenting with a neurological condition affecting the upper extremity or with neurological findings related to cervical disc herniation were excluded. Patients with complete rupture of one of the rotator cuff tendons, evidence of calcific tendinitis, previous shoulder surgery, or prior receipt of physical therapy, rehabilitation, or corticosteroid injections for the same complaints within the last 6 months were excluded from the study. Based on the study by Emadi et al.,⁸ the sample size required for an effect size of 0.894 and $\alpha=0.05$ at a 95% (1- $\beta=0.95$) power level was calculated to be 38 individuals using the G*Power 3.1.9.2 software. This effect size was selected due to methodological similarities with the present study, particularly in terms of population characteristics and US assessment. Given the exploratory nature of the present study, the sample size was considered adequate for detecting moderate to large associations. To account for potential data losses, 44 individuals were enrolled in the study. The protocol for this study was approved by the Near East University Ethics Committee (approval no: YDU/2023/115-1751, date: 21.06.2023). All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

Assessment Methods

Acromio-humeral distance

US is a non-invasive, portable imaging method that does not involve ionising radiation and is based on the interaction of high-frequency sound waves with biological tissues.⁹ In this study, all measurements were performed using a GE LogiqP6 Pro with a linear transducer. Participants were evaluated in a seated position according to standard shoulder scanning protocols.⁹ AHD was measured as the perpendicular distance from the most lateral edge of the acromion to the superior aspect of the humeral head. Rotator cuff tendons, including the SSp, infraspinatus (ISp), and subscapularis (SSc), as well as the long head of biceps tendon (LHBT), were assessed and tendon thicknesses were recorded according to standard anatomical landmarks. All US measurements were performed by the same experienced examiner using standardized procedures.

Pain

The visual analogue scale (VAS) was used to quantify pain intensity, with scores ranging from 0 (no pain) to 10 (worst imaginable pain). Participants indicated their pain levels for rest, activity, and night pain by marking the scale, and the corresponding values were measured in centimetres.¹⁰

The McGill Melzack Pain Questionnaire provides a multidimensional evaluation of pain by examining sensory qualities, pain characteristics, intensity, and temporal aspects. For quantitative scoring, the total number of descriptors selected in the second section ranges from 0 to 78. The actual pain intensity score in the fourth section ranges from 1 (mild) to 5 (unbearable). The Turkish version of the McGill Pain Questionnaire has demonstrated acceptable validity and reliability.¹¹

Kinesiophobia

We assessed kinesiophobia using the Fear-Avoidance Beliefs Questionnaire (FABQ). It includes 16 items divided into two subscales: physical activity and work. The physical activity subscale comprises

five items, whereas the work-related subscale includes eleven items. All items are being scored on a 7-point Likert scale where 0 denotes “strongly disagree” and 6 indicates “strongly agree”. Each subscale can be evaluated separately. The physical activity section is scored between 0 and 20 points, and the work section is scored between 0 and 42 points. It is assumed that, as the total score approaches 0, fear-avoidance behaviour within the section decreases, whereas it increases as the score approaches the maximum. The validity and reliability of the scale in Turkish have been established.¹² All questionnaires were administered by a physiotherapist face-to-face.

Function and disability

The DASH-T questionnaire was used to assess physical impairments and symptoms in order to evaluate upper extremity disability. It consists of 30 questions.¹³ The first 21 questions assess the patient’s difficulty with daily living activities; five questions assess symptoms (pain, activity-related pain, tingling, stiffness, weakness); and the remaining four questions each assess social function, work, sleep, and the patient’s self-confidence. A total score ranging from 0 to 100 is obtained. High scores indicate severe disability (0 points: no disability; 100 points: maximum disability). The validity and reliability of the questionnaire in Turkish have been established.¹⁴

Postural Assessment

Postural assessment was performed using an artificial intelligence-based posture analysis system capable of quantitatively evaluating body posture, spinal alignment, joint alignment and angular relationships, as well as overall postural symmetry.^{15,16} In this context, postural deviations in individuals diagnosed with SAPS were assessed using the AI-based Posture Evaluation and Correction System® (APECS®) mobile application. All measurements were conducted by the same physiotherapist to ensure consistency. For clarity, APECS variables used in the analysis were defined according to their anatomical representations, including ANHT, anterior knee alignment (ANKA), and lateral body alignment (LBA).

Statistical Analysis

All statistical analyses were performed using SPSS 26.0 software. The distributional characteristics of the variables were assessed using the Shapiro-Wilk test, which showed that the data were normally distributed. Therefore, Pearson correlation analysis was used to evaluate the relationships among US tendon thickness measurements, AHD, pain intensity, kinesiophobia, posture parameters, and functional status because the data were normally distributed. Correlation coefficients were interpreted as very weak (0.00-0.20), weak (0.21-0.40), moderate (0.41-0.60), strong (0.61-0.80), and very strong (0.81-1.00). A significance level of $p < 0.05$ was accepted for all statistical analyses. Data were screened for outliers prior to analysis. Given the exploratory nature of the study, more than ten correlations were examined to identify potential relationships among variables. No formal correction for multiple comparisons was applied; therefore, the findings should be interpreted with caution.

RESULTS

Table 1 shows the socio-demographic characteristics of the 44 participants included in the study. The average age of the participants was 42.84 ± 11.97 years, with 54.5% being female. The mean body mass index was 28.41 ± 0.83 kg/m², where 40.9% classified as normal weight, 36.4% as overweight, and 22.7% as obese. The right arm was dominant in 70.5% of cases. Secondary disease was reported in 11.4% of

participants. 81.8% worked in light or medium jobs, and 18.2% worked in heavy jobs. The smoking and regular alcohol consumption rates were 31.8% and 11.4%, respectively.

Table 2 presents the results of Pearson correlation analysis between the ultrasound tendon measurements, AHD, pain intensity, kinesiophobia, posture parameters (APECS sub-dimensions), function disability.

No statistically significant correlations were found between most examined clinical and functional variables and participants’ AHD values ($p > 0.05$). However, a weak-to-moderate negative correlation was observed between AHD and APECS-LBA ($p < 0.05$). An increase in lateral posture was associated with a significant decrease in AHD ($r = -0.338$, $p < 0.05$) (Figure 1).

Measurements obtained in the US are significantly and positively correlated ($p < 0.05$). Accordingly, a positive relationship was found between supraspinatus tendon thickness (SSp-US) and the tendon thicknesses of the Isp-US, SSc-US, and long head of the biceps brachii (LHBT-US), as well as the overall rotator cuff tendon thickness (RC-US), which is calculated as the combined US thickness of the SSp, Isp, and SSc tendons. Furthermore, significant positive correlations were observed between Isp-US and SSc-US, between Isp-US and LHBT-US, between Isp-US and RC-US, between SSc-US and LHBT-US, between SSc-US and RC-US, and between LHBT-US and RC-US ($p < 0.05$).

Participants’ total FABQ scores showed statistically significant positive correlations with both VAS activity scores ($r = 0.491$, $p < 0.05$) and McGill total pain scores ($r = 0.400$, $p < 0.05$). Furthermore, a strong positive correlation was observed between participants’ FABQ and DASH scores ($r = 0.677$, $p < 0.001$) (Figure 2).

The study revealed positive correlations between the APECS subscales and ultrasound measurements among participants ($p < 0.05$). The APECS subscales were positively correlated with ANHT scores, SSp, and SSc, while APECS-ANKA scores were positively correlated with SSc and LHBT. Increases in APECS-ANKA scores paralleled increases in LHBT tendon thickness, and a positive, moderately significant relationship was observed between them ($r = 0.445$, $p < 0.01$). This significant relationship between APECS-ANKA and LHBT-US is shown in Figure 3. In contrast, negative correlations were found between APECS-LBA scores and SSp-US, Isp-US, and LHBT-US ($p < 0.05$).

Table 1. Participants’ demographic and clinical characteristics			
Variable	n	%	Mean ± SD
Gender			
Female	24	54.5	
Male	20	45.5	
Age (years)			42.84±11.97
BMI (kg/m ²)			28.40±0.83
Normal (18.5-24.9)	18	40.9	
Overweight (25-29.9)	16	36.4	
Obese (≥30)	10	22.7	
Dominant arm			
Right	31	70.5	
Left	13	29.5	
BMI: Body mass index, SD: Standard deviation.			

Table 2. Correlations between clinical, postural, and ultrasonographic measurements

		AHD	SSp-US	ISp-US	SSc-US	LHBT-US	RC-US	VAS-actv	MCGILL total	FABQ total	APECS-ANHT	APECS-ANKA	APECS-LBA	DASH total
AHD	r	1												
SSp-US	r	0.005	1											
ISp-US	r	0.062	0.510**	1										
SSc-US	r	-0.137	0.582**	0.495**	1									
LHBT-US	r	-0.123	0.340*	0.317*	0.547**	1								
RC-US	r	0.08	0.555**	0.497**	0.554**	0.454**	1							
Vas-actv	r	-0.059	0.19	0.18	0.17	0.246	0.261	1						
MCGILL total	r	-0.065	0.174	0.348*	0.119	-0.026	0.15	0.621**	1					
FABQ total	r	-0.266	-0.018	0.046	0.128	0.12	0.087	0.491**	0.400**	1				
APECS-ANHT	r	0.23	0.508**	0.148	0.422**	0.231	0.314*	0.116	0.233	-0.014	1			
APECS-ANKA	r	0.151	-0.096	0.131	0.271	0.445**	0.208	-0.106	-0.21	-0.222	0.271	1		
APECS-LBA	r	-0.338*	-0.410**	-0.377*	-0.246	-0.192	-0.252	0.027	0.209	0.105	-0.126	-0.11	1	
DASH total	r	-0.149	0.057	0.287	0.226	0.069	0.139	0.592**	0.0642**	0.677**	0.021	-0.156	0.275	1

*p<0.05.

**p<0.01.

US: Ultrasonographic, AHD: Acromio-humeral distance, SSp: Supraspinatus tendon, ISp: Infraspinatus tendon, SSc: Subscapularis tendon, LHBT: Long head of biceps tendon, RC: Rotator cuff; FABQ: Fear-Avoidance Beliefs Questionnaire, DASH: Disabilities of the arm, shoulder and hand, APECS: Posture Evaluation and Correction System, Vas-actv: Activity visual analog scale.

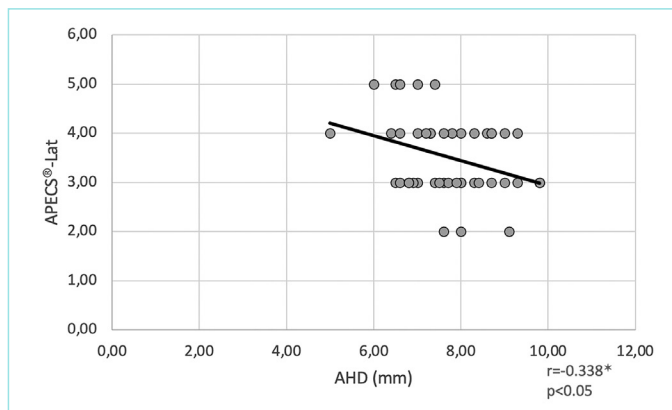


Figure 1. Distribution graph of the relationship between the acromio-humeral distance (AHD) and lateral postural alignment (APECS-LBA). *Indicates statistical significance (p<0.05).

APECS-LBA: Posture Evaluation and Correction System-lateral body alignment.

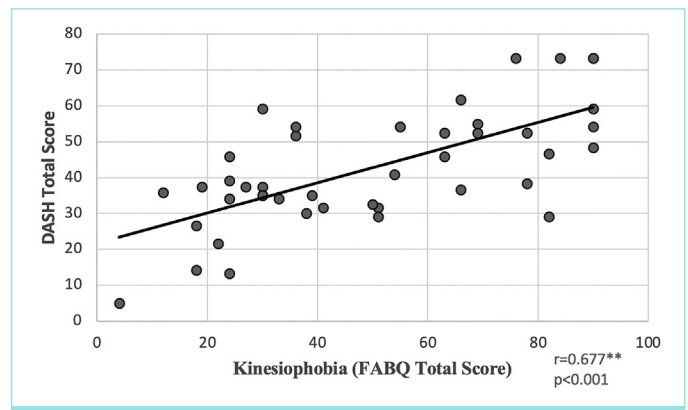


Figure 2. Distribution graph of the relationship between kinesiophobia (FABQ) and upper extremity functional impairment (DASH). **Indicates statistical significance (p<0.001).

FABQ: Fear-Avoidance Beliefs Questionnaire, DASH: Disabilities of the arm, shoulder and hand.

DISCUSSION

The relationship between the musculoskeletal system and body posture plays a fundamental role in both static alignment and functional biomechanics. Previous studies have suggested that thoracic kyphosis and altered scapulothoracic alignment may contribute to the pathomechanics of SAPS, although these relationships have not always been consistently confirmed through clinical assessments.^{3,5} The main finding of the present study indicates that AHD was negatively associated with kyphotic posture in individuals with SAPS, while positive associations were observed between postural assessment

parameters, such as head tilt, shoulder equality, and knee equality, and the thicknesses of the SSp, SSc, and biceps tendons. These findings may suggest that the pathomechanics of SAPS cannot be explained solely by local tendon structure or subacromial space narrowing; rather, they may reflect a multidimensional interaction among postural alignment, tendon loading, and clinical presentation. From a clinical perspective, this may indicate that, in addition to structural imaging findings, a comprehensive evaluation of the postural chain extending from the lower extremities, through the scapula, to the upper extremities may provide clinically relevant complementary information for decision-making in individuals with SAPS.

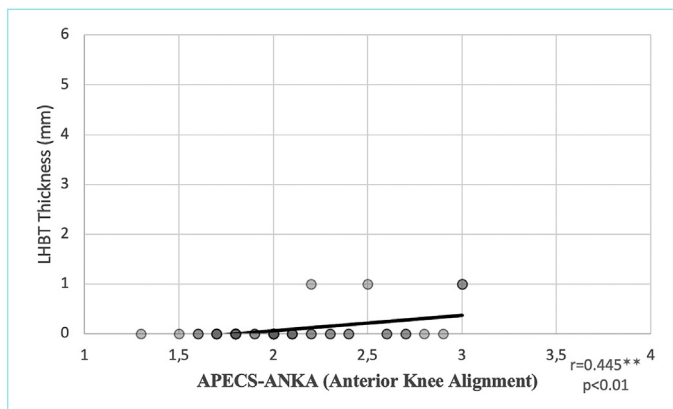


Figure 3. Scatter plot of the relationship between anterior knee alignment (APECS-ANKA) and long head of the biceps tendon thickness measured by ultrasonography (LHBT-US). A positive, statistically significant correlation was observed between APECS-ANKA and LHBT-US ($r=0.445^{**}$, $p<0.01$).

LHBT: Long head of biceps tendon, US: Ultrasonographic, APECS: Posture Evaluation and Correction System, ANKA: Anterior knee alignment, VAS: Visual analogue scale.

Studies on shoulder pathologies have reported increase in kinesiophobia, pain levels, functional loss, disability and anxiety scores, along with decrease in shoulder range of motion (ROM).^{6,7} However, the relationship between these clinical parameters and AHD or tendon thickness remains unclear. Recent studies have reported no consistent association between AHD and clinical findings.¹⁷⁻²⁰ Consistent with this literature, our study found no significant relationships between AHD and tendon thickness, pain, kinesiophobia, function, or disability. AHD was negatively correlated only with the lateral postural parameter assessed using APECS®, which may suggest that AHD is more sensitive to postural alignment and scapulothoracic biomechanics than to clinical symptoms. A hunched back, characterised by increased thoracic kyphosis, anterior positioning of the head and neck, and scapular protraction, may be associated with alterations in humeral head positioning, potentially contributing to superior translation and reduced AHD. Ito and Kawakami²¹ demonstrated that the supine position significantly reduces AHD due to anterosuperior humeral head shift associated with scapular anterior tilt and internal rotation. Kim et al.²² reported that posterior and upward scapular rotation achieved through muscle training increased AHD. These findings suggest the potential role of scapular position and scapulothoracic rhythm in AHD variation.²² Supporting this biomechanical framework, Harput et al.²³ showed that reduced scapular upward rotation was associated with superior humeral head displacement, while Bdaiwi et al.²⁴ reported improvements in AHD following activation of the both lower trapezius and serratus anterior muscle couple force. Eraslan et al.²⁵ further suggested that AHD is more closely related to muscle strength, scapulothoracic control, and biomechanical balance than to clinical symptoms. Taken together, these findings may indicate that kyphotic posture is associated with reduced AHD, potentially through changes in scapular positioning and humeral head translation. From an interpretative perspective, the lack of association between AHD and clinical parameters in our study, together with its relationship with postural alignment, may support the concept of a structural-functional mismatch in SAPS. The absence of a linear association between AHD and clinical outcomes

such as pain and disability may suggest that structural narrowing of the subacromial space alone does not adequately reflect clinical severity. Instead, functional impairment in SAPS may be better understood as a multifactorial interaction among biomechanical alignment, postural adaptations, neuromuscular control, and psychosocial factors rather than by isolated anatomical measurements.

Our study also found that the total thicknesses of the SSp, ISp, SSC, LHBT, and RC tendons were interrelated. These findings suggest that the RC within the shoulder complex may function anatomically and biomechanically as an integrated unit, consistent with current literature. Arrillaga et al.²⁶ reported that, due to their anatomical proximity, degenerative changes may affect the structure of more than one tendon. Similarly, Kim et al.²⁷ demonstrated that, the SSp, ISp, and SSC tendons run parallel to each other in healthy adults and may respond collectively to loads while aging. Relatedly, studies in symptomatic population revealed the association of clinical parameters with SSp tendon thickness.²⁷ For example, Dede et al.²⁸ reported that SSp thickness may be associated with clinical functional scores. Favoring this finding, Hunter et al.²⁹ reported that the SSp tendons of patients with SAPS were thicker than those of the healthy individuals and were associated with AHD. Taken together, these findings suggest that RC tendons respond as a functional unit during degeneration, mechanical loading, and compression, potentially due to their anatomical proximity and the continuity of their tendon fibers. When evaluated by thickness, this may reflect a complex and integrated structural organisation rather than independent tendon behaviour.

Numerous studies have examined the relationships among pain, function, kinesiophobia, and shoulder joint ROM in shoulder pathologies. Previous research has consistently demonstrated that reductions in shoulder ROM are associated with increased pain and functional impairment. Anwer et al.³⁰ reported moderate negative correlations between shoulder flexion, abduction, rotation ROM and pain and functional scores in individuals with shoulder dysfunction. Similarly, Sahinoglu³¹ reported that glenohumeral ROM provided limited contribution to functional level, whereas muscle strength and pain intensity were stronger predictors of disability. However, shoulder ROM measurements were not included in the correlation analysis in the present study; therefore, no direct inferences regarding ROM can be drawn from the current findings. Functional outcomes were assessed using the DASH scale. Our findings suggest that increased pain intensity and kinesiophobia were associated with greater functional disability. In line with these findings, higher levels of kinesiophobia were associated with increased pain intensity and disability, which may support the role of fear-avoidance beliefs in symptom severity. These findings suggest that psychological factors, particularly fear-avoidance behaviour, may be stronger determinants of functional disability than isolated biomechanical markers such as tendon thickness or AHD. This structural-functional mismatch may add to the growing body of evidence that clinical severity in SAPS cannot be explained solely by anatomical measurements. Instead, a biopsychosocial framework that integrates psychological and perceptual factors alongside biomechanical assessment may be essential for understanding functional outcomes in individuals with SAPS. These results suggest that functional limitations in SAPS should not be interpreted solely as a consequence of biomechanical factors, but as encompassing an additional interaction between pain intensity and psychosocial factors. Luque-Suarez et al.⁶ demonstrated that higher kinesiophobia levels in chronic shoulder pain

were significantly associated with both pain intensity and disability and were linked to poorer clinical outcomes. This relationship was further supported by Martinez-Calderon et al.,³² who emphasized the role of negative pain beliefs and activity avoidance in perpetuating disability. The significant association observed in this study between DASH scores, pain intensity, and kinesiophobia supports the notion that pain, kinesiophobia, and functional impairment constitute an interrelated clinical framework in SAPS, while their lack of association with structural parameters such as AHD and tendon thickness may highlight the multidimensional nature of clinical symptoms.

In this study, significant correlations were observed between anterior and lateral posture measurements assessed with APECS[®], RC tendon thicknesses and AHD, which may support the biomechanical role of postural factors in SAPS. Positive associations between anterior postural parameters (head tilt, shoulder equality, and knee equality) and SSp, SSc, and biceps tendon thicknesses are consistent with evidence that forward head posture and shoulder protraction may adversely affect scapular biomechanics, potentially contributing to increased mechanical stress within the shoulder complex. Weon et al.³³ reported that forward head posture limits serratus anterior muscle activity and scapular upward rotation; Fathollahnejad et al.³⁴ demonstrated increased stress on shoulder structures associated with forward head and rounded shoulder posture. Khosravi et al.³⁵ further showed that head posture alterations combined with serratus anterior weakness may negatively affect scapular stabilisation. Additionally, the observed relationship between knee-level equality and the thickness of the LHBT may highlight the influence of the kinetic chain extending from the lower extremity to the shoulder. Previous studies have demonstrated that impairments in the alignment of the knee, pelvis, and thorax can disrupt scapular kinematics and increase loading of the shoulder. Optimal upper extremity movement requires coordinated interaction between the lower extremities, lumbopelvic complex, and the thoracic region,³⁶ and it has been shown that lumbopelvic stability influences scapular muscle activity.^{36,37} Collectively, these findings may support the concept that disruptions along the postural chain may be associated with increased mechanical load on the shoulder complex, consistent with reports linking trunk and lower extremity factors to shoulder pathologies.^{38,39} Importantly, the combined use of the APECS[®] digital posture analysis system and high-frequency US represents a methodological strength of this study, providing an objective and quantitative assessment of postural alignment and tendon structures while minimising observer-related bias. The moderate but significant association between lateral posture and AHD may further support the influence of global postural alignment on local shoulder biomechanics. However, given the cross-sectional design of the present study, causal relationships between the investigated variables cannot be established, and these findings should therefore be interpreted as hypothesis-generating rather than confirmatory. Additionally, given the number of correlations tested, the possibility of a type I error should be considered. Therefore, some of the observed associations may represent false-positive findings and should be interpreted as exploratory.

Study Limitations

Although the sample size of this study is acceptable for clinical research, studies in larger populations may more accurately reveal the strength of these relationships. Furthermore, the study population included individuals with both acute and chronic presentations and did not exclude physically active participants, including athletes; however,

subgroup analyses were not performed. Therefore, the findings should be interpreted with caution when generalising them to specific subpopulations, particularly to post-surgical shoulder conditions, which were not represented in the present sample. Finally, posture assessments were performed using the APECS[®] system, which is based on two-dimensional measurements; as scapular and scapulothoracic motion is inherently three-dimensional and dynamic, this approach may not fully reflect the complex movement characteristics of the scapula during functional upper-extremity activities.

Additionally, because more than 10 correlation analyses were performed, the risk of type I error due to alpha inflation may have increased. Due to the exploratory nature of the study, no post-hoc correction was applied, and the findings should be interpreted with caution. Future studies using multivariable regression models are needed to identify independent predictors.

CONCLUSION

A clinically relevant finding of our study is that kyphotic posture may be associated with AHD and with disputable variations in the thickness of certain tendons. These findings suggest that specific postural parameters may be associated with tendon loading and subacromial space characteristics, and may provide clinically relevant complementary information, particularly in settings with limited assessment tools. Furthermore, the significant association between kinesiophobia and pain intensity, function, and disability may indicate that, in addition to biomechanical approaches in SAPS management, patient education and behavioural strategies targeting psychosocial components could contribute to improved treatment outcomes. Taken together, the consideration of postural factors, tendon structure, and psychosocial components may offer a comprehensive framework for the clinical assessment and management of SAPS; however, these findings should be interpreted with caution because of the study's cross-sectional design. Future longitudinal studies with larger sample sizes and advanced measurement methods, such as three-dimensional motion analysis, are needed to further clarify these relationships.

MAIN POINTS

- Postural parameters, particularly kyphotic posture, showed a significant relationship with acromio-humeral distance (AHD) in individuals with subacromial impingement syndrome (SAPS).
- AHD was not associated with pain intensity, functional disability, or kinesiophobia, suggesting limited clinical value when evaluated in isolation.
- RC tendon thicknesses were interrelated, indicating a collective biomechanical response rather than isolated tendon involvement.
- Kinesiophobia and pain intensity were strongly associated with functional disability, highlighting the importance of psychosocial factors in SAPS.
- Comprehensive postural assessment may provide clinically relevant biomechanical insight beyond conventional imaging-based evaluations.

ETHICS

Ethics Committee Approval: The protocol for this study was approved by the Near East University Ethics Committee (approval no: YDU/2023/115-1751, date: 21.06.2023).

Informed Consent: Written informed consent was obtained from all participants prior to participation in the study.

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Footnotes

Authorship Contributions

Concept: U.K., T.Y., A.Ö., Design: U.K., T.Y., A.Ö., Data Collection and/or Processing: U.K., T.Y., A.Ö., Analysis and/or Interpretation: U.K., T.Y., A.Ö., Literature Search: U.K., Writing: U.K., T.Y., A.Ö.

DISCLOSURES

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process: During the preparation of this work, the author(s) used Google Translate and DeepL Translate for translation support and to improve the readability and language of the manuscript. After using these tools/services, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

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