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Research Article

Radiographic Assessment of the Critical Shoulder Angle, the Lateral Acromion Angle and the Acromial Index in a Sample of Normal Adult Individuals: A Cross-Sectional Analytical Study

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ABSTRACT

Background: Several radiological parameters used to assess the shoulder joint; among these, the critical shoulder angle (CSA), acromion index (AI), and lateral acromion angle (LAA) are widely used. Objectives: the primary objective of our study was to establish a reference value for these parameters among healthy Iraqi adults, and secondly to explore the influence of some anthropometric parameters on these shoulder parameters.

Materials and Methods: the CSA, AI, and LAA were measured for all participants using AP radiographs of the shoulder joints on both sides, the anthropometric parameters were also recorded. The data were tabulated and statistically analyzed.

Results: the study shows no statistically significant differences in the measurements of CSA, AI, or LAA between males and females and also no differences between right and left sides. There was a weak correlation between the CSA measures and all anthropometric parameters, while there was a strong positive correlation between AI measures both age and body weight. Conversely, the LAA showed significant negative correlations with age and BMI. Interestingly we found that age was a major predictor of both AI and LAA, while weight and BMI were predictors CSA.

Conclusion: The findings of our study suggest that critical shoulder angle is relatively constant shoulder parameters among individuals, however acromial index and the lateral acromial angle vary with age and BMI, and this may affect the biomechanics of the shoulder.

Introduction

The shoulder joint is a synovial ball and socket joint that allows for an extensive range of motion at the expense of its stability, rendering it prone to dislocation and other conditions like rotator cuff tears and shoulder impingement syndromes[1,2,3]. To assess the shoulder joint, several radiological parameters are used; among these, the critical shoulder angle (CSA), acromion index (AI), and lateral acromion angle (LAA) are widely used [4]. CSA is the angle between two lines "one line connecting the upper and the lower margins of the glenoid cavity, and the other line passing through the inferolateral border of the acromion. The AI is estimated by dividing the distance from the glenoid plane to the lateral border of the acromion process (GA) by the distance from the glenoid plane to the outer margin of the head of the humerus (GH). LAA is assessed at the intersection of two lines, "one line representing the glenoid cavity and the other line representing the undersurface of the acromion" [5,6,7].

To our knowledge, there were inadequate data about the normal values of these parameters in the Iraqi population [8]. So, the primary objective of our study was to measure these parameters among normal Iraqi adult individuals and to increase the understanding of shoulder anatomy, and to participate in the development of the local clinical practices [9].

In summary, this study would not only contribute to the increasing knowledge about these parameters but may also serve as a valuable resource for Iraqi clinicians, as recognizing normal values for these parameters can help in the early diagnosis and management of shoulder pathologies [10].

Subjects and Methods

Study Design and Study Population

The study was an analytical cross-sectional in designed, conducted at Al-Kindy teaching hospital, Baghdad, Iraq. It includes 70 normal adult participants. Inclusion criteria: male and female Iraqi adults who are willing to join the study. Exclusion criteria: A history of shoulder trauma, shoulder surgery, or any diagnosed shoulder disorders.

Ethical Considerations

The study was performed under the ethical rules of the WMA Declaration of Helsinki and was conducted with verbal approval before any examination and was ethically approved by the local committee of the Al-Kindy Medical College.

Data Collection

age and gender, body weight, height, and BMI were first recorded, followed by a full medical history and physical examination to exclude shoulder pathologies. Subsequently, radiological evaluations of the three shoulder parameters (CSA, AI, and LAA) were measured using an anteroposterior (AP) radiograph of both shoulders using the DXR 3 [dicomPACS®] device. To ensure accurate measurements, two qualified radiologists reviewed the images.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics 29 and Microsoft Excell 360. Descriptive statistics (including means and standard deviations) for CSA, AI, and LAA, were estimated. Inferential statistics, like t-test, ANOVA and correlation analysis, were used to investigate the relationships between anthropometric parameters and shoulder angles, regression analysis was performed to compute regression equations. A significance level of $p<0.05$ was set for all analyses to determine the statistical significance of the findings[11].

Results

The participants' average age was 30± 8.03 years (19 to 44 years), descriptive statistics of the participants data are illustrated in table 1.

Effect of gender on different shoulder parameters

A student t-test was executed to test the effect of gender on different shoulder parameters; the results indicate that there were statistically insignificant differences between male and female (p-values 0.06 for CSA, 0.79 for LAA, and 0.21 for AI). The means were closely identical, and the test confirmed that any detected differences were probably due to random variation [Figure 2].

Effect of side on different shoulder parameters

An ANOVA test has shown there were no significant differences in shoulder parameters between right and left sides (F-value = 0.108, P-value = 0.743, F critical = 3.864). This means that the shoulder parameters (CSA, AI, LAA) do not significantly differ between the right and left sides. Again, the means were nearly identical, and the test confirmed that any detected differences were probably due to random variation [Figure 2].

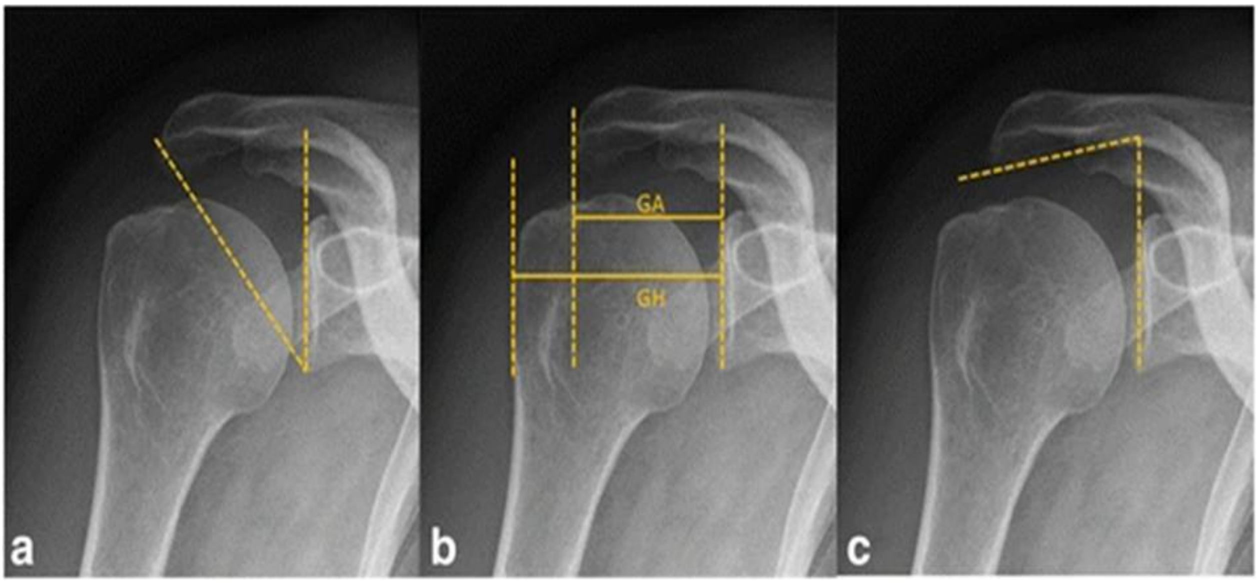

Figure 1: Radiological measurements of critical shoulder angle (CSA), acromion index (AI), and lateral acromion angle (LAA) using AP radiographs

Table 1: Descriptive Statistics

	Gender	Age	Weight	Height	BMI	CSA	AI	LAA
Mean	Male	30.56	66.89	175.82	21.69	33.08	0.68	79.96
	Female	30.68	65.13	164.35	24.09	33.48	0.69	80.33
SD	Male	8.37	10.14	3.39	3.56	0.96	0.02	3.74
	Female	7.65	9.81	3.16	3.37	0.75	0.01	3.60
Minimum	Male	19	51	169	15.87	30.10	0.65	73.80
	Female	20	52	158	18.87	32.10	0.66	72.50
Maximum	Male	44	88	181	29.07	35	0.72	85.20
	Female	44	80	169	29.71	34.90	0.71	85.10

CSA: Critical shoulder angle, AI: Acromial index, LAA: Lateral acromial angle

Correlation between shoulder parameters and anthropometric factors

CSA showed weak negative correlations with weight, BMI, and age, and a weak positive correlation with height. AI showed strong positive correlations with weight, BMI, and age, and a moderate positive correlation with height. LAA showed strong negative correlations with age, BMI, and weight moderate positive correlation with height. In conclusion, CSA remained relatively stable across the different anthropometric parameters. AI significantly increases with weight, BMI, and age and decreases with height, meaning heavier and older individuals tend to have a higher AI, while taller individuals have a slightly lower AI. On the other hand, LAA decreases significantly with weight, BMI, and age and increases with height, suggesting that heavier and older individuals tend to have a lower LAA, while taller individuals have a slightly higher LAA. [table 2], [figure 3]

Table 2. **Correlation - shoulder parameters and anthropometric factors**

	Weight	*Height*	*BMI*	*Age*
CSA	- 0.250	0.070	- 0.253	- 0.147
AI	0.801	- 0.330	0.809	0.847
LAA	- 0.531	0.364	- 0.559	- 0.783

Correlation between different shoulder parameters

CSA & AI show no significant correlation (r =0.011, suggests that CSA and AI are almost independent of each other). CSA & LAA also show no significant relationship (r = 0.056, means that CSA and LAA are nearly independent). While AI & LAA show a moderate negative correlation (r = -0.530, meaning that as AI increases, LAA tends to decrease). [figure4]

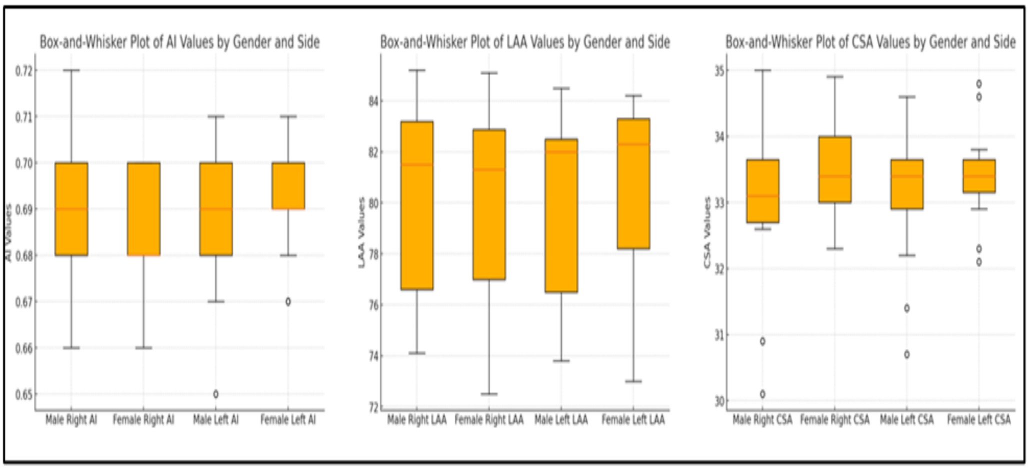

Figure 2: Box and Whisker plots of different shoulder morphology parameters by gender and side

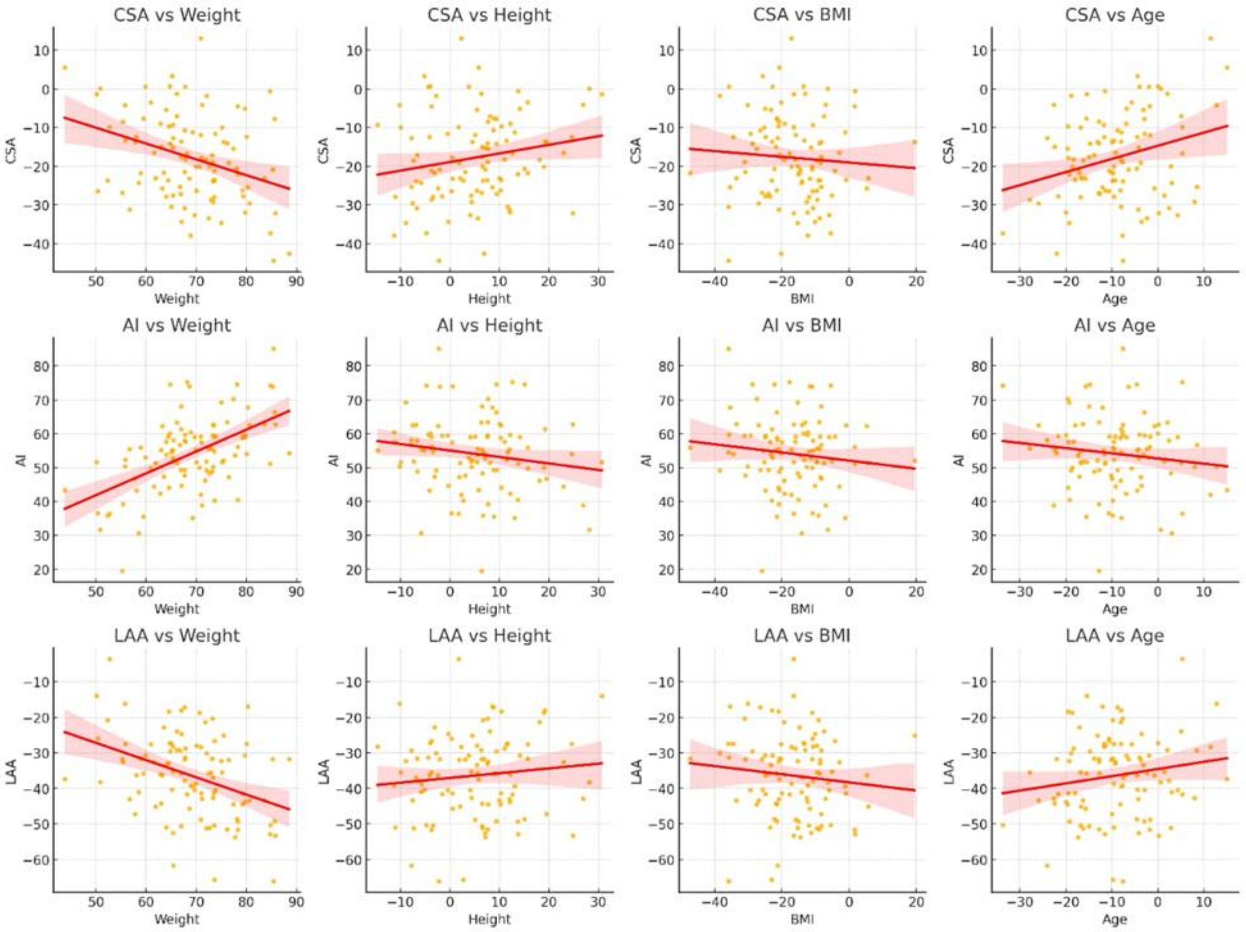

Figure 3: scatter plots showing relationships between shoulder parameters and anthropometric factors. The trends suggest that AI tends to increase with weight and BMI, while LAA decreases as weight, BMI, and age increase. CSA shows only weak correlations with these factors.

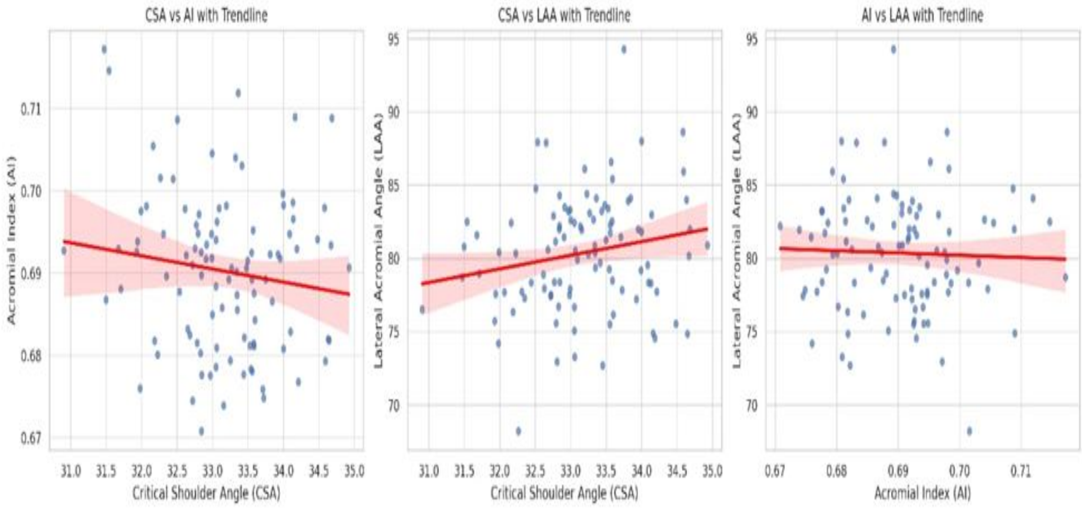

Figure 4: scatter plots showing relationships between CSA, AI, and LAA:
CSA vs. AI → No clear pattern, confirming their near-zero correlation (r =0.011).
CSA vs. LAA → No strong trend, supporting their weak correlation (r =0.056).
AI vs. LAA → Noticeable negative trend indicating a moderate negative correlation (r=-0.530).

Regression Equations

CSA = -17.53 + (-0.4125 x Weight) + (0.2938 x Height) + (1.1929 x BMI) + (0.0245 x Age)

The regression equation shows that for each 1-Kg increase in body weight the CSA decreases by 0.4125° (assuming other variables remain constant), for each 1-cm increase in height the CSA increases by 0.2938° (assuming other variables remain constant), for each 1-unit increase in BMI the CSA increases by 1.1929° (assuming other variables remain constant), and for each 1-year increase in age, CSA increases by 0.0245° (assuming other variables remain constant ($P = 0.105$, not statistically significant).

In conclusion, the weight, the height, and the BMI are significant predictors of CSA (p values < 0.001), conversely, the age is statistically insignificant ($P = 0.105$).

AI = 0.6294 + (0.00057 x Weight) + (-8.48E-06 x Height) + (0.00013 x BMI) + (0.00066 x Age)

The regression equation shows that each 1-kg increase in weight increases the AI by 0.00057 units (assuming other variables remain constant), each 1-cm increase in height decreases the AI by 8.48×10^{-6} units (assuming other variables remain constant), each 1-unit increase in BMI increases the AI by 0.00013 units (assuming other variables remain constant) and each 1-year increase in age increases the AI by 0.00066 units (assuming other variables remain constant)

In conclusion, age is the only significant predictor for AI ($P = 0.0002$) while weight, height, and BMI do not significantly contribute to the prediction (p values > 0.05).

LAA = 54.96 + (-0.359 x Age) + (-0.354 x Weight) + (0.213 x Height) + (1.018 x BMI)

For each 1-Kg increase in weight, LAA decreases by 0. 354° (assuming other variables remain constant), for each 1-cm increase in height, LAA increases by 0. 213° (assuming other variables remain constant), for each 1-unit increase in BMI, CSA increases by 1. 018° (assuming other variables remain constant) and for each 1-year increase in age, LAA decreases by 0. 359° (assuming other variables remain constant)

In conclusion, only age is a significant predictor (p value <0.001) while weight, height, and BMI do not show a significant contribution to LAA prediction ($P > 0.05$).

Discussion

The outcomes of this study provide insights into the relationship between shoulder morphological parameters and some anthropometric parameters and mostly in a relatively young adult population. Descriptive statistics showed that the mean age of participants was 30 years which indicates a young and moderately diverse cohort, which is relevant as age-related shoulder changes (like for example rotator cuff degeneration) tend to be more obvious in older populations [12]. The mean height of 170.74 cm and BMI of 22.75 were within the normal ranges, indicating that the individuals represent a general adult population with no extreme variations in body composition [13].

Gender and Side Differences in Shoulder Parameters

Our study revealed that there were no statistically significant differences in CSA, AI, and LAA between the two genders; the likely explanation for this finding is that shoulder parameters are predominantly affected by intrinsic skeletal structure rather than by sexual dimorphism [15]. Similarly, the study showed that there were no statistically significant differences in these parameters between the left and right sides, and this may be explained by the fact that differences between dominant and non-dominant shoulders might not significantly influence shoulder morphology [16.17].

Correlation Between Anthropometric Factors and Shoulder Morphology

Correlation analysis reveals that CSA displayed weak correlations with age, body weight, height, and BMI, which may suggest that CSA is a structurally inherent factor and is not significantly influenced by age or anthropometric parameters [18]. However, AI showed strong positive correlations with both age and body weight, a finding that may be explained by the gradual skeletal adaptations over time (age), whereas increased body weight influences scapular positioning [19]. Conversely, LAA showed strong negative correlations with age and body weight, suggesting that acromial morphology may change with aging [20].

Remarkably, the study found a minimal correlation between CSA and AI, suggesting that these function independently. In contrast, there was a moderate negative correlation between LAA and AI, which may highlight the potential interaction between acromial morphology and shoulder mechanics [21].

Regression Analysis: Predictors of Shoulder Morphology

The regression analysis found that CSA was significantly predicted by both body weight and height, but not by age, a finding that may indicate that increasing body mass could affect glenoid morphology [20]. Conversely, the AI predicted by age, but not by body weight and height, which may indicate that AI is affected by age-related skeletal changes more than by body composition [21]. Similarly, LAA was affected by age only, while body weight and height showed no significant correlations, which further supports the perception that acromial angulation changed progressively with ageing, which may contribute to the increased risk of rotator cuff pathologies in older individuals [19].

Conclusion

Our study measured CSA, AI, and LAA in normal adults and found no significant differences between genders or sides. CSA was stable across age and body measures, AI increased with age, weight, and BMI, while LAA decreased with these factors. Weight, height, and BMI predicted CSA; age predicted AI and LAA. These values provide baseline references for our population, though the small sample size warrants larger future studies.

Here's a polished Limitations section addressing Reviewer 2's comment about sample size:

Limitations

This study's relatively small sample size may limit the generalizability of the findings to the wider population. While the data provide valuable baseline reference values for shoulder parameters in our population, larger-scale, multicenter studies involving more diverse cohorts are necessary to validate and extend these results. Additionally, the cross-sectional design limits the ability to infer causal relationships between anthropometric factors and shoulder morphology.

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This research did not receive any specific fund.

Conflict of Interest

Authors declare no conflict of interest.

Data availability

Data are available upon reasonable request.

Author Contributions

MA contributed to the conception, design, analysis, interpretation, drafting, revision, and proofreading of the manuscript. SA contributed to the conception, design, data acquisition, drafting, revision, and proofreading. SA contributed to the conception, design, data acquisition, drafting, revision, and proofreading. All authors read and approved the final version of the manuscript.

All authors meet the ICMJE criteria for authorship and agree to be accountable for all aspects of the work.

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