Original Article

Correlation of Carrying Angle with Body Mass Index among Females of Hyderabad Pakistan

Pinky[1], Komal Kumari[2], Jaya Kumari[2], Maham Memon[2], Reeta[3], Iqra Shaikh[2], Sidra Hanif[4]*

[1]Lecturer, Institute of Physiotherapy and Rehabilitation Science, Liaquat University of Medical and Health Sciences Jamshoro, Pakistan.
[2]House Officer, Institute of Physiotherapy and Rehabilitation Science, Liaquat University of Medical and Health Sciences Jamshoro, Pakistan.
[3]Senior Lecturer, Sindh Institute of Physical Medicine and Rehabilitation Karachi, Pakistan.
[4]Senior Lecturer, University Institute of Physical Therapy, Ibadat International University Islamabad, Pakistan.
*Corresponding Author: Sidra Hanif, Senior Lecturer; Email: drsidrahhaneefpt@gmail.com
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ABSTRACT

Background: The carrying angle (CA) of the elbow is a critical biomechanical feature that varies between genders and with physical characteristics like Body Mass Index (BMI). Past studies have shown mixed results regarding the influence of BMI on CA, making it an area ripe for further investigation.

Objective: To explore the correlation between BMI and the CA of the elbow among adult females in Hyderabad, Pakistan, and to assess how variations in BMI affect the elbow's CA.

Methods: This cross-sectional study involved 385 adult females from Hyderabad, Pakistan, selected through non-probability convenient sampling. Participants were required to be over 18 years of age and without any prior upper limb surgeries. The CA was measured using a manual goniometer while standing in the anatomical position. BMI was calculated using measured weight and height. Statistical analysis was conducted using SPSS version 25, with the Pearson correlation test determining the relationship between BMI and CA.

Results: Among the participants, 71.9% exhibited a normal CA, 23.6% displayed a decreased CA, and 4.4% had an increased CA. The Pearson correlation test showed a significant positive correlation between BMI and CA (p-value = 0.006), indicating that higher BMI is associated with an increased CA.

Conclusion: The study found a significant association between BMI and CA among females in Hyderabad, Pakistan. This suggests that BMI is a relevant factor in the biomechanical characteristics of the elbow, which may have implications for the clinical assessment of joint function and health.

Keywords: Body Mass Index, Carrying Angle, Elbow Joint, Biomechanics, Female Orthopedic Health, Cross-Sectional Study, Pearson Correlation, SPSS.

INTRODUCTION

The carrying angle (CA) of the elbow, defined as the angle formed in the coronal plane between the outstretched arm and forearm when the forearm is supinated, is an important anatomical feature influenced by several physiological factors. This angle, which deviates laterally from a straight line, is primarily due to the valgus angulation of the trochlea relative to the capitellum (1, 2). Historically, Potter first quantitatively studied this obliquity in 1895, noting that it is more pronounced in females than in males, with typical angles ranging from 5° to 10° for males and 10° to 15° for females (3, 4). The development of CA continues until the ages of 15 to 18, corresponding to skeletal maturity, after which it stabilizes or slightly decreases (5). Additionally, variations in CA have been associated with individual differences in height, skeletal structure, and during locomotion, where CA adjustments help align the body's center of mass beneath the supporting hand in the walking phase (2, 6).

The biomechanical relevance of the CA extends to differences observed across genders and life stages, with findings suggesting broader pelvises in females potentially contributing to increased CAs due to a direct correlation with pelvic width (10). Such distinctions in CA are also evident during the fetal period, where males are reported to exhibit higher CAs than females (9). The functional significance of CA is underscored by its role in optimizing lever arm mechanics and avoiding interference with the lower

limb bones during load carrying (11). Furthermore, this anatomical feature exhibits variability with other anthropometric indices such as shoulder, hip, waist circumferences, as well as with age, weight, height, body mass index (BMI), and hand dominance (10, 12).

BMI, a widely accepted measure for assessing body weight relative to height and categorizing medical risk (weight in kg/height in m^2), correlates significantly with various metabolic processes and health outcomes according to WHO standards, which define ranges from underweight to obesity (13, 14). Notably, overweight children show increased soft tissue around the elbow joints, potentially reducing mobility at this joint (15). CA measurement can be performed clinically using a goniometer, where the elbow is held fully extended and supinated, aligning the device's arms with the axes of the arm and forearm (18). This method, along with radiography, provides reliable assessments essential for both clinical evaluations and research studies investigating the interplay between anatomical and biomechanical properties of the elbow.

MATERIAL AND METHODS

A descriptive correlational survey was undertaken over a six-month period from July to December 2023 in Hyderabad, Pakistan, to investigate the relationship between the carrying angle (CA) of the elbow and body mass index (BMI) among adult females. The study utilized a nonprobability convenient sampling method to select participants. The Rao Soft calculator was employed to determine the required sample size, based on a 5% margin of error and a 95% confidence level, considering the total female population of the Hyderabad division as 5,378,225 (22). This calculation yielded a sample size of 385 individuals.

Eligibility criteria for participants included females aged 18 and above who consented to participate and had no history of surgical interventions on the upper limbs. Exclusion criteria encompassed those with any congenital abnormalities, mental instability, or current pregnancy. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, ensuring all participants provided informed consent after being briefed on the nature and objectives of the research.

Data on participants' weight and height were collected using a standard weighing machine and measuring tape, respectively, to calculate BMI. The elbow CA of the dominant hand was measured using a manual goniometer. For this measurement, participants were positioned standing in an anatomical pose, with the goniometer's axis placed on the cubital fossa. The stationary arm of the goniometer was aligned with the arm, while the movable arm was aligned with the forearm axis. The angle displayed on the goniometer was then recorded.

Data analysis was performed using SPSS version 25. The information collected was tabulated and graphically represented to facilitate analysis. The Pearson correlation test was applied to determine the association between the CA and BMI, with statistical significance set at a p-value of 0.05. This comprehensive approach ensured the reliability and validity of the findings, providing valuable insights into the biomechanical relationships of the upper limb in relation to body mass among females in Hyderabad.

RESULTS

Table 1: Frequency and Percentage Distribution of Carrying Angle (CA) Among Participants (n=385)

CA Category	Frequency	Percentage (%)
Decreased	91	23.6
Normal	277	71.9
Increased	17	4.4

Table 2: Pearson Correlation Results Between Body Mass Index (BMI) and Carrying Angle (CA)

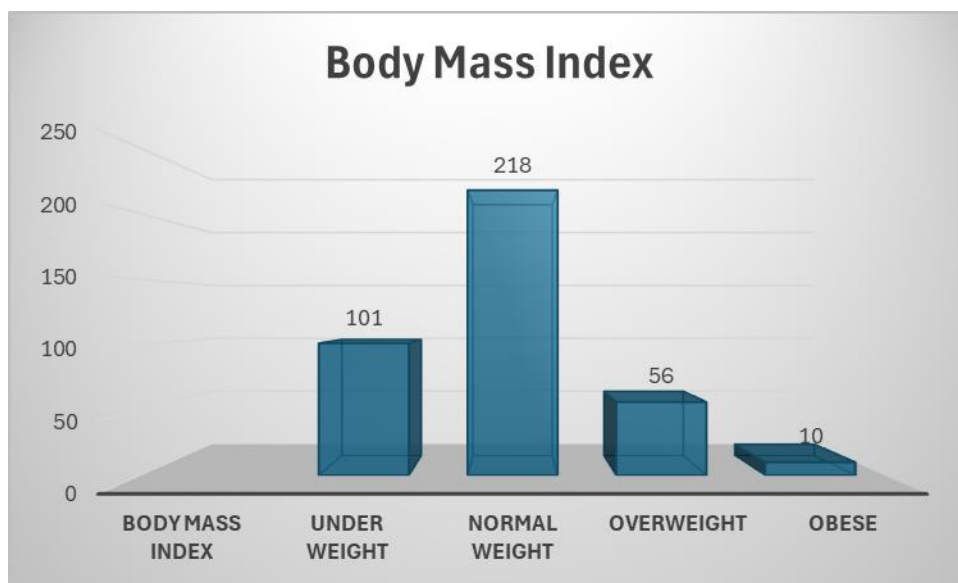| Variable	Correlation with CA	p-value
BMI	Positive	0.006

Figure 1 Distribution of Body Mass Index Categories

Figure 1 illustrates the BMI distribution among the 385 participants. The majority of participants fall within the 'Normal weight' category, numbering 218 individuals, representing 56.6% of the total sample. This indicates a predominant trend towards a healthy weight range within the study cohort. The 'Underweight' category includes 101 participants, accounting for 26.2% of the sample, which highlights a considerable proportion of the population with BMI values below the normal range. Meanwhile, those classified as 'Overweight' are fewer, with 56 participants or 14.5% of the total. The 'Obese' category has the smallest representation, with only 10 participants, making up approximately 2.6% of the sample. This distribution suggests a skewed prevalence towards normal and underweight classifications within this demographic.

The correlation statistics presented in **Table 2** further enrich these findings. The Pearson correlation test reveals a statistically significant positive relationship between BMI and the Carrying Angle (CA) of the elbow (p-value = 0.006). This indicates that as BMI increases, there is a tendency for the CA to increase as well, suggesting that body mass can influence the biomechanical properties of the elbow joint.

These results, depicted quantitatively in **Figure 1** and supported by the correlation data in **Table 2**, provide a comprehensive overview of the interplay between BMI and elbow CA, emphasizing the impact of body mass on anatomical and functional characteristics of the elbow among females in Hyderabad, Pakistan.

DISCUSSION

The study conducted was a cross-sectional analysis to ascertain the correlation between Body Mass Index (BMI) and Carrying Angle (CA) among females in Hyderabad, Pakistan. A total of 385 women participated after providing informed consent. Measurements of weight, height, and CA using a goniometer facilitated the calculation of BMI. The findings indicated that 71.9% of participants had a normal CA, 23.6% had a decreased CA, and 4.4% had an increased CA. The correlation analysis revealed a statistically significant association between BMI and CA, with a p-value of 0.006, suggesting that increases in BMI are linked to increases in CA.

This outcome is supported by other research in the field, such as a study by Vikas Verma et al. (2022), which also identified a strong correlation between CA and both age and BMI (12). However, results from different regions and study setups show a range of correlations. Anibore E et al. (2016) observed only a weak positive relationship between these variables in Nigeria (8), while Md Ashraful Kabir et al. (2022) found no significant relationship in a Bangladeshi sample comprising both genders (15). This variation in findings could be attributed to differences in demographic and methodological aspects between studies.

Moreover, Muhammad Ayaz et al. (2020) provided insights into gender differences in CA, noting that females typically exhibit a larger CA, and that the dominant limb often has a larger CA than the non-dominant limb (1). These variations underscore the complexity of CA as a physiological characteristic potentially influenced by multiple factors, including hand grip strength, which has been negatively correlated with CA in young adults (19).

While CA variations have been investigated for their forensic application in sex determination due to significant gender differences, their clinical relevance is also notable in the assessment of traumatic elbow injuries and the management of conditions like distal humerus fractures (20, 21). Possible contributors to CA variations include BMI, gender, and other morphometric factors. However, the relationship with conditions such as ulnar nerve neuropathies, medial and lateral epicondylitis, and elbow deformities remains less clear (17).

Despite the significant findings, this study had limitations that need acknowledgment. The use of a nonprobability convenience sample may limit the generalizability of the results. Future research should consider a probabilistic sampling method to enhance the

representativeness of the findings. Additionally, exploring the mechanisms underlying the observed relationships in a longitudinal framework could provide insights into causality rather than mere associations.

CONCLUSION

The observed correlation between BMI and CA among the female population of Hyderabad emphasizes the need to consider BMI in assessments of joint mechanics and health. The impact of BMI on CA could potentially influence the risk of developing musculoskeletal disorders, highlighting the importance of further research in this area. Future studies should also aim to incorporate diverse populations and enhance sampling techniques to better understand the dynamics of BMI and CA across different settings.

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