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Association Between Elbow Carrying Angle and The Lateral Epicondylitis: A Cross-Sectional Study in Iraqi Adults

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ABSTRACT

Lateral epicondylitis (LE) is a common tendinopathy caused by repetitive activities involving upper limb. While normally correlated to occupational and other appropriate variables, anatomical factors like the carrying angle (CA) have not been completely investigated. The CA may influence joint loading and predispose individuals to LE. **Aims**: to investigate the relationship between CA and LE in sample of Iraqi individuals and to reveal whether the increasing CA correlates with higher prevalence of LE. A cross-sectional observational study was performed on 100 adult individuals aged 20–60 years, they were divided into two groups: 50 patients diagnosed with LE and 50 healthy controls. CA was measured using a conventional goniometer. Demographic data, handedness, and clinical results were recorded. Statistical analyses were conducted. The mean CA was found to be significantly larger in the LE group compared to controls (14.5° vs. 12.9°, $p < 0.01$). Females were documented to have higher CA values than males in both groups ($p < 0.05$). There was no significant correlation between age and CA ($r = 0.07$). These results indicate a possible biomechanical influence of increased CA on the development of LE. This study highlights a link between increased CA and the development of LE, indicating that CA may be a biomechanical risk factor. Incorporating that the assessment of CA into clinical evaluation could improve diagnosis and facilitate targeted preventive and rehabilitation programs. Future studies are required to explain causal relationships and generalize results across populations.

Keywords: Lateral epicondylitis, Carrying angle, Biomechanics, Elbow alignment, Tendinopathy

Introduction

The musculoskeletal condition known as lateral epicondylitis (LE), or tennis elbow, is characterized by pain and soreness over the lateral aspect of the elbow. It is mostly caused by degeneration of the extensor carpi radialis brevis (ECRB) tendon. Although repetitive wrist extension and forearm supination are often linked to the disorder, it is now understood to be a tendinopathy rather than a traditional inflammatory process (1). About 1-3 percent of the general population suffers from LE, a serious clinical problem that peaks in those between the ages of 35 and 54 (2). Its symptoms can have a major influence on functional performance and quality of life, and it is particularly common in people who conduct repeated arm activities, whether in everyday life, sports, or at work (3).

Mechanical strain, microtrauma, vascular compromise, and anatomical predispositions are all part of the complex etiology of LE (4). Anatomical differences in the elbow joint have not been thoroughly studied as potential causes of the disorder, even though biomechanical and occupational aspects have been thoroughly established. One such anatomical characteristic is the carrying angle, which is the angle formed by the ulna and the humeral longitudinal axis when the forearm is supinated and the elbow is fully extended. Sex, age, handedness, and degree of physical activity are some of the variables that affect this angle (5). Females typically have a larger carrying angle than males, which may be caused by hormonal factors and variations in pelvic breadth.

Notables are the biomechanical effects of a larger carrying angle. When engaging in repetitive extension and supination exercises, a larger angle may result in a different force distribution across the elbow joint, which could put more strain on the lateral elbow tissues, such as the ECRB tendon (8). According to some research, people who have a larger carrying angle may be more

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susceptible to lateral soft-tissue overuse injuries like LE because of increased elbow valgus stress. Moreover, compensatory processes in the wrist and shoulder may result from abnormal kinematics in these patients, which could contribute to chronic pain syndromes (10).

There is still a dearth of empirical research examining the relationship between carrying angle and the incidence of LE despite these biomechanical insights. Without taking into consideration underlying anatomical predispositions, the majority of the literature to date has concentrated on ergonomic and occupational issues. Furthermore, there is a dearth of regional research on this topic, especially among Middle Eastern communities where lifestyle, work, and cultural factors may have distinct effects on musculoskeletal health. The necessity of additional anatomical and biomechanical evaluation in this population was underlined by MH Assi's study in Iraq, which examined the morphometric measurement of carrying angle among Iraqi medical students and revealed notable diversity based on gender and handedness (11). Furthermore, regional morphological variations in elbow structure were noticed by Al-Dabbagh et al. (2020), who suggested more investigation into how these characteristics can predispose people to prevalent elbow disorders (13).

By investigating the connection between carrying angle and lateral epicondylitis in adult Iraqis, this study seeks to close this information gap. The study aims to determine whether a higher carrying angle is associated with a higher prevalence of LE by using physical data and biomechanical reasoning. Comprehending this connection may have significant clinical ramifications, such as the creation of focused preventative tactics, ergonomic adjustments, and customized rehabilitation regimens.

In the end, understanding anatomical elements like the carrying angle may improve the precision of diagnosis and the design of interventions for patients with LE. In patients who come with lateral elbow pain, especially in groups with high exposure to repetitive arm motions, doctors may think about measuring carrying angle as part of a normal evaluation if a substantial link is found. By providing data unique to the Iraqi population, this work fills a significant gap in regional musculoskeletal health research while also advancing our understanding of LE globally.

Materials and Methods

Study Design and Study Population: The purpose of this cross-sectional observational study was to evaluate the association between carrying angle and lateral epicondylitis (LE) in Iraqi adults. Over the course of six months (August 2024 to February 2025), participants were gathered from a Baghdad outpatient clinic and physiotherapy center. Iraqi adults between the ages of 20 and 60 made up the study population. Healthy volunteers without a history of elbow pain and those with a clinical diagnosis of LE, as verified by routine orthopedic testing, were the inclusion criteria. Any history of upper limb trauma, congenital abnormalities, prior elbow surgery, or systemic inflammatory joint illnesses were all grounds for exclusion. There were two groups in the study:

Group A: Individuals having an LE diagnosis.

Group B: Controls of the same age and sex who did not have any elbow musculoskeletal issues.

Ethical Considerations: The study complied with the Declaration of Helsinki's ethical guidelines and received ethical approval from Al-Musatansiriyah Medical College Institutional Review Board (IRB). Before taking part, participants gave written informed consent after being fully aware of the study's goals. Every piece of information was gathered anonymously and handled with the utmost discretion.

Data Collection: Age, sex were among the demographics that were recorded. Tenderness at the lateral epicondyle and a positive result from Cozen's and Mill's tests were the basis for the clinical diagnosis of LE (14).

Measurement Technique: A common universal plastic goniometer was used to measure the carrying angle with a 1° precision. The participants were instructed to stand with their arms completely extended and their forearms supinated, which is the anatomical position. The fulcrum of the goniometer was situated above the lateral epicondyle of the humerus, the movable arm was orientated with the ulna's midline, and the stationary arm was orientated with the humeral shaft, To guarantee dependability and reduce observer bias, two independent measurements were made for each arm, and the average was noted.

Statistical Analysis: SPSS version 25 was used to code and analyze the data (IBM Corp., Armonk, NY, USA). For demographic variables and carrying angle measurements, descriptive statistics including mean, standard deviation, and frequency

were employed. Normality of data was assessed using the Shapiro-Wilk test, and homogeneity of variances was evaluated using Levene's test prior to applying the independent samples t-test. Pearson's correlation coefficient was used to examine the relationship between age (as a continuous variable) and carrying angle. The mean carrying angles of the LE and control groups were compared using the independent samples t-test. P-values below 0.05 were regarded as statistically significant (15). Sex and handedness-based subgroup analyses were conducted.

The statistical methodology was reviewed by a qualified biostatistician to ensure appropriateness of test assumptions and reporting

Results

Descriptive statistics for the carrying angle variable across both groups are summarized in Table 1

A significant difference in carrying angles was observed between males and females in both groups. In the Lateral Epicondylitis (LE) group, females had a higher mean carrying angle (14.69°) compared to males (14.02°), with a statistically significant difference ($p = 0.031$) (Figure 1).

In the normal group, females also showed a higher carrying angle (13.02°) than males (12.06°), with a statistically significant difference ($p = 0.024$) (Figure 1).

Correlation analysis shows a weak and statistically insignificant correlation between age and carrying angle in both groups ($r = 0.07$ overall) Fig. **2**, Fig. **3**.

correlation in both groups (correlation coefficient $r = 0.07$, $p = 0.486$) (Figures 2 and 3).

An independent-samples t-test showed that individuals with lateral epicondylitis (LE) had significantly higher mean carrying angles compared to the normal group (14.39° vs. 12.66°, $p = 0.001$) (Figure 4).

Discussion

The recent study highlighted the significant association between increased carrying angle and the diagnosis of lateral epicondylitis enhancing the implication of biochemical factors in the development of upper limb tendinopathies. Particularly, the mean CA in individuals with lateral epicondylitis was significantly higher than in the control group (12.9° vs 14.5°), indicating that elbow joint alignment might influence the pathomechanics of lateral epicondylitis.

The carrying angle (CA), defined as the valgus angle between the arm and the forearm when the elbow is extended and the forearm is in supination, pays an essential part in load transmission through the elbow during upper limb activities. A larger CA is supposed to increase valgus stress at the elbow joint, particularly damaging lateral tissues such as the origins of the common extensor tendon which identified as the principal site of disease in lateral epicondylitis (17). Repetitive or prolonged overuse under these distorted mechanical conditions may encourage microtrauma, inflammatory changes, and subsequent tendinosis, consistent with clinical and histopathological features of lateral epicondylitis (18).

Sex-based differences help to understand this finding. In the current study, females show a significantly higher CA than males, consistent with prior anatomical studies (19). This is often linked to a wider pelvis in females, demanding larger lateral forearm angulation for functional alignment (20). While these differences are believed to be physiologic, our findings indicate that even after controlling sex, increased CA remains significantly associated with lateral epicondylitis. This validates its role as an independent biomechanical risk factor (22).

Dominance related variations are also worth noting, while the dominant arm is more commonly affected in lateral epicondylitis, probably due to increasing use and repetitive load (23), we noted the occurrence of lateral epicondylitis on the non-dominant side. In such instances, asymmetry in CA could clarify uneven joint loading, possibly increased its susceptibility to injury. Side-by-side comparisons of CA have showed variation of up to 3–5° in some peoples (24), and this asymmetry might interrelate with task-specific biomechanical demands to influence onset of lateral epicondylitis. Future studies should classify data by dominance and compare inter-limb differences in CA.

Interestingly, we found that the correlation between CA and age was modest and statistically insignificant ($r = 0.07$ overall), confirming previous findings that CA stays relatively constant throughout adulthood (25). This finding confirms the hypothesis that the increased CA in patients with lateral epicondylitis is unlikely to be age-related but instead it may reflect structural or behavioral factors, such as recurrent use patterns or congenital alignment anomalies.

Table 1: Descriptive Statistics

Group	Gender	N	Mean (°)	SD (°)	Min (°)	Max (°)
	Male	23	12.06	1.05	9.3	14.5
Normal	Female	27	13.02	1.07	10.1	14.7
	Both genders	50	12.66	1.18	9.3	14.7
	Male	25	14.02	1.44	11.9	17
LE	Female	25	14.69	1.43	11.9	17.6
	Both genders	50	14.39	1.48	11.9	17.6
Overall	All	100	13.52	1.59	9.3	17.6

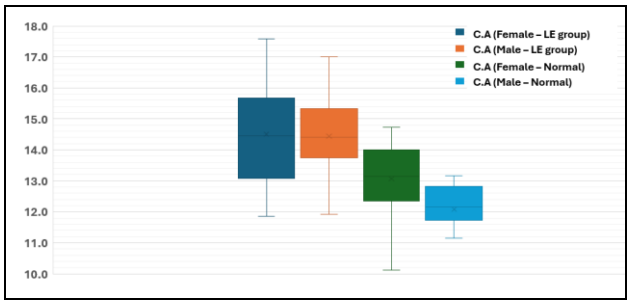

Fig. 1. Box-and-whisker plot comparing carrying angles between males and females in both LE and normal groups. Statistical test: independent samples t-test. LE group: p = 0.031; Normal group: p = 0.024

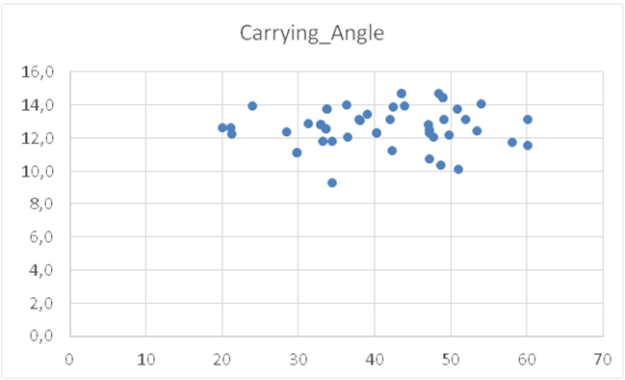

Fig. 2. Scatter plot showing the relationship between age and carrying angle in the normal group. Pearson correlation: r = 0.07; p = 0.486

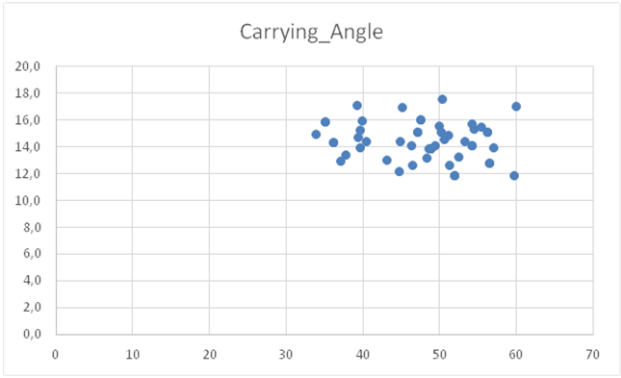

Fig. 3. Scatter plot showing the relationship between age and carrying angle in the LE group. Pearson correlation: r = 0.07; p = 0.486

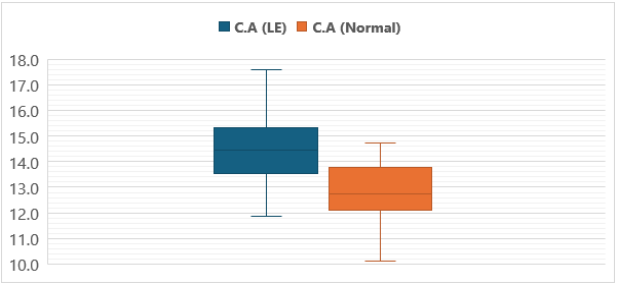

Fig. 4. Box & Whisker graph comparing carrying angles between normal and LE groups

The clinical consequences of these results are significant. First, screening for excessive CA might serve as an early predictor of the risk of lateral epicondylitis in people engaged in repetitive upper limb activities, such as athletes, musicians, or manual laborers. Second, the management options for lateral epicondylitis could be customized based on the alignment of elbow joint. Rehabilitation programs may focus on strengthening stabilizers of the lateral elbow and adapting wrist or shoulder loading techniques to moderate the effects of a larger CA [26]. In some circumstances, orthotic support or ergonomic tool design may reorganize joint forces to decrease strain (27).

However, several limitations need consideration, the cross-sectional nature of the study implies casual inferences, and the static assessment of CA might not exactly reflect joint dynamics during activity.

Furthermore, other confounding variables such as sport activity, occupation, and overall upper extremities kinematics were not controlled for, even though they may considerably increase the risk of lateral epicondylitis (28).

Future studies should utilize longitudinal study designs for further understanding the chronological associations between the alignment of the elbow and the onset of lateral epicondylitis.

Dynamic imaging or 3D motion analysis might deliver more accurate data on how CA involves real-time force distribution over the elbow [29]. Additionally, increasing the size of the sample to involve ethnic groups of the population may enhance the generalization.

The study contributes to the growing understanding of the biochemical reinforcements of lateral epicondylitis, highlighted the significance of CA as a potential changeable or modifiable risk factor. Designed prevention and rehabilitation efforts that deliberate individual anatomical variation might improve outcomes and reduce recurrence.

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