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A comparative study of carrying angle on sexual dimorphism in young males and females

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ABSTRACT

Introduction: The carrying angle, the acute angle between the arm and forearm when the upper limb is fully extended and supinated, demonstrates sexual dimorphism and lateral asymmetry. It plays a crucial role in biomechanics and is influenced by various anthropometric factors. This study aims to evaluate the carrying angle in young Nepalese males and females to investigate sexual dimorphism, side differences, and correlations with height, forearm, and arm lengths.

Methods: A cross-sectional study was conducted at KUSMS among 160 healthy individuals aged 18–25 years (110 males, 50 females). Carrying angles were measured on both limbs using a manual goniometer. Participants' height, forearm length, and arm length were recorded. Statistical analysis was performed using SPSS v16.0. Independent and paired t-tests, along with Pearson correlation, were used to analyze sex and side differences and their associations with anthropometric parameters.

Results: Females showed significantly higher left carrying angles (8.6°±3.9°) than males (7.3°±3.1°, p= 0.026), while right-side angles were comparable. In males, the right angle was significantly greater than the left (p< 0.001), suggesting lateral asymmetry. Arm length showed a positive correlation with carrying angle in both sexes, more strongly in females (r= 0.408 to 0.459). No consistent correlations were found with height or forearm length.

Conclusion: This study confirms sexual dimorphism and right-left asymmetry in the carrying angle among young Nepalese adults. Arm length emerged as a statistically significant correlate, particularly in females. These findings underscore the need for population-specific normative data to aid clinical assessments and orthopedic planning.

Keywords: Anthropometry, Asymmetry (left-right), Elbow joint, Sex characteristics, Young adult

INTRODUCTION

The carrying angle is defined as the angle formed between the long axes of the arm and forearm when the upper limb is fully extended and supinated.[1] This valgus angulation is vital in enabling free arm movement during walking and preventing the forearm from striking the hips when carrying objects.[2] Anatomically, the carrying angle arises due to the oblique orientation of the trochlea and the asymmetry of the elbow joint.[1,3]

Sexual dimorphism in the carrying angle is well-documented, with females typically exhibiting a larger angle than males. This difference has been attributed to broader pelvic structure, hormonal influences, and increased ligamentous laxity in females.[4,5] Similarly, other studies have shown a statistically significant difference in carrying angle between sexes, with dominance also playing a contributing role—right limbs often exhibit greater angles in both sexes.[6,7]

Apart from sex, factors such as age, forearm length, height, and handedness influence this angle, making it a clinically relevant measure in orthopedic assessment, particularly in diagnosing and managing deformities such as cubitus varus or valgus following trauma.[5,6] Despite the growing literature, findings on sexual dimorphism and lateral differences remain inconsistent across ethnicities. Therefore, this study aims to compare the carrying angle between young males and females, highlighting its sexual dimorphism in a specific South Asian Population.

METHODS

The present study used a cross-sectional design and was conducted in the Department of Anatomy, Kathmandu University School of Medical Sciences (KUSMS), Dhulikhel, Kavrepalanchowk, Nepal, during January–March 2025.The ethical clearance was obtained from the Institutional Review Committee of Kathmandu University School of Medical Sciences (IRC-KUSMS Ref. no. 338/24). Convenience sampling was used to collect data.

Based on the study of Rajesh B et al,[2] sample size was calculated using the formula ($n= z^2 \times \sigma^2/ e^2$). Where n is minimum required sample size, z is 1.96 at 95% Confidence Interval (CI), σ is standard deviation of 1.0, and e is margin of error, 5%.The sample size obtained was 153.64, and the study will be done among 160 students.

A total of 160 apparently healthy students (110 males and 50 females), aged 18–25 years, from KUSMS were included in the study. All participants provided written informed consent before data collection. Participation was entirely voluntary, and no monetary or academic compensation was given. Students were assured that refusal would not affect their academic standing. The use of convenience sampling among medical students may introduce selection bias and limit generalizability to the broader Nepalese young adult population.

The carrying angle was measured using a manual goniometer made of flexible, transparent plastic with fixed and movable arms. With the elbows extended, the fixed arm was aligned with the midline of the upper arm, and the movable arm with the midline of the forearm. The humeral axis

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was defined using the line connecting the acromion's lateral border and the midpoint of the bicipital groove. The forearm axis was aligned with a line between the radial styloid and the midpoint between the radial and ulnar styloid processes.

A transparent plastic manual goniometer (Goniometer 360° -Plastic 8"), calibrated before data collection, was used for the measurement of the angle.Anatomical landmarks, including the bicipital groove, the biceps brachii tendon at its insertion, and the palmaris longus tendon at the wrist, were palpated and marked to define the mid-axes of the upper and lower arms. Carrying angles were measured in degrees on both right and left arms to assess side-to-side differences, with the right arm measured first. Participants' age, sex, and height (measured in centimeters using a stadiometer, barefoot, in the anatomical position) were also recorded. Individuals with fractured limbs, a history of upper limb injury or surgery, or congenital deformities were excluded. To minimize technical error and ensure reproducibility, all measurements were conducted by the same observer using the same instrument. Data were recorded in Microsoft Excel and analyzed using SPSS Statistics for Windows, version 16.0.

RESULTS

The descriptive statistics of the anthropometric parameters and carrying angles for both sexes are presented in Table 1. The mean age and standard deviation of male participants were 21.1±1.3 years, while those of females were slightly lower at 20.6±1.2 years. Males were significantly taller than females, with mean heightsof 171.9±5.9 cm and 159.3±6.8 cm, respectively. Similarly, the average lengths of the forearm and upper arm were greater in males (25.7±1.3 cm and 37.6±2.3 cm, respectively) than in females (23.8±1.3 cm and 35.6±2.6 cm, respectively). In terms of carrying angle, the mean value for the right side was 8.3±3.6° in males and 8.7±3.3° in females. On the left side, the mean carrying angle was 7.3±3.1° in males and 8.6±3.9° in females.

Table 1: Descriptive Statistics of the anthropometric parameters and carrying angles for both sexes (n=160)

Particulars	Sex	Mean	Median	SD	Min	Max
Age (yrs)	Male	21.1	21	1.3	18	25
	Female	20.6	21	1.2	18	23
Height (cm)	Male	171.9	172.0	5.9	154.0	185.9
	Female	159.3	159.2	6.8	145.0	173.0
Carrying Angle Rt (°)	Male	8.3	9.0	3.6	1	19
	Female	8.7	9.5	3.3	2	16
Carrying Angle Lt (°)	Male	7.3	7.5	3.1	1	15
	Female	8.6	8.0	3.9	3	20
Length of Forearm (cm)	Male	25.7	25.7	1.3	22.8	29.7
	Female	23.8	23.7	1.3	21.0	26.5
Length of Arm (cm)	Male	37.6	37.5	2.3	30.2	42.0
	Female	35.6	35.5	2.6	31.0	41.0

To examine sexual dimorphism, independent samples t-tests were conducted for each parameter. The results are summarized in Table 2. Statistically significant differences were observed in height ($t = 11.922$, $p < 0.001$), forearm length ($t = 8.429$, $p < 0.001$), and arm length ($t = 4.809$, $p < 0.001$), with males exhibiting larger mean values across all three anthropometric dimensions. While the difference in the right carrying angle between males and females was not statistically significant (t=0.828, p= 0.409), the left carrying angle showed a significant difference (t= 2.255, p= 0.026), with females having a higher mean angle.

Paired samples t-tests were performed separately for males and females to compare the right and left carrying angles within individuals. In males, the right carrying angle was significantly greater than the left (mean difference = 0.9°, $t = 4.404$, $p < 0.001$). In contrast, no significant side difference was observed in females (mean difference= 0.2°, t= 0.370, p= 0.713). These findings suggest that side-related asymmetry in carrying angle is evident among males but not among females.

Pearson correlation coefficients were calculated to explore the association between carrying angle (right and left) and three anthropometric parameters: height, forearm length, and arm length. The results are summarized in Table 3.Among males, a weak but statistically significant positive correlation was found between arm length and both right (r= 0.201, p= 0.035) and left (r= 0.307, p= 0.001) carrying angles. No significant correlation was observed with height or forearm length.Among females, stronger and more consistent associations were observed. The right carrying angle showed positive correlations with forearm length (r= 0.308, p= 0.030) and arm length (r= 0.408, p= 0.003). The left carrying angle was significantly correlated with arm length ($r = 0.459$, $p = 0.001$), while correlations with height and forearm length did not reach statistical significance.

Agreement between right and left carrying angle measurements was assessed using the Bland–Altman approach. The analysis demonstrated a small mean bias, indicating minimal systematic difference between sides. The majority of measurements lay within the 95% limits of agreement. Regression analysis of the differences against the means showed no significant proportional bias ($p = 0.403$), indicating that the magnitude of disagreement did not vary with measurement size. These findings suggest that right and left carrying angle measurements show acceptable agreement and may be considered interchangeable at the group level, although occasional large individual differences were observed.

Boxplot demonstrates sex-related differences in carrying angle for both the right and left upper limbs. For the right side (Rt), females exhibited a slightly higher median carrying angle compared with males. Although males showed a wider overall range of values, the interquartile ranges of the two groups overlapped. For the left side (Lt), a similar pattern was observed, with females again showing a higher median carrying angle than males. The variability was comparable between sexes, and substantial overlap of distributions was noted(Figure 2).

DISCUSSION

The present study aimed to investigate the carrying angle of the elbow joint among 160 young Nepalese individuals (110 males and 50 females), evaluating sexual dimorphism, side-wise asymmetry,

Table 2: Independent Samples t-test showing comparison of anthropometric parameters and carrying angles between males and female

	Male	Female	t	d.f.	Mean Diff	p-value	CI (95%)
Height	171.9± 5.9	159.3± 6.8	11.922	158	12.6	0.000	10.55 – 14.74
Carrying Angle Rt	8.3± 3.6	8.7± 3.3	0.828	158	0.5	0.409	0 – 1.67
Carrying Angle Lt	7.3± 3.1	8.6± 3.9	2.255	158	1.3	0.026	0.16 – 2.43
Length of Forearm	25.7± 1.3	23.8± 1.3	8.429	158	1.8	0.000	1.43 – 2.31
Length of Arm	37.6± 2.3	35.6± 2.6	4.809	158	2.1	0.000	1.13 – 2.87

Table 3: Pearson Correlation between carrying angle and selected anthropometric parameters in male and female participants (n = 160)

Carrying Angle/Sex		Male			Female		
		Height	Length of forearm	Length of Arm	Height	Length of forearm	Length of Arm
Carrying Angle Rt	r	-0.036	-0.057	0.201	0.244	0.308	0.408
	p-value	0.708	0.553	0.035	0.087	0.030	0.003
Carrying Angle Lt	r	-0.023	0.034	0.307	0.175	0.200	0.459
	p-value	0.813	0.722	0.001	0.225	0.163	0.001

and correlations with anthropometric parameters. The current study demonstrated a statistically significant difference in the left-side carrying angle between males and females with females exhibiting a higher mean than males. These findings align with previous research that consistently demonstrates greater carrying angles in females. Ruparelia et al. reported significantly higher carrying angles in females, right side 11.85±2.27°, compared to 6.90±1.25° in males.[8] Similarly, Sharma et al. observed right and left angles of 4.95±3.78° and 7.80±3.95°, respectively, in females versus 4.55±3.37° and 7.03±3.40° in males.[9] Beigh et al. also found significant sex-based differences, with male vs. female values of 12.18° vs. 14.53° on the right (p <0.01) and 10.17° vs. 13.43° on the left (p <0.001). Rajesh B et al. reported 13.3± 2.4 ° in girls and 6.7 ± 1.0° inboys.[10]

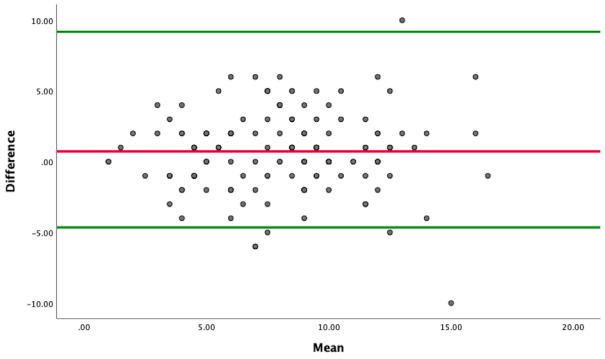

Figure 1: Bland-Altman Plot

Airan et al. have shown mean right-side angles of 12.31° (females) and 8.71° (males), with statistical significance (p < 0.001).[11] Kaewpornsawan et al., in a study conducted in Thailand, found a mean carrying angle of 6.9±3.8 in boys and 8.5±4.1 in girls, with girls demonstrating significantly greater carrying angle than boys (p < 0.001).[4] In African populations, Oladipo et al. reported sex differences; 9.75±2.26° in females vs. 9.31±1.67° in males on the right, and 9.58±2.10° vs. 8.99±1.53° on the left, with larger carrying angles in females on both sides.[12] In contrast, Steel and Tomlinson, in their study done in the UK, reported higher mean values in males and higher overall means than the population of other regions, males 19.28° and females 18.38°.[13] These results confirm the generalizability of our findings and underscore the anatomical dimorphism in carrying angle. These collective findings strongly support the presence of sexual dimorphism in carrying angle across ethnic groups, with our study falling within the expected range of South Asian populations, but on the lower end of the global scale.[9,10,11]

In our study, a significant difference between right and left carrying angles was observed in males (right: 8.3±3.6°, left: 7.3±3.1°; p < 0.001), indicating right-sided dominance, whereas no significant difference was observed in females. The finding is mirrored in the study conducted by Oladipo et al., which reported a significant difference in male subjects between the right and left carrying angle (t=2.62, p=0.01), but not in female subjects.[12] Beigh et al. reported statistically significant right-left asymmetry in males (12.18° vs. 10.17°, p <0.001), the difference in females (14.53° vs. 13.43°) was also statistically significant (p <0.001).[10] Similarly, Kazi et al. noted significant right-dominance in carrying angle, in both males (8.03° in right vs 7.09° in left, p<0.001) and females (11.05° in right vs 10.26° in left, p<0.001).[7] Manoranjitham et al. reported that the carrying angle was significantly greater on the right side in both sexes (male: 11.9±3.81° in right vs 11.1±3.2° in left, p<0.001) and (female: 14.7±4.41° in right and 13.6±4.08° in left, p<0.001).[14] These consistent findings across diverse populations support the notion that carrying angle exhibits significant right-left asymmetry, especially in males.

The present study found a significant positive correlation between carrying angle and arm length in females, with a modest correlation for forearm length and no significant association with height. In males, only arm length showed a significant correlation, while other parameters were not statistically related. Similarly, Rajesh B et al. reported that, in their Indian sample, carrying angle was positively correlated with arm length in females (p < 0.05). At the same time, in males, the correlation was not statistically significant.[2] While our study didn't find a significant association between carrying angle and height,Kalpana Sharma et al. reported a statistically significant correlation between height and carrying angle (r= 0.08, p= 0.048<0.05).[9] Kazi et al. found no statistically significant correlation between carrying angle and forearm length, arm length, or height in females.[6] In contrast, Kazi et al. reported weak negative correlations between carrying angle and anthropometric parameters in males. Specifically, the right carrying angle showed inverse associations with forearm length (r= –0.269, p= 0.012), arm length (r= –0.236, p= 0.028), and height (r= –0.348, p= 0.001), though the strength of these correlations was limited.[6] This suggests that the correlation between

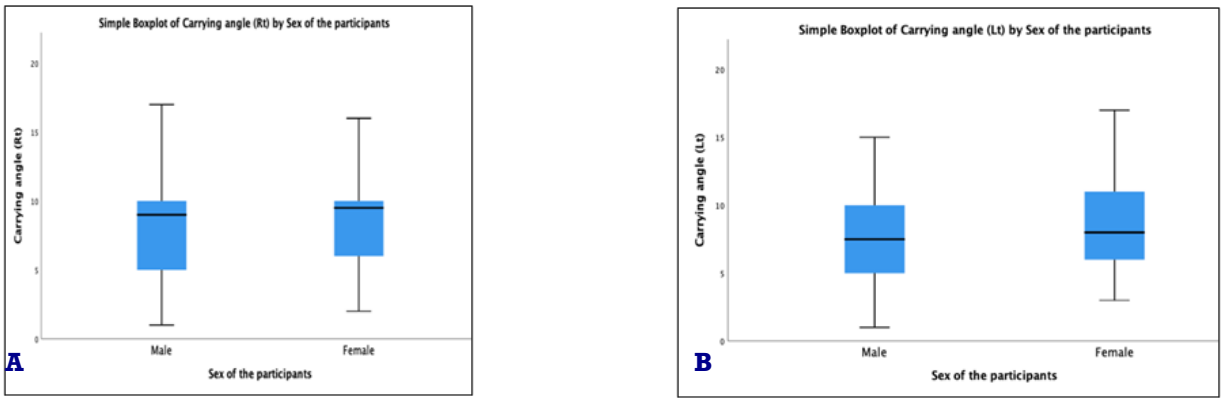

Figure 2: Boxplot showing carrying angle (A)Right (B)Left between males and females

carrying angle and anthropometric parameters such as height, arm length, and forearm length remains weak, inconsistent, and often sex-dependent, with studies showing conflicting results and no universally established pattern across populations.

Our sample was limited to young urban adults, which may affect generalizability. Future research should explore age- and occupation-related changes, and validate angles using imaging modalities. Cross-ethnic comparative studies and larger, more diverse samples will refine the anthropometric understanding of this trait.

CONCLUSION

This study highlights notable sexual dimorphism and side-wise asymmetry in the carrying angle among young Nepalese adults. Females demonstrated a significantly higher left carrying angle than males, aligning with findings from various global populations. While males showed significant right-left asymmetry in carrying angle. Anthropometric correlations revealed that arm length was positively associated with carrying angle in both sexes, with stronger and more consistent associations observed in females. The weak or inconsistent correlations with height and forearm length suggest that these parameters are less predictive of carrying angle.

DECLARATION

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Author Contributions

SM, NS and PS conceptualized and designed the research. SS, SA and BK collected the data. SM and NS analyzed and interpreted the data. All authors were involved in drafting and reviewing the manuscript for important intellectual content. All authors approved the final version of the manuscript for submission and agreed to be accountable for all aspects of the work.

Conflict of interest

None

Ethical Approval

This research was approved by the IRC of Kathmandu University School of Medical Sciences with reference number: IRC-KUSMS Ref. no. 338/24 on 15 December 2024.

Consent/Assent

All participants provided written informed consent before data collection.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Standring S. Diencephalon. Gray's anatomy the anatomical basis of clinical practice, 38th edition. Churchill-Livingstone: Elsevier, London 1995. p. 642-3.
2. Rajesh B, Reshma VR, Vaithilingam A, Jaene RC, Somasekhar IT. An evaluation of the carrying angle of the elbow joint in adolescents. Int J Med Biomed Res. 2013 Sept-Dec;2(3):221-5. | DOI |
3. An KN, Morrey BF, Chao EY. Carrying angle of the human elbow joint. J Orthop Res. 1984;1(4):369-78. | DOI |
4. Kaewpornsawan K, Kamegaya M, Udompunturak S, Eamsophana P, Ariyawatkul T. The normal reference values of carrying angle from birth to adolescence. Siriraj Med J. 2018;70: 284-8. | DOI |
5. Manandhar B, Shrestha R, Pradhan P. Study of carrying angle and its correlation with various parameters. J Nepal Med Assoc. 2022;60(247):282-5. | Full Text |
6. Bari W, Alam M, Omar S. Goniometry of elbow carrying angle: a comparative clinical study on sexual dimorphism in young males and females. Int J Res Med Sci. 2015 Dec;3(12):3482-4. | Full Text |
7. Kazi S, Keche HA, Joshi PK, Wanjari AN. The comparison and evaluation of carrying angle of elbow with anthropometric measurements in both sexes. Int J Anat Res. 2017;5(4.3):4686-90. | Full Text |
8. Ruparelia S, Patel S, Zalawadia A, Shah S, Patel SV. Study of carrying angle and its correlation with various parameters .Natl. J. Integr. Res. Med. 2010;1(3):28-23. | Full Text |
9. Sharma K, Mansur DI, Khanal K, Haque MK. Variation of carrying angle with age, sex, height and special reference to side. Kathmandu Univ Med J. 2013 Oct-Dec;11(44):315-8. | Full Text |
10. Beigh IA, Bhat TA, Mantoo Sa, Bhat SA, Mohammad J, AhmadZ.Carrying angle variations between dominant and non-dominant limb in jammu region of North India.J. med. sci. clin. res.2019;7(11):936-9.| DOI |
11. Airan N, Dwivedi AK. A comparative study of carrying angle among males and females in Garhwal region of Uttarakhand. MedPulse – International Journal of Anatomy. May 2018; 6(2): 13-17. | Full Text |
12. Oladipo GS, Paul JN, Amasiatu VC, et al. An examination of carrying angle of students in Madonna University, Elele, Port Harcourt, Rivers State, Nigeria. J Appl BiotechnolBioeng. 2019;6(2):95-99. | Full Text |
13. Steel FL, Tomlinson JD. The carrying angle in man. J Anat. 1958 Apr;92(2):315-7. | PubMed |
14. Manoranjitham R, Gosai SR, Arunkumar KR, Shalini R, Parathasarathi R. Study of carrying angle of medical students by using goniometer. Indian Journal of Basic and Applied Medical Research. 2015 june;4(3):459-66.| Full Text |