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CARRYING ANGLE AND ITS CORRELATION WITH HEIGHT IN CENTRAL INDIAN PAEDIATRIC POPULATION

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ABSTRACT

Introduction: Carrying Angle (CA) is formed between long axis of arm and forearm when arm is supinated and elbow joint is fully extended leading to lateral deflection of forearm. In healthy growing children the range of elbow joint motion and CA increases with age until skeletal maturity, increasing up to 15 years thereafter decreasing slightly. Effect of increasing height on CA at elbow has not been extensively studied in paediatric population creating a void.

Aims & Objective: Present study finds out correlation between height and CA in paediatric population. Objectives were to identify gradual variation in CA according to height variation in children as their age advanced.

Material & Method: Five hundred four (504) children of both sexes aged 6-14 years, grouped in four groups [I, II, III and IV] were assessed for CA using manual goniometer while height was measured using stadiometer. Statistical calculations were done using Prism software.

Result: Present study reports a positive correlation between CA and height as the CA increased gradually in all the four groups with increasing height from group I to group IV.

Discussion & Conclusion: This study demonstrates the positive correlation of CA with height in paediatric population irrespective of gender. Apparently present is the only study till date showing gradual CA increase with advancing height according to age in children (6-14 years) undergoing active skeletal growth and maturation period.

Clinical Relevance: Knowledge of CA and its variation is important anatomic feature assisting orthopaedic surgeons in management of elbow fractures, restoration, implants, and other diseases. It may be useful for forensic anthropologists in assessing skeletal remains.

Keywords: *Carrying angle, height, dominant limb, non-dominant limb.*

1. INTRODUCTION

The carrying angle (CA) or cubital angle apparently develops as a response to pronation of the forearm and keeps the swinging upper extremity away from the side of the pelvis during walking. When the arm is supinated and the elbow joint is fully extended, the forearm remains laterally deflected and not in a straight line with the arm. This leads to the development of an angle flanked by the long axis of the arm and the long axis of the forearm, which is referred to as the carrying angle of the elbow. This angle changes with skeletal growth and maturity[1, 2, 3]. As per literature reports, CA undergoes a progressive increase reaching its maximum value during puberty[4, 5] being greater in females[5, 6, 7] and being higher on dominant side[3, 6], yet some do not encountered such relationships[2, 4, 8].

Carrying angle is the measurement of lateral obliquity of the fully extended and supinated forearm, and comes out to be approximately 11° in men and 14° in women [170° - 175° in males and 165° - 167° in females][1, 9]. Kothapalli et al.,[10] and others have reported for negative correlation between CA and forearm length in males but no such correlation in females[11, 12]. Similar yet contrasting[13] outcomes are reported by others[14, 15].

Several workers have investigated the connection between CA and age, sex, dominant side, height, race etc., [10, 11, 12, 13, 14, 15] but reports involving such studies on paediatric population remain scanty. Therefore, we aim to study the carrying angle and its variation as height increases both in girls and boys in the different age groups of Central Indian paediatric population.

2. MATERIAL AND METHODS

The present study was done on 504 paediatric age group subjects (156 girls and 348 boys) grouped into convenient four categories [Group I – 6-8 years; Group II – 9-10 years; Group III – 11-12 years; Group IV – 13-14 years] in Central Indian population which were school going children in and around Mount Index International School, Indore (Madhya Pradesh). A written consent from all the subjects, an ethical clearance from Ethical Committee and an approval of Institutional Research Committee of Malwanchal University, Indore (M.P.) was taken prior to conduct of the study.

Inclusion Criteria:

Subjects well within the age range 6 – 14 years, of Central Indian origin with normal and healthy profile and informed consent were only included.

Exclusion Criteria:

Subject with history of trauma, congenital anomalies or deformities affecting limb, endocrine disorders affecting skeletal system, bone disorders due to malnutrition or vitamin deficiency, any previous history of surgery, fracture around shoulder, elbow and wrist, or pathology around elbow and wrist joints were not involved.

Measurement Procedure

The subject's nationalities, age (verified from school documents), gender, height and dominant side were recorded on a specific investigation paper sheet. **Height** was measured using **stadiometer.** Height is precise in anatomical position. Subjects were made to stand on their heels together, buttocks, shoulder and head touched the walls of stadiometer. Measurement was taken from vertex to the heel of subject and the mark on stadiometer was recorded on participant's investigation sheet. The **carrying angle** was measured by **universal (manual) goniometer** with the subject in standing position with the upper extremity to be measured placed in anatomical position. The measurements were done for both dominant and non-dominant hand for each subject and the mean values of the carrying angle were calculated and recorded.

Statistical Analysis

The statistical analysis was done by using **Graph pad Prism software.** All the values were expressed as mean with standard deviation (mean ± SD). Variations were analysed using paired **Student's t-test** and significance was accepted at **P-values < 0.05**.

3. RESULTS

In the present study, in general females showed a greater carrying angle (CA) as compared to the males in both dominant and non-dominant limbs. While comparing dominant and non-dominant arm, CA was recorded to be significantly more in dominant arm than in non-dominant in all the four groups irrespective of gender (Table 1; Figure 1).

In group I including subjects of age 6-8 years, in girls, the CA in dominant arm was significantly greater (8.108974° ± 2.462586) than the non-dominant arm (7.2564105° ± 2.412201) ($p = 0.0158$). For boys, the CA in dominant arm followed same path and was significantly greater (8.1069445° ± 1.841239782) than in non-dominant arm (7.434722° ± 2.529066006) ($p = 0.0158$).

In group II involving volunteers aged 9-10 years, females showed more CA in dominant limb (8.589412° ± 2.856315) which was significantly higher than non-dominant limb (6.98° ± 2.306407) ($p = 0.0068$). For boys, again the CA was significantly greater in dominant limb (8.0122595° ± 2.472095) than in non-dominant one (6.611298° ± 2.486994) ($p = 0.0068$).

In group III comprising of participants aged 11-12 years, the CA in dominant arm of females was significantly greater (9.9210285° ± 2.829533) than in non-dominant arm (7.985803° ± 2.740184) ($p = 0.0015$). Similarly, in males, the CA was significantly greater in dominant arm (8.503876° ± 2.403146) than in non-dominant arm (6.9050385° ± 2.520486) ($p = 0.0015$). In group IV encompassing 13-14 years pupils, significantly higher CA was recorded in dominant limb (8.9833335° ± 2.912424) than non-dominant limb (7.2416665° ± 2.425979) ($p = 0.0101$) of females. Likewise, males also showed higher CA in dominant limb (9.08° ± 2.662786) than non-dominant limb (7.6144445° ± 2.926184) ($p = 0.0101$).

Groups	Sex	Average Height (cm)	Average CA of Dominant Arm (degree)	Average CA of Non-Dominant Arm (degree)	P value	Significance
Group I (6-8 years)	Girls (n= 19)	119.11 ± 7.887365	8.108974 ± 2.462586	7.2564105 ± 2.412201	0.0158	Significant
	Boys (n=61)	120.20 ± 9.102370135	8.1069445 ± 1.841239782	7.434722 ± 2.529066006		
Group II (9-10 years)	Girls (n=42)	135.31 ± 7.241319	8.589412 ± 2.856315	6.98 ± 2.306407	0.0068	Significant
	Boys (n=100)	133.69 ± 7.352489	8.0122595 ± 2.472095	6.611298 ± 2.486994		
Group III (11-12 years)	Girls (n=72)	144.50 ± 7.319762	9.9210285 ± 2.824533	7.985803 ± 2.740184	0.0015	Significant
	Boys (n=116)	141.631 ± 7.154597	8.503876 ± 2.403146	6.9050385 ± 2.520486		
Group IV (13-14 years)	Girls (n=23)	149.4348 ± 7.774235	8.9833335 ± 2.912424	7.2416665 ± 2.425979	0.0101	Significant
	Boys (n=71)	150.7014 ± 10.83802	9.08 ± 2.662786	7.6144445 ± 2.926184		

Table 1: Comparative values of average height and Carrying Angle of females and males in dominant and non-dominant limbs among four age groups of children.

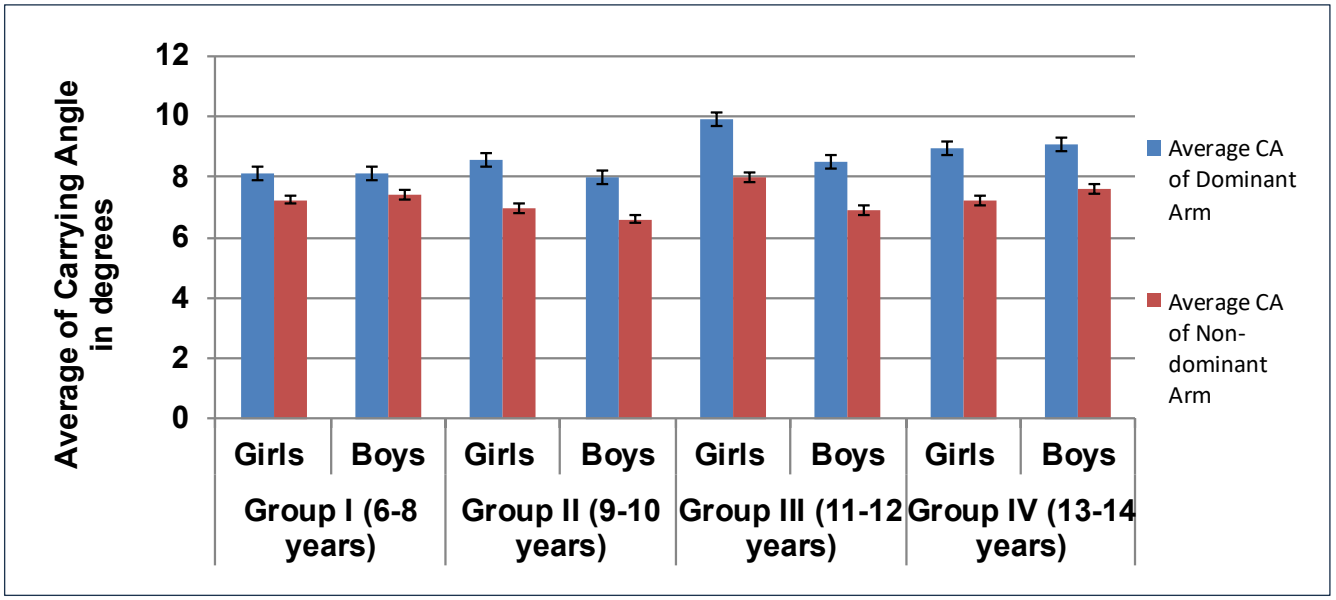

Figure 1: Graph showing comparative values of average Carrying Angle of females and males in dominant and non-dominant limbs among four age groups of children.

When recorded for all 504 participants (aged 6-14 years), the mean height came out to be 137.0887 cm for females while for males it was 136.5556 cm. When considering individual groups, the average height was recorded as follows (Table 1; Figure 2).

For group I, the mean height for girls was 119.11 ± 7.887365 cm while for boys it was 120.20 ± 9.102370135 cm. For group II, for girls it was 135.31 ± 7.241319 cm while for boys it was 133.69 ± 7.352489 cm. For group III, for girls and boys it was 144.50 ± 7.319762 cm and 141.631 ± 7.154597 cm, respectively. For group IV, in girls it was 149.4348 ± 7.774235 cm while that for boys was 150.7014 ± 10.83802 cm.

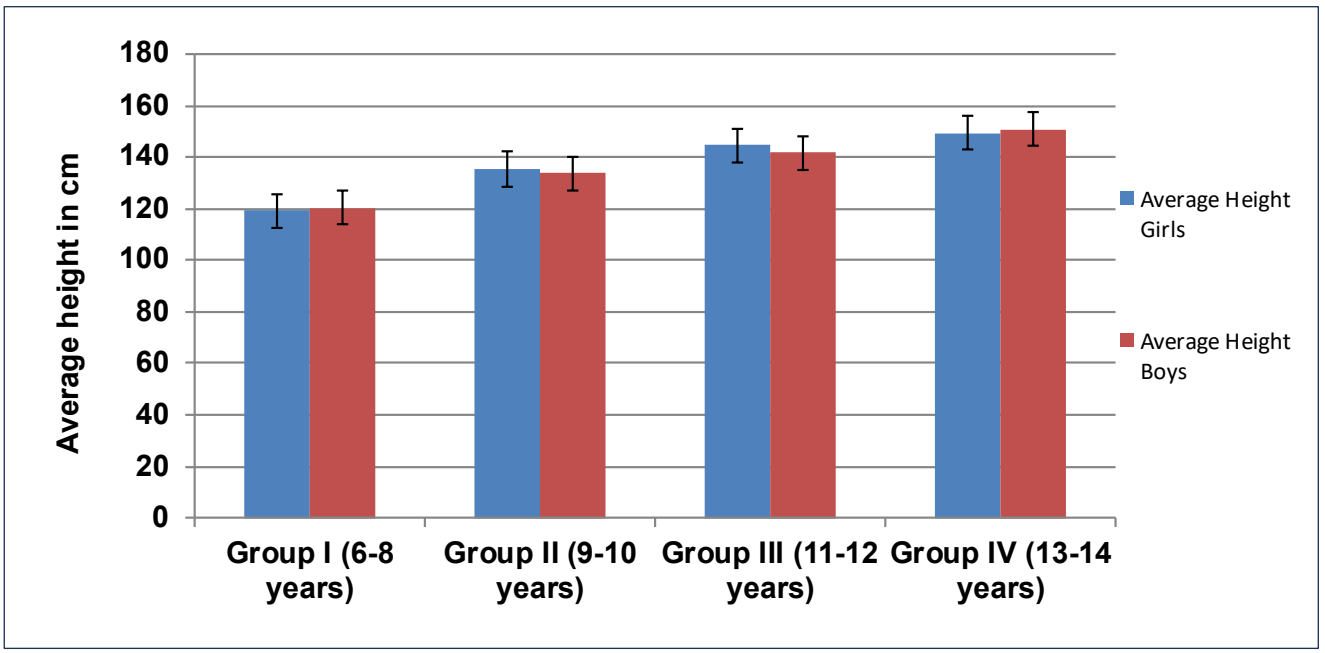

Figure 2: Graph showing comparative values of average height of females and males among four age groups of children.

4. DISCUSSION

As per literature reports, CA undergoes a progressive increase reaching its maximum value during puberty[4, 5] being greater in females[5, 6, 7] and being higher on dominant side[3, 6], yet some do not encountered such relationships[2, 4, 8]. Literature is full of such contradictory reports, some showing CA to be directly related with height, weight or length of the ulna or humerus, while others stating CA to be non-correlated with such variables. Reports suggest that CA and range of movement at elbow joint increases with age until puberty or age of 15 or 16 years followed by a slight decrease in this angle as by puberty skeletal maturity is attained and stabilized[4, 5, 7]. They have also suggested that CA increment rate per year is 0.42° in boys and 0.60° in girls[5].

Different accounts appear for CA being associated with height of person in literature. Sharma et al.,[14] while their study (532 children; aged 5-15 years) recorded for positive correlation of height of the individual with CA left while negative correlation of height of an individual with CA right. Others have reported for greater CA in shorter people[4, 12]. They have explained it by saying that shorter person has shorter lever arm and so for carrying out routine work, the hand is required to be in pronated position which requires more angulations of proximal end. To achieve this, the medial part of trochlear notch of ulna retreats from the medial flange of trochlea resulting in greater CA in shorter people. CA of dominant and non-dominant limb in females is directly proportional to height of person while in males, the CA of dominant limb was inversely proportional and that of non-dominant limb was directly proportional to height[14]. No correlation of CA with height or weight, humeral or ulnar length was reported by Balasubramanian et al.,[5]. Sharma and Siddiqui[11] have showed height and length of forearm to be higher in males than females while average CA was more in females as compared with males, thus reporting a significant negative correlation between CA and height and length of forearm.

In the current study, we found a direct correlation between CA and height and age. As age increases, height also increased irrespective of gender. Similarly, CA was also seen to increase with increasing height (as age progressed), being significantly more obvious in dominant limb than non-dominant, both in girls and boys. Greater CA in dominant limb can be attributed to more stress applied due to developmental changes and greater use of dominant limb by the growing child. Apparently present is the only study till date showing gradual CA increase with advancing height according to age in children (6-14 years) undergoing active skeletal growth and maturation period.

5. CONCLUSION

In the present study, we found a direct correlation between CA and height and age. As age increases, height also increased, similarly CA was also seen to increase with increasing height, being significantly more obvious in dominant limb than non-dominant, irrespective of gender. Moreover, CA was greater in girls than boys. These findings would add to the baseline reference values for different age groups and help understand the evolution with gradual skeletal growth as age increases. Moreover, it would support orthopaedic surgeons in correction of traumatic paediatric elbow displacements, injuries and fractures that require reconstruction.

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