

## Comparative Study of Carrying Angle Between Dominant and Non-Dominant Limbs in Central Indian Paediatric Population

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### ABSTRACT

**Introduction** –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 formation of an angle between the long axis of the arm and the long axis of forearm, which is referred to as the carrying angle (CA) of the elbow. The evidence in literature falls short when comparing sexual dimorphism regarding CA and comparing dominant with non-dominant hand. Thus, the present study aimed at measuring the CA between dominant and non-dominant limb in both girls and boys.

**Material And Methods** – CA was measured in 504 paediatric school going children of both sexes using a manual goniometer. All the subjects were categorised into four separate groups according to age (Group I – 6-8 years; Group II – 9-10 years; Group III – 11-12 years; Group IV – 13-14 years) and the observations were recorded accordingly. Statistical calculations, Student's t-test, were done using Prism software.

**Result-** Present study showed significant difference in CA between dominant and non-dominant limb in both the sexes and in all the four groups.

**Conclusion** – The result of our study could be useful in gaining more insight in measurement of carrying angle and its variation between dominant and non-dominant limb while evaluating traumatic elbow injuries in childhood and adolescence and other elbow disorders requiring reconstruction or arthroplasties..

**Keywords:** *Carrying angle, dominant limb, non-dominant limb, goniometer*

### 1. INTRODUCTION

The humerus in the upper arm and the radius and ulna in the forearm together form the elbow joint. This joint allows the movement of the hand towards and away from the body, and also allows the forearm for its powerful grasping and fine motor motions of the hand<sup>1</sup>. 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. The carrying angle may also be defined as the acute angle made by the median axis of the arm and that of fully extended and supinated forearm and thus measuring the lateral obliquity of the forearm.

The carrying angle (CA) was first described in 1879 by anatomists Braune and Kyrklund<sup>2</sup> who studied 11 anatomical preparations and reported for average CA to be 166.64°, while von Mikulicz<sup>3</sup> (in the same year) studied 20 upper limbs of

cadavers and reported for mean CA to be  $164^\circ$  with a range of  $157^\circ$ - $178^\circ$ <sup>4</sup>. CA can generally be considered as a secondary sexual characteristic since it is generally observed to be greater in females ( $10^\circ$ - $15^\circ$ ) than in males ( $5^\circ$ - $10^\circ$ )<sup>5</sup>. The various natural forces acting upon the elbow of dominant and non-dominant arm also influence this angle<sup>4</sup>. Moreover, developmental, ageing and racial influences possibly add towards variability observed<sup>6, 7</sup>. Moreover, it is in addition reported to be greater in the dominant arm; thus, forming its study a long-debated issue among researchers in Anatomy and Anthropometry. This can furthermore be accounted on non-significant differences reported by some researchers in CA of females and males<sup>8</sup>.

Several workers have investigated the connection between CA and age, sex, dominant side, height, race etc.,<sup>9, 10, 11</sup> but reports involving such studies on paediatric population remain scanty. Therefore, we aim to study the carrying angle and its comparison between dominant and non-dominant limb 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. The subject study was conducted on 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 (girls and boys) well within the age range 6 – 14 years were only involved (Age was verified from school documents). Subjects 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 subjects nationalities, age, gender, height and dominant side were recorded on a specific investigation paper 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. At the elbow, the arms of the goniometer were kept in straight line and the goniometer's axis placed at fulcrum (midline of elbow joint). The fixed arm of the goniometer was aligned with the middle of the subject's upper arm. The movable arm of the goniometer was moved along until it lined up along the middle of subject's forearm. These measurements were done for both dominant and the 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  $\pm$  SD). Variations amid dominant and non-dominant limbs 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; Graph 1).

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

Similar outcomes were recorded for other groups too. In group II involving volunteers aged 9-10 years, females showed more CA in dominant limb ( $8.589412^\circ \pm 2.856315$ ) which was significantly higher than non-dominant limb ( $6.98^\circ \pm 2.306407$ ) ( $p = 0.0068$ ). For boys, again the CA was significantly greater in dominant limb ( $8.0122595^\circ \pm 2.472095$ ) than in non-dominant one ( $6.611298^\circ \pm 2.486994$ ) ( $p = 0.0068$ ).

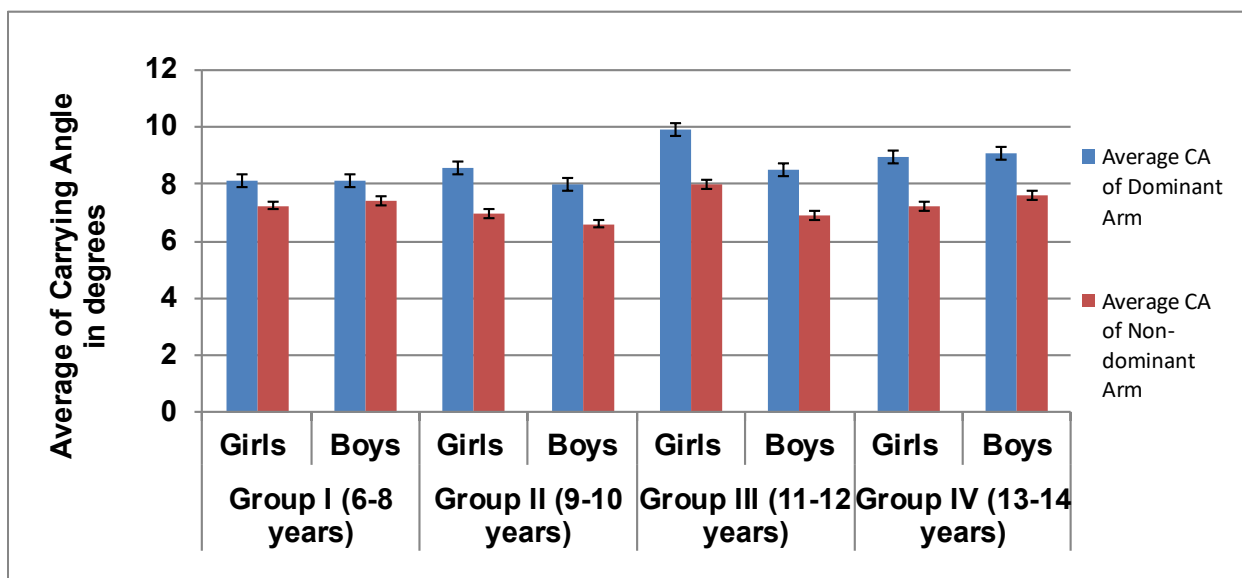
In group III comprising of participants aged 11-12 years, the CA in dominant arm of females was significantly greater ( $9.9210285^\circ \pm 2.829533$ ) than in non-dominant arm ( $7.985803^\circ \pm 2.740184$ ) ( $p = 0.0015$ ). Similarly, in males, the CA was

significantly greater in dominant arm ( $8.503876^\circ \pm 2.403146$ ) than in non-dominant arm ( $6.9050385^\circ \pm 2.520486$ ) ( $p = 0.0015$ ).

In group IV encompassing 13-14 years pupils, significantly higher CA was recorded in dominant limb ( $8.9833335^\circ \pm 2.912424$ ) than non-dominant limb ( $7.2416665^\circ \pm 2.425979$ ) ( $p = 0.0101$ ) of females. Likewise, males also showed higher CA in dominant limb ( $9.08^\circ \pm 2.662786$ ) than non-dominant limb ( $7.6144445^\circ \pm 2.926184$ ) ( $p = 0.0101$ ).

Age Groups	Sex	Average CA of Dominant Arm (degrees) (mean $\pm$ SD)	Average CA of Non-Dominant Arm (degrees) (mean $\pm$ SD)	P value	Significance
Group I (6-8 years)	Girls (n= 19)	8.108974 $\pm$ 2.462586	7.2564105 $\pm$ 2.412201	0.0158	Significant
	Boys (n=61)	8.1069445 $\pm$ 1.841239782	7.434722 $\pm$ 2.529066006		
Group II (9-10 years)	Girls (n=42)	8.589412 $\pm$ 2.856315	6.98 $\pm$ 2.306407	0.0068	Significant
	Boys (n=100)	8.0122595 $\pm$ 2.472095	6.611298 $\pm$ 2.486994		
Group III (11-12 years)	Girls (n=72)	9.9210285 $\pm$ 2.824533	7.985803 $\pm$ 2.740184	0.0015	Significant
	Boys (n=116)	8.503876 $\pm$ 2.403146	6.9050385 $\pm$ 2.520486		
Group IV (13-14 years)	Girls (n=23)	8.9833335 $\pm$ 2.912424	7.2416665 $\pm$ 2.425979	0.0101	Significant
	Boys (n=71)	9.08 $\pm$ 2.662786	7.6144445 $\pm$ 2.926184		

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



Graph 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.

#### 4. DISCUSSION

Carrying angle (CA) is the measurement of lateral obliquity of the forearm positioned in fully extended and supinated condition and comes out to be approximately  $11^\circ$  in men and  $14^\circ$  in women ( $170^\circ - 175^\circ$  in males and  $165^\circ - 167^\circ$  in females)<sup>12, 13</sup>. As a generalised finding and reporting in literature, CA is manifested to be affected by natural forces, developmental changes, age advancements and stress applied, and comes out to be greater in dominant limb as compared with non-dominant, irrespective of gender differences<sup>14, 15</sup>. Still some show no such differences being greater in Dominant limb<sup>16</sup> or being greater in non-dominant limb than dominant in children<sup>15</sup>. Moreover an incidental yet interesting fact regarding equal CA in both right and left limb in 3 participants (using both hands equally) is reported by Vichard et al., (2014)<sup>17</sup>. As per literature reports, CA undergoes a progressive increase reaching its maximum value during puberty<sup>11, 18</sup> being greater in females<sup>18, 19, 20</sup> and being higher on dominant side<sup>4, 20</sup>, yet some do not encountered such relationships<sup>8, 11, 20</sup>. 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<sup>11, 18, 19</sup>. They have also suggested that CA increment rate per year is  $0.42^\circ$  in boys and  $0.60^\circ$  in girls<sup>18</sup>.

In present study we report significantly greater CA in dominant limb than non-dominant limb irrespective of gender. This can be attributed to more stress applied due to developmental changes and greater use of dominant limb. Greater CA was reported in females unlike males but we did not tried to find out its sexually dimorphic correlation as our main study target was to determine dominant versus non-dominant limb. Moreover, our age group was 6-14 years, where usually fewer variations appear between boys and girls until attaining 10 years of age when some changes start to appear due to early onset of puberty in certain children.

#### 5. CONCLUSION

In this study CA was observed to be significantly more in dominant limb than non-dominant limb in both males and females. CA is shown to be affected by natural forces, developmental changes and stress applied, and comes out to be greater in dominant limb (more used and stressed) as compared with non-dominant, irrespective of gender differences. Present study would add to the reference values of CA contributing to the literature statistics which would assist orthopaedic surgeons in managing elbow fractures, restoration, reconstructions, etc. in childhood and adolescence

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