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Comparative Study of Carrying Angle Among Athletes in Selected Sports and Non-athletes in South-South and South-East Nigeria.

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ABSTRACT
The study was carried out to compare the carrying angle of athletes in selected sports and non-athletes in South-South and South-East Nigeria, from age 22 to 36years old. Measurements were done using universal goniometer and flexible curve. A total of four hundred and seventy-two (472) males (140 non-athletes and 136 athletes) and female (115 non-athletes and 81 athletes) subjects were selected from South-South and South-East Nigeria using a purposive sampling technique for athletes and simple random sampling for non-athletes. Themean value and standard deviation of rightcarrying angle (RCA) for male is 11.00±2.46^0 for non-athletes and 11.79±2.44^0 for athletes while that of the female is 14.12±2.83^0 for non-athletes and 16.11±2.67^0 for athletes at $p < 0.001$. The mean value and standard deviation of left carrying angle (RCA) is 9.66±2.28^0 for male non-athletes and 9.89±2.28^0 for male athletes while that of the female is 12.47±2.59^0 for non-athletes and 13.39±1.95^0 for athletes at $p < 0.001$. Statistical analysis using T-test showed that the carrying angle is significantly higher in athletes (male and female) than in non-athletes at $p<0.001$ indicating changes in the alignment of anatomical structure due to sporting activities. The carrying angle is also significantly higher in females than in males at $p<0.001$ which indicates sexual dimorphism. The knowledge of these values is important because normal values of carrying angles are useful parameters in clinical anatomy, evaluation, repair and counselling in sports.

Key Words: Carrying angle, athletes and non-athletes.

INTRODUCTION
The anatomical description of the human body is about standing erect and facing forward with the upper limbs by the sides and the palms facing forward while the lower limbs together with the toes faces forward [(1)]. This is achieved by the structure and shapes of the bones, especially the long bones of the upper and lower limbs. The lengthy symmetry of the fully extended ulna forms an angle of about 170^0 with the long axis of the humerus. This bony arrangement brought about the formation of the carrying angle. The name carrying angle was coined based on the way the forearm is angled laterally from the body when carrying loads and this angle can be disrupted during pronation of the forearm [(2)]. The carrying angle of the elbow is one of the features that distinguished man and apes from other primates. In apes, it evolved as a result of the need to bring the gravitational force acting on the body, beneath the supporting hand during suspensory movement to the centre as seen in the lower limbs of humans, in which the valgus knees bring the feet nearer to the centre of the body [(3)].

The carrying angle is formed by the long axis of the humerus and the long axis of the ulna, this angle varies between sexes, ages, races and can also show morphological changes [(4,5)]. The carrying angle of the elbow is therefore defined as the angle formed by the long axis of the arm and the long axis of the forearm in the frontal plane when the elbow is fully extended and the forearm is supinated [(6)]. Studies have shown that the carrying angle develops apparently in response to pronation of the forearm, thereby keeping the swinging upper extremity away from the side of the pelvis during walking [(7)]. During flexion and extension at the elbow joint, the long axis of the fully extended ulna makes an angle of approximately 170° with the long axis of the humerus [(8)]. The carrying angle helps the arms to swing without hitting the hips while walking and it is normally 5-15^o away from the body or 165-175^o towards the body and anatomically, the carrying angle in human adults is approximately 10° in men and 13° in women [(9)]. This is as a result of the broad shoulders and narrow hips of the males which allow the arms to hang straight downwards with the long axis of the upper and lower arm segment approximately in the same straight line while in the females, the narrow shoulders and broader hips require a spraying out of the forearm axis in order that the hanging arms clear the hips. This observation became the basis for the theory of "carrying angle" [(10)]. A study that was carried out on male and female subjects showed that, the carrying angle is a suitable secondary sexual

characteristic. [11].

Limb dominance influences carrying angle, with the dominant limb having a wider carrying angle compared to the non-dominant limb in both sexes, which suggests that natural forces acting on the elbow could modify the carrying angle. The carrying angle is greater in the dominant limb than in the non-dominant limb of both sexes, suggesting that natural forces like developmental factors, racial influences and aging influence the variability of the carrying angle [12].

The carrying angle was reported to be (Right = 16.9°±4.14° and Left = 14.2°±3.53°) in males and (Right=20.5°±3.82° and Left=17.5°±3.87°) in females[13]. The carrying angle is greater in females than in males as well as in dominant arm. The carrying angle is higher in females than in males and it is ethnic specific with no correlation between carrying angle and height [14]. Subsequently other researchers [15,16] have all shown the mean carrying angle to be significantly greater in females than in males as well as in dominant limb than non-dominant limb. The carrying angle is not higher in dominant limb when compared to the non-dominant limb as established by several authors [17]. Though the carrying angle is greater in females than in males but it is not proportional to the height of individual.

MATERIALS AND METHODS

A total number of 472 participants which includes 217 athletes (136 males and 81 females) and 225 non-athletes (140 males and 115 females) within the age range of 22-36years, without injury, fracture, amputation, deformity or history of any surgical procedure of the limbs were selected from South-South and South-Eastern Nigeria. The nature of study was explained to the participants individually while informed consent was sought for before carrying out the study. Ethical approval to carry out the research was granted from the Ethical Review Committee for human experimentation of the College of Graduate Studies, University of Port Harcourt. The carrying angle was measured as the participant was told to stand in anatomical position with the palms gently rotated to face forward while the forearm is fully extended and supinated. Three anatomical landmarks where used in measuring the carrying angle; the tip of the acromial process (point-1), the lateral and medial epicondyles of humerus (point-2); the styloid processes of radius and ulna (point-3). The flexible curve was used to locate the mid-point on the surface of the arm by placing it on the lateral and medial epicondyles of the humerus which was dotted using cosmetic pencil. The mid-wrist point was located by placing the flexible curve on the styloid processes of radius and ulna which was located through palpation while the cosmetic pencil was used to make a dot to show the mid-point. A full circle universal goniometer (35cm) with two long arms (stationary and mobile) was placed at the centre of the cubital crease as determined using the flexible curve. The arms of the goniometer were straightened out such that the tip of the stationary arm was directed towards the lateral edge of the acromial process and the mobile arm was directed towards the mid-point of the wrist as determined by the flexible curve such that the readout on the plate will show 0 or 180 degrees. The goniometer was adjusted until a good level of accuracy was met while the angle was read and recorded in degrees and the process was repeated.

Data analysis was carried out using SPSS (statistical package for the social sciences). The difference between the carrying angles of athletes and non-athletes were determined using independent sample t-test ($p<0.05$).

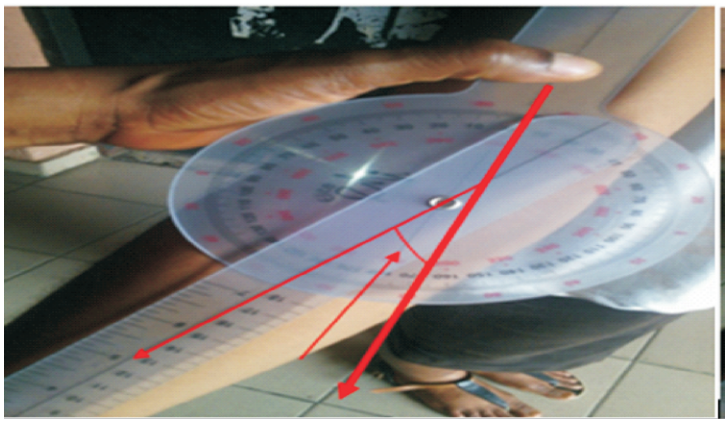

Figure 1: Measurement of the carrying

Figure 2A: Location of the mid-arm point

2B: Location of mid-wrist point

RESULTS

The distribution of the sample population by sex as presented in Figure1; a total of 472 males (140 non-athletes and 136 athletes) and female (115 non-athletes and 81 athletes) participants were involved in this study. Table 1 showed the result of the anthropometric parameters of male and female athletes and non-athletes with the mean±S.D value for the Right carrying angle (RCA) as follows; 11.00±2.460 for male non-athletes and 11.79±2.440 for male athletes while that of the females were recorded as 14.12±2.830 for female non-athletes and 16.11±2.670 for female athletes respectively. The analysis of variance of the measured parameters of the male and female non-athletes as presented in Table 2: showed that, there was a significant difference ($p<0.001$) in the mean±S.D carrying angle between the male (11.79±2.440 for RCA and 9.89±2.280 for LCA) and female (14.12±2.830 for the RCA and 12.47±2.590 for the LCA) non-athletes. Table 3: shows the analysis of variance of the right and left carrying angles of male and female athletes. The result showed that there was a significant difference ($p<0.001$) in the mean±S.D carrying angle between the male (11.00±2.460 for RCA and 9.66±2.280 for LCA) and female (16.11±2.670 for the RCA and 13.39±1.950 for the LCA) athletes.

Table 1: Anthropometric parameters of male and female athletes and non-athletes

Parameters	Male								Female							
	Non-athlete [N=140]				Athlete[N=136]				Non-athlete [N=115]				Athlete [N=81]			
	Mean	S.D	Min	Max	Mean	S.D	Min	Max	Mean	S.D	Min	Max	Mean	S.D	Min	Max
Age (yrs)	26.19	3.98	19.00	39.00	25.10	3.59	22.00	36.00	26.30	4.02	19.00	38.00	25.00	2.66	22.00	33.00
RCA (^{0})	11.00	2.46	6.00	20.00	11.79	2.44	6.00	18.00	14.12	2.83	9.00	24.00	16.11	2.67	8.00	24.00
LCA (^{0})	9.66	2.28	5.00	16.10	9.89	2.28	5.00	16.10	12.47	2.59	7.00	18.00	13.39	1.95	9.00	22.00

Note: RA-L=Right arm length, LA-L=Left arm length, RFA-L=Right forearm length, LFA-L=Left forearm length, RCA=Right carrying angle, LCA=Left carrying angle, SW=Shoulder width, AS=Arm Span
N=distribution, S.D=Standard deviation, Min=Minimum, Max=Maximum

Table 2: Analysis of variance of measured parameters of male and female non-athletes

Parameter	Comparison	SS	df	F-value	P-value	Inf.
Right carrying angle	M vs F	310.03	1	40.48	<0.001	***S***
Left carrying angle	M vs F	420.04	1	71.61	<0.001	***S***

M=Male, F=Female, SS=Sum of Squares, df=degree of freedom, F-value=Fisher's value, P-value=Probability value, Inf.=Inference (S=Significant, NS=Not significant).

Table 3: Analysis of variance of measured parameters of male and female athletes

Parameter	Comparison	SS	Df	F-value	P-value	Inf.
Right carrying angle	M vs F	479.802	1	52.81	<0.001	S
Left carrying angle	M vs F	286.440	1	41.75	<0.001	S

M=Male, F=Female, SS=Sum of Squares, df=degree of freedom, F-value=Fisher's value, P-value=Probability value, Inf.=Inference (S=Significant, NS=Not significant).

DISCUSSION

In our study the mean values for the right and left carrying angles are significantly higher in females (athletes and non-athletes) than in males (athletes and non-athletes), which shows the existence of sex differences. This is in agreement with the findings by other researchers[18] on determination of sex and age using carrying angle among Shiraz population of Iran, [19] on the radiographic study of the CA in Southern Nigeria, [17] on differences in the carrying angle with respect to age, gender and stature, [16] on the radiographic examination of carrying angle to goniometric examination of carrying angle among Saharanpur population, [20] on the examination of the elbow structure with regards to the carrying angle among South Indian population, [21] in his evaluation of carrying angle in adult Nigerian population,[22] on the radiographic evolution of carrying angle of the elbow joint of different age groups that are free from any fractures and musculoskeletal deformities and nutritional disorder, [15] on the anthropometry of the elbow carrying angle in young adults of different ethnic groups of Malaysia, [23] on the comparative evaluation of carrying angle clinically based on sexual differences among male and female Indian population, [24]on carrying angle and its relationship with sex, upper limb dormancy and non-dormancy in Rajesh population.

The higher carrying angle in females is regarded as secondary sex characteristic which is influenced by higher secretion of female hormones like oestrogen which stimulates the development of female secondary characteristics at puberty. It can also be as a result of the impact of body mass index which can cause deviation from the developmentally aligned carrying angle [25]. Wider pelvis in females may result in a greater lateral deviation of the forearm thereby increasing the carrying angle [5].

Comparison of carrying angles of female non-athletes and athletes

The mean values for the right elbow carrying angle of females in female athletes were significantly higher compared to the right elbow carrying angle of female non-athletes. The mean values of the left elbow carrying angle of female athletes showed no significant difference with that of female non-athletes. This is in agreement with the studies carried out by various researchers who gave similar report on the difference in carrying angles based on limb dominance [24, 26, 13, 21, 27].

When comparing the result gotten from the present study to the report by [28] in his study on the carrying angle of the elbow in the upper extremities of male athletes in relation to other variables in Iranian population. They reported lower values for the carrying angles of athletes and non-athletes. [14]On comparing the carrying angle between two ethnic groups, Ibo and Yoruba in Nigeria and its correlation with Height of subjects, gave higher values of elbow carrying angles mainly for the Yoruba ethnic group (non-athletes). [18]Reported low values for elbow carrying angle with respect to sex and age determination among non-athletes of Shiraz population.

The difference in values could be as a result of variation in populations studied and also the biomechanical impact of sports on the alignment of anatomical structure [28]. It could also be as a result of dominant upper limb as the elbow carrying angle has been reported to increase due to limb dominancy [27]. Age can also lead to variation in elbow carrying angle due to bone growth and ossification as carrying angle has been reported to increase with age [18].

In conclusion, measurement of carrying angle is very important for studies on population variation, influence of biomechanical activities on anatomical alignment of joint, orthopaedic surgery, manufacturing of elbow prosthesis, forensic science and sports anatomy as its

importance in sports medicine will help in recognizing young athletes at risk for overuse injuries due to increased biomechanical work load and also help in diagnosis, repair and counselling in sports.

This research work has established the mean values for carrying angle among athletes in selected sports and non-athletes in South-South and South-Eastern Nigeria. Normal values of these parameters can be used by clinicians as reference values in the evaluation, repair and counselling in sports.

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