Measurement of the Carrying Angle in Jordanians with Respect to Different Body Parameters

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Abstract

The carrying angle is defined as the angle made by the long axes of the arm and fore arm in the coronal plane when the forearm is fully extended and supinated. This angle is important in the management of fractures and surgeries that occur around the elbow joint. The present study aimed to investigate the carrying angle variations in a Jordanian population with respect to several body parameters including age, sex, height, weight, and dominant side. The study included students and employees from the Jordan University of Science and Technology and younger students from elementary public schools in Jordan. The supplementary carrying angles (SCAs) of these volunteers were measured using a universal manual goniometer. SCA is the acute angle that complement carrying angle to 180°. The results indicate that SCA increased significantly after 10 years of age. The SCA was greater in Jordanian women than in the men. However, no variation in SCA was found with respect to height and weight in the Jordanians. Furthermore, the SCA was significantly greater in the dominant side. In conclusion, age, sex, and handedness were important factors that influenced the carrying angle in our Jordanian study samples. However, height and weight did not seem to have any influence on the values in our study.

Keywords: Dominant side, Elbow, Jordan, Supplementary carrying angle.

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Introduction

The carrying angle (CA) of the human elbow joint is defined as the angle formed by the long axes of the upper arm and forearm in the coronal plane.[1] It is also referred to as the obliquity between the upper arm and the supinated forearm when the elbow is fully extended.[2] This angle is most apparent when carrying an object with a fully extended and supinated forearm. The CA is considered important in determining the pathogenesis of different kinds of fractures that occur around the elbow joint and in the assessment of deformities that may result after treatment of distal humerus fractures.[3,4]

Previous studies in different populations related the CA with different parameters such as age, sex, height, weight, and

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handedness.[1,3,5,6] The CA was found to become more prominent with age in a Turkish population.[1,3] In addition, a greater deviation of the CA was reported in females than in males within Indian and Turkish populations.[1,7]

Among Indian people, short persons were indicated to have a more prominent CA than tall ones.[5]Moreover, a greater lateral deviation of the elbow was recorded in obese people than in slender ones of Greek origin.[6]The CA of the dominant side arm was found to be more deviated than the non dominant side arm in both sexes of Greek and Turkish populations.[1,6]

Considering that CA may vary significantly among different ethnicities, this work specifically aimed to study the CA in a Jordanian population. It aimed to investigate the variation in CA with age, sex, and other physical characteristics in Jordanians. Similar to the previous studies and for ease of description, we examined the supplementary CA (SCA), which is the acute angle between the longitudinal axes of the arm and forearm, in this study.[1,3,4,6]

Materials and Methods

Study Sample

This study included volunteer students and employees from the Jordan University of Science and Technology (JUST) and younger students from elementary public schools in Jordan. Individuals with a history of trauma, fractures, or dislocation in the upper limbs were excluded from the study. The SCA measurements were performed on the dominant and non dominant sides for each volunteer. The total study sample consisted of 1223 Jordanian individuals with ages ranging from7 to 35 years. Among the study subjects, 767 were females and 456 were males.

Measurement Procedure

The measurement procedure was performed with the approval of the Review Committee for Research on Humans at JUST. The measurements in the elementary public schools were conducted with the approval of the Ministry of Education/Jordan and Irbid Second Directorate of Education.

A specific survey sheet was prepared to record the required information and measurements for each volunteer. The sheet included information about each volunteer's nationality, sex, age, height, weight, and dominant side. The participants were asked gently whether they would like to volunteer for the study, and the full details of the measurement method using the survey sheet was explained to them. After completing the survey sheet, the measurements were obtained using a universal manual goniometer made of clear plastic.

The SCA measurement was performed using the method described by Amis and Miller[8] and applied by previous researchers.[1,4] In brief, the upper limb was placed in a fully extended and supinated position. The hinge of the goniometer was located in the center of the cubital fossa, and the goniometer arms were adjusted to become parallel to the long axes of the arm and forearm (Figure 1). Both sides were measured for each individual. Each side was measured 3 times, and the mean value of the angle was calculated. After congregating the requested information and measurements, the data were transferred into a computer to perform the required statistical analysis.

Statistical analysis

After applying the Levene test to determine

the homogeneity of variance, the data were evaluated by one-way analysis of variance (ANOVA) or independent samples *t*-test at 5% and 1% levels of significance. The Scheffe *post hoc* analysis test was performed, when needed, to examine statistical differences between the groups. The data were presented as mean ± standard error of the mean (SEM).

Table 1. Measurements of the supplementary carrying angle (SCA) with respect to height in the adult Jordanian men

Height interval (cm)	Right SCA	Left SCA
160–169	13.2 ± 0.33	10.5 ± 0.41
170–179	12.9 ± 0.24	10.6 ± 0.25
180–189	12.9 ± 0.35	10.6 ± 0.40
190–199	11.7 ± 0.17	10.0 ± 1.05

The data represent mean SCA ± standard error of the mean (SEM) values. The measurements were performed for 351 adult Jordanian men between 18 and 30 years of age. No significant SCA variation with height was observed.

Table 2. Measurements of the supplementary carrying angle (SCA) with respect to height in the adult Jordanian women

Height interval (cm)	Right SCA	Left SCA
150–159	16.6 ± 0.28	14.8 ± 0.71
160–169	17.2 ± 0.24	14.6 ± 0.23
170–179	17.4 ± 0.63	15.4 ± 0.56

The data represent mean SCA ± standard error of the mean (SEM) values. Measurements were performed for 496 adult Jordanian women between 18 and 30 years of age. No significant SCA variation with height was observed.

Results

Variation in CA with age

The Jordanian volunteers were distributed over 3 different age groups as follows: up to10 years of age (n = 216), 11–20 years of age (n = 563), and 21–30 years of age(n = 429). Right (P<0.01) and left (P<0.05) SCAs were significantly increased after the first 10 years of age. However, no significant difference was observed between the remaining groups (Figure 2).

Variation in CA with sex

The Jordanian volunteers were divided according to sex as follows: male (n = 456) and female groups (n = 767).The SCA in both sides was significantly (P<0.01) greater in the female subjects than in the male subjects, indicating that the CA was more prominent in

the female subjects than in the male subjects. The mean SCA ± SEM in the female subjects was 16.6°± 0.14 in the right side and 14.5°± 0.23 in the left side, where as that in the male subjects was 13.0°± 0.15 in the right side and 10.8°± 0.16 in the left side (Figure 3).

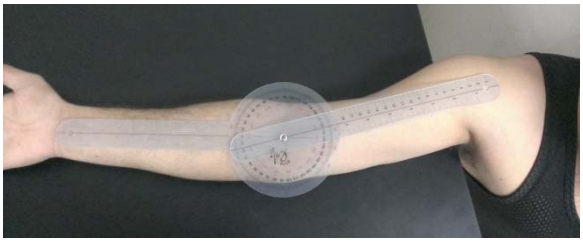

Figure 1. Measurement of the supplementary carrying angle using a standard universal goniometer

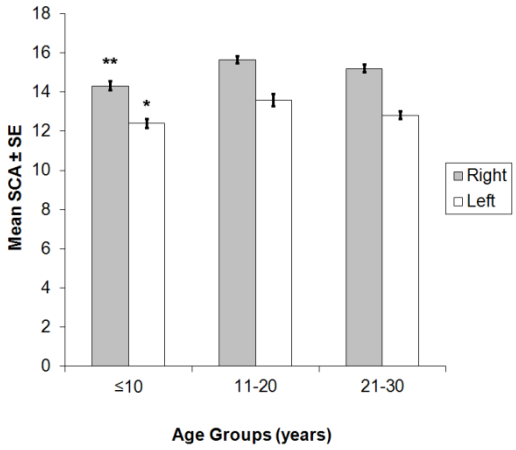

Figure 2. Variation of the carrying angle with age in Jordanians. Each column represents the mean supplementary carrying angle (SCA) ± standard error of the mean (SE). **P<0.01, *P<0.05 (ANOVA)

Variation in CA with height

A sample of 847 adult Jordanians aged between 18 and 30 years was divided according to sex as follows: male: 351 and female: 496. Each category was studied separately to determine the variation in CA with height. The male subjects were divided into 4 groups according to their heights (Table 1). Each group included a height interval of 10cm.No significant (P>0.05) variation in SCA with height was observed in both sides of the male subjects (Table 1). The female subjects were divided into 3 groups according to their heights, with each group consisting of a 10-cm interval. No significant (P>0.05) variation in SCA with height was observed in both sides of the female subjects (Table 2).

Variation in CA with weight

A sample of 846 adult Jordanians aged between 18 and 30 years was divided according to sex: male, 340 and female, 506. Each category was studied separately to determine the variation in SCA with weight. The male subjects were divided into 5 groups on the basis of their weights. Each group

included a weight interval of 10 kg. No significant (P>0.05) variation in SCA with weight was observed in both sides of the male subjects (Table 3). The female subjects were also divided into 5 groups according to their weights, with each group including a weight interval of 10 kg. No significant (P>0.05) variation in SCA with weight was observed in both sides of the female subjects (Table 4).

Table 3. Measurements of the supplementary carrying angle (SCA) with respect to weight in the adult Jordanian men

Weight Interval (kg)	Right SCA	Left SCA
50–59	14.0 ± 0.56	11.7 ± 0.76
60–69	13.6 ± 0.30	11.1 ± 0.31
70–79	12.6 ± 0.28	10.5 ± 0.36
80–89	12.5 ± 0.48	10.4 ± 0.47
90–99	12.4 ± 0.47	9.4 ± 0.41

The data represent mean SCA ± standard error of the mean (SEM) values. Measurements were performed for 340 adult Jordanian men between 18 and 30 years of age. No significant SCA variation with weight was observed.

Table 4. Measurements of the supplementary carrying angle (SCA) with respect to weight in the adult Jordanian women

Weight Interval (kg)	Right SCA	Left SCA
40–49	16.9 ± 0.49	14.1 ± 0.43
50–59	17.1 ± 0.26	15.2 ± 0.52
60–69	17.2 ± 0.31	14.4 ± 0.30
70–79	16.3 ± 0.75	14.2 ± 0.68
80–89	18.0 ± 0.18	16.4 ± 1.19

The data represent mean SCA ± standard error of the mean (SEM) values. Measurements were performed for 506 adult Jordanian women between 18 and 30 years of age. No significant SCA variation with weight was observed.

Variation in CA with the dominant side

The SCA was measured in a sample of 854 right-hand dominant Jordanian volunteers. The right SCA was significantly (P<0.01) greater than the left SCA in these volunteers. The mean SCA ± SE was 15.4° ± 0.14 in the right side and 12.9° ± 0.19 in the left side (Figure 4A).

In addition, the SCA was measured in another sample of 65Jordanian volunteers with left-hand dominance. The left SCA was significantly (P<0.01) greater than the right SCA. The mean SCA ± SE was 16.3° ± 0.59 in the left side and 13.9° ± 0.48in the right side (Figure 4B).

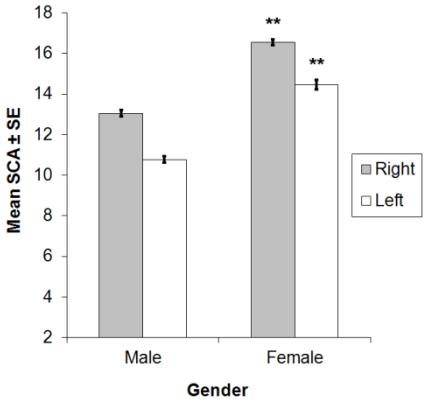

Figure 3. Variation of the carrying angle with sex in adult Jordanians. Each column represents the mean supplementary carrying angle (SCA) ± standard error of the mean (SE). **P<0.01 (*t*-test)

Discussion

To the best of our knowledge, this is the first study to provide information about CA measurements in a Jordanian population. It provides new knowledge about the CA and its relation to several body parameters in Jordanians. Its results were in agreement with results reported earlier in different populations regarding the variation in CA with age, sex, and dominant side.[1,3,6] However, we found that the CA does not differ significantly with regard to height and weight in Jordanians.

The present study demonstrated an increase in the SCA with age in our Jordanian population. Similar results were reported in a Turkish population.[1,3] The statistical analysis revealed that the difference in our sample was between children in the first 10 years of age and older individuals. This could, probably, be due to the rapid growth and development of the muscles around the elbow joint during this period. The CA of the forearm was suggested to be formed via the action of 2 powerful muscles, namely the brachioradialis and extensor carpi radialis longus.[6]The stronger the muscles, the greater the lateral deviation of the elbow. This explains why adults have a more prominent CA than children.

We found that the SCA was greater in the female subjects than in the male subjects within our Jordanian sample. It is well established in the literature that the CA is more prominent in women than men.[1,2,6,9] Tükenmez et al.[3] found that the SCA is greater in girls than in boys at the age of 6 years, but at the age of 14 years, this difference was not significant. We found that the SCA difference between the male and female subjects was 3.6° in the right side and 3.7° in the left side. Atkinson and Elftman[10] studied the possibility of considering the CA as a secondary sex character. They reported a significant

difference of 1.8° between the male and female subjects in their study sample. However, this difference was not enough to be of practical value as a secondary sex character.

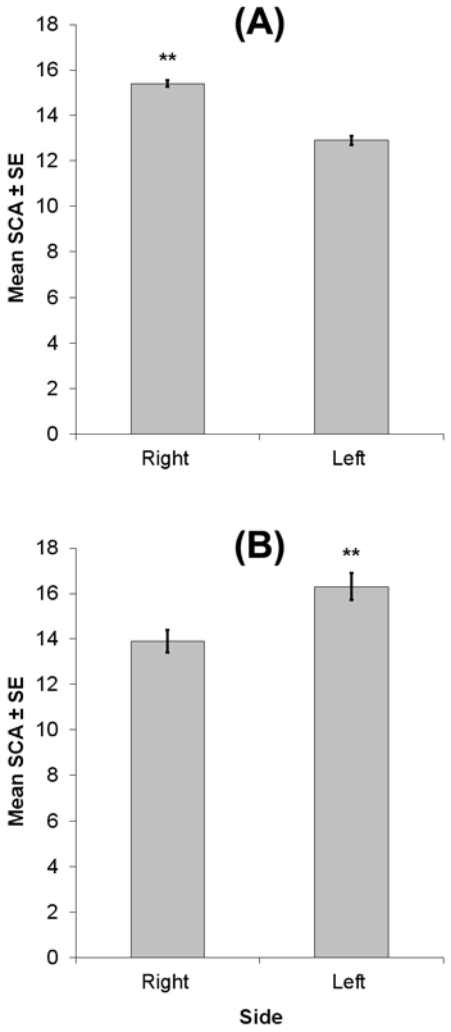

Figure 4. Variation of the carrying angle with dominant side in adult Jordanians.(A) right side dominant Jordanian volunteers, (B) left side dominant Jordanian volunteers. Each column represents the mean supplementary carrying angle (SCA) ± standard error of the mean (SE). *****P*<0.01 (*t*-test)

It was hypothesized previously that the more prominent CA in women is developed as a response to the broader pelvis than that in men to help keep the forearm away from the side of the pelvis as the upper limb swings during walking.[11]However, this hypothesis was refuted later on.[5] The reason to disclaim this hypothesis is that the forearm is pronated and slightly flexed during walking. The CA is formed only when the forearm is fully extended and supinated, and disappears in pronation and flexion of the forearm.[4]

There are 2 hypotheses to explain why the CA is more prominent in women than in men. The first hypothesis is related to the hormonal factor, which may influence the value of the

CA in women.[6,7] The second hypothesis is related to genetic factors. Many clinical observations reported that women with an XO genetic defect (Turner's syndrome) have greater CA than normal ones, whereas those with an abnormal increase in the number of X or Y chromosomes usually have lesser CA.[12]

We did not find any relation between the CA and the height or weight in both sexes among our study subjects. A similar trend in CA variation with height and weight was reported by Balasubramanian et al.[7] in a South Indian population. Khare et al.[5] claimed an inverse relationship between the CA and the height of a person. However, they did not present any data or statistical information to support their findings.

The SCA was significantly greater in the dominant side of both sexes among our Jordanian study population. This finding corroborates the previous reports in the literature that the CA is more prominent in the dominant side.[1,3,6] The muscle theory discussed earlier supports that the CA is more obvious in the dominant side.[6] This is because the dominant side of a person has stronger muscles than the non dominant side

In conclusion, this study demonstrated that age, sex, and dominant side are important factors that affect the value of the CA in our Jordanian study population. Moreover, it demonstrated that height and weight did not have a critical role in influencing the CA among the Jordanians in our study. Further studies are in progress to investigate the variation in CA with respect to ethnicity and intercondylar distance of the humerus.

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قياس زاوية الحمل لدى الأردنيين

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الملخص

يعد مفصل المرفق البشري ذا أهمية كبرى في حركة الطرف العلوي من الهيكل العظمي بشكل عام، والساعد بشكل خاص. يتشكل هذا المفصل من ارتباط عظم العضد الموجود في الذراع مع عظمتي الكعبرة والزند الموجودتين في الساعد. يحمل الجزء السفلي من العضد سطحين مفصليين ناعمين: الوابلة وحشياً، والبكرة أنسيا. تقع البكرة قاصياً بالنسبة للوابلة، ويمتد جزؤها الأنسي إلى أسفل، مما يجعل سطح التمفصل العضدي مائلاً إلى الخارج، وهذا يفسّر وجود زاوية الحمل التي تمثل مقدار الانحراف الوحشي للساعد عن الذراع. سمّيت هذه الزاوية (زاوية الحمل) لأنها تظهر بوضوح أكثر عند حمل الأوزان المختلفة باليد. تعد هذه الزاوية مهمة جدا في مجال التقييم الطبي، حيث إن لها علاقة في قياس درجة الكسور في الطرف العلوي للهيكل العظمي، وكذلك في تشخيص بعض أمراض العظام التي قد تصيب منطقة العضد والساعد.

تعد هذه الدراسة الأولى من نوعها في الأردن، وقد هدفت إلى قياس الاختلافات في زاوية الحمل لدى المجتمع الأردني فيما يتعلق بالعديد من العوامل الجسدية بما في ذلك السن، والجنس، والطول، والوزن، والجانب المهيمن. شملت الدراسة 1223 متطوعا معظمهم من طلاب وموظفي جامعة العلوم والتكنولوجيا الأردنية وبعض طلبة المدارس الحكومية في الصفوف الأساسية. تم قياس الزاوية المكمّلة لزاوية الحمل لدى هؤلاء المتطوعين باستخدام مقياس زوايا يدوي خاص.

تشير النتائج إلى أن الزاوية المكمّلة زادت بشكل ملحوظ بعد 10 سنوات من العمر. وكانت أكبر في النساء، مما هي عليه في الرجال. مع ذلك، تبين عدم وجود اختلاف في هذه الزاوية فيما يتعلق بعاملي الطول والوزن عند الأردنيين. علاوة على ذلك، كانت الزاوية المكملة أكبر بكثير في الجانب المهيمن. ختاماً، لقد بيّنت هذه الدراسة بأن العمر، والجنس، والجانب المهيمن هي عوامل مؤثرة في مقدار زاوية الحمل في عيّنة الدراسة من الأردنيين. ومع ذلك، فإنّ الطول والوزن لا يبدو أن لديها أي تأثير على قيمة زاوية الحمل في عيّنتنا الدراسية.

الكلمات الدالة: زاوية الحمل، الأردنيين، الجانب المهيمن، المرفق.