The Determination of Upper Extremity Anthropometric Measurements in Healthy Subjects Aged Between 18-25 Years

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Abstract

Background: The present study was aimed to analyze the morphometric measurements of upper extremities and estimate the total body surface area, hand and palm area in healthy subjects aged between 18-25 years.

Materials and Methods: After taking hand tracing, the length and width measurements were performed, and hand-palm indexes were calculated from 407 adult subjects (243 females; 164 males) aged 18 to 25 years. Also, arm span, height and weight were measured. Additionally, total body surface area was calculated using DuBois Formula and hand and palm area was estimated from hand tracing and the percent of hand and palm surface area were formulated.

Results: In females, the mean values of age, weight, height, BMI and arm span were found as 19.68±2.42 years, 55.96±8.32 kg, 164.1±2.93 cm and 20.79±3.03 kg/m² and 1.60±0.06 m, respectively, whereas the same values were 20.22±3.40 years, 71.48±1.98 kg, 176.96±6.26 cm, 22.80±3.44 kg/m², and 1.76±0.05 m, respectively in males. Moreover, the significant difference was found between measurements such as height, weight, body mass index and arm span and gender. Total body surface area was estimated as 1.88±0.16 m² and 1.60±0.12 m² in males and females, respectively. Also, hand area of males was found as 156.31±11.25 m² and 154.71±11.92 m² in right and left side, respectively. The same values of females were measured as 128.15±11.14 m² and 125.56±10.80 m² in right and left side, respectively. The values of males were 88.30±8.11 m² and 87.52±8.61 m² in right and left side, respectively. Moreover, there were significant differences in measurements of hand area, palm area, total body surface area, the percents of hand and palm area surface area between gender. The hand index was found as 42.33±2.97 (right), 41.67±2.91 (left) in females, whereas the same values were established as 41.95±2.56 (right) and 42.03±2.64 (left) in males.

Conclusions: The observations presented in present study, can provide principal knowledge about anatomic parameters. They need to be taken into consideration when surgical procedures are performed in hand region for female and male population. Also, the total body surface area, the percents of hand and palm surface area, hand and palm area values help to determine burns area, or extent of burn and wounds. Moreover, we can say that differences between measurements can depend on some factors such as gender, age, race, ethnic groups, geographical situations.

Key Words: Anatomy, Hand index, Hand and palm area, Total body surface area

Öz

Amaç: Bu çalışmada, 18-25 yaş arası sağlıklı bireylerde üst ekstremite ile ilgili morfometrik ölçümlerin incelenmesi ve tüm vücut yüzey alani ile el ve el ayısı alanının hesaplanması amaçlandı.

Materyal ve Metod: El ölçümü alındıktan sonra, 18-25 yaş arası 407 adet birey (243 kadını; 164 erkek) uzunluk, genişlik ölçümü ve diğer ölçümler alındı. Ayrıca, boynun uzunluğu, boy uzunluğu ve vücut ağırlığı de ölçülmüştü. Toplu vücut yüzey alanı, el ve el ayası yüzey alanının toplam vücut yüzey alanı olarak hesaplandı. El ve el ayısı alanı, kumaş ölçümü ve yaralanma alanının hesaplanması amaçlandı.

Sonuçlar: Kadınlarda, ortalaması 1.88±0.16 m² ve 1.60±0.12 m², erkeklerde ise 1.86±0.17 m² ve 1.60±0.12 m² ve 1.76±0.05 m² olarak ölçüldü. En yüksek değerler kadınlarda ölçüldü. Toplu vücut yüzey alanı, el ve el ayısı alanının toplam vücut yüzey alanı olarak hesaplandı. El ve el ayısı alanı, kumaş ölçümleri ve yaralanma alanının hesaplanması amaçlandı.

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**Introduction**

The internal structure of hand is variety of bones, muscles, nerves, and veins. The hand is primarily formed twenty-seven bones and it divided into three groups named as eight carpals, five metacarpals and fourteen phalanges. Carpals play an important role in backwards and forwards movement of hand/wrist; whereas metacarpals which are five in number, are located in palm. The fourteen phalanges divided into three groups called as proximal, medial and distal (1-3). The two phalanges are located in thumb; whereas, three phalanges are in each four fingers. Bones are the most significant part of the human hand and function for about all the activities of the hand (3).

Hand suffers damage from industrial hazard nearly in the ratio of 1/3. It is declared hand is connected with brain development in anthropology and thumb plays a significant role in fine motor skills (1). Hand measurement parameters are essential for planning surgical procedure in design of hand held objects. In addition, hand anthropometric measurements are suitable parameters for sports of rowing, and judo as well as sports of handball, volleyley and basketball. They play a crucial role in grip and these parameters helps to evaluate which sports branch can be more suitable for the athletes/subjects (4-10).

Hand anthropometric measurements give important information in design of hand-held devices such as surgical stapler, computer mice and lanthoscopic devices. The design of hand-held devices requires especially finger anthropometry providing fine motor skills and especially thumb is a key point in fine motor skills (1,11). Amirsheybani et al reported that hand length could be a good predictor of the body surface area independent of the gender (12). Also, the human palm is defined as the inner portion of the hand and palmar surface area, the hand area and palm area measurements of the total body surface area, the presents of arm span in our population. Also, this study is aimed to measurements of the total body surface area, the presents of hand and palmar surface area, the hand area and palm area in our healthy population and compare them to the other population.

**Materials and Methods**

Bilateral hand tracing were obtained from 407 adult subjects (243 females, 164 males) between 18 and 25 years of age with no history of trauma or congenital anomalies. Each individual was asked to place her/his hand in suitable position to measure on a paper. A hand tracing was made by a pen. The following parameters were measured using electronic digital caliper, and non-elastic tape measure.

- **Hand length:** The subjects were asked to place their hand on paper with the palm facing upwards with fingers extended and adducted and the tracing made from the radial styloid process to ulnar styloid process. A line was drawn between radial and ulnar styloid process. This line was determined as interstyloid line. It was measured from the midpoint of the interstyloid line to distal tip of the middle finger (14,20-22).
- **Hand width:** The distance between the radial side of the second metacarpal joint to ulnar side of fifth metacarpal joint were measured and recorded as mm (8,23).
- **Palm length:** The distance between the midpoint of the distal wrist crease and the base of the middle finger (5,23).
- **Thumb length:** The distance from the base of the finger to distal tip of the thumb was measured (23).
- **Index finger length:** The distance from the base of the index finger to distal tip of the index finger was measured (23).
- **Hand width:** The distance between the radial side of the second metacarpal joint to ulnar side of the fifth metacarpal joint were measured and recorded as mm (8,23).
- **Palm length:** The distance between the midpoint of the distal wrist crease and the base of the middle finger (5,23).
- **Thumb length:** The distance from the base of the finger to distal tip of the thumb was measured (23).
- **Index finger length:** The distance from the base of the index finger to distal tip of the index finger was measured (23).

After these measurements obtained from hand tracing, body surface area, hand area, palm area, and the presents of hand and palm surface area were estimated.

Body surface area was calculated using DuBois Formula 

$$[0.007184*(body\ height\ in\ cm^{0,725})*(body\ weight\ in\ kg^{0,425})]$$

(12,14,18,19).

Hand width was multiplied with the hand length and palm to calculate hand and palm area, respectively (14).

Arm span: The distance was measured from the tip of the middle finger of one hand to the tip of the middle finger of the other hand with the subject standing with their back to the wall with both arms abducted to 90°, the elbows and
wrist extended and the palms facing directly forward (24). Body height: The distance between floor and the highest point on the head when subject was in standard standing position (21). Also, the body mass index (BMI) was calculated from height and weight (kg/m² formula) (14).

This study was approved by the Institutional Review Ethics Committee at Cukurova University. (Ethics Committee number 10 and date 10 November, 2017). The research study was explained to each participant prior to data collection. All subjects signed the informed consent form before taking part in study.

Statistical Analysis

The SPSS 22.0 program was used for statistical analysis of the measurement results. From these measurements, means, standard deviations (SD), minimum and maximum values were calculated. Normality were evaluated by Shapiro Wilks test and the data tested were normally distributed (p>0.05). Also, one way ANOVA test were one of the parametric tests were chosen to determine the significance between gender. The Pearson Correlation analysis were performed to assess the relation between measurements. Additionally, the p<0.05 value was considered as significant.

Results

The records of 407 healthy females and males aged between 18-25 years were assessed. The mean and standard deviation values of age, weight, height, BMI and arm span measurements were found to be, 19.68±2.42 years, 5.96±3.03 kg/m² and 1.60±0.12 m in males and females, respectively. The Pearson Correlation analysis were performed to assess the relation between measurements. Additionally, the p<0.05 value was considered as significant.

| Table 1. Demographic data in healthy subjects aged between 18-25 years |
|------------------|-----------------|-----------------|-----------------|------------------|-----------------|
| Measurement      | Age (years) | Height (cm) | Weight (kg) | Body mass index (kg/m²) | Arm span (m) |
|-----------------|-------------|-------------|-------------|------------------------|---------------|
| Gender          | Female (243) | 19.68±2.42 | 164.12±5.93 | 55.96±8.32 | 20.79±3.03 | 1.60±0.06 |
|                 | Male (164)  | 20.22±2.40 | 176.96±4.06 | 71.48±11.98 | 22.80±3.44 | 1.77±0.05 |
| P               |              | <0.001     | <0.001      | <0.001       | <0.001       | <0.001       |

Table 2. The hand anthropometric values in healthy adult females and males

| Measurements | Female (243) | Male (164) |
|--------------|-------------|-----------|
| Phalanx I length (mm) | 60.3±3.74 | 63.9±9.08 | <0.001 |
| Phalanx II (index finger) | 71.8±5.04 | 79.5±6.59 | <0.001 |
| Palm area (left) | 42.3±2.97 | 41.9±3.56 | 0.249 |
| Palm area (right) | 42.0±2.64 | 0.202 |

Table 3. The area surface measurements in healthy females and males

| Measurements | Female (243) | Male (164) |
|--------------|-------------|-----------|
| Hand area right | 128.15±11.14 | 156.31±11.25 | <0.001 |
| Hand area left | 125.56±10.80 | 154.71±11.92 | <0.001 |
| Palm area right | 75.11±6.04 | 88.30±8.11 | <0.001 |
| Palm area left | 70.24±6.19 | 87.52±8.61 | <0.001 |
| Hand surface area right | 42.5±2.97 | 41.9±3.56 | 0.249 |
| Hand surface area left | 41.6±2.91 | 42.0±2.64 | 0.202 |

However, there were significant difference in measurements of the total body surface area, hand area, palm area and the persents of hand and palm surface area between two gender (Table 3). The right and left side comparisons of measurements in healthy adult females and males were shown in Table 4. Additionally, according to the comparison of right and left measurements there were significant
difference in all parameters (except palm length). The correlation analysis of hand and phalanx measurements were shown in Table 5.

Table 4. The right and left side comparison of measurements in adult females and males

| Measurements                      | P      |
|-----------------------------------|--------|
| Phalanx I length (mm)             | <0.001 |
| Phalanx II (index finger) length (mm) | =0.001 |
| Hand width (mm)                   | <0.001 |
| Hand length (mm)                  | =0.023 |
| Palm length (mm)                  | =0.124 |
| Hand index                        | 0.004  |
| Hand area m²                      | <0.001 |
| Palm area m²                      | <0.001 |
| Hand surface area left (% of total surface area) | <0.001 |
| Palm surface area left (% of total surface area) | <0.001 |

mm: millimeter; p: significant value; %: percent

Discussion

The human hand is an incomparable structure in habitual locomotor duty and functions of manipulation. The importance of hand in these activities is due to special arrangement of the bones and muscles. Hand play an important role in both special motor tasks and transmission of sensory information such as temperature, figure, characteristic of objects to the brain (5). Hand anthropometric measurements give important information in design of hand-held devices such as surgical stapler, computer mice and lanthoscopic devices. The design of hand-held devices requires especially finger anthropometry providing fine motor skills and especially thumb provides critical information in fine motor skills (1,11). Hand length parameter was found as 156.11 ± 0.86 mm and 172.76 ± 0.84 mm in Malay female and male, whereas the same parameter was 157.58 ± 1.05 mm and 168.36 ± 0.84 mm in females and males of Chinese population (21). In Swedish males the same measurement was reported as 19.3 cm (right) and 19.4 cm (left) (25). Moreover, in a study performed in three different regions from Nigeria, the hand length of females was 19.85 cm in Hausa population, 19.97 cm in Igbo population, 19.27 cm in Yoruba population. The corresponding value was found as 20.62 cm in Hausa region, 20.22 cm in Igbo area and 19.55 cm in Yoruba region (26). In several papers from different populations, it was declared that the hand length value was 17.00±0.80 cm and 18.30±1.10 cm in Malay females and males (27); 18.00 cm and 19.00 cm in Indonesian females and males; 17.00 and 19.00 cm in Singaporean females and males (28); 17.95±3.44 cm and 19.75±7.82 cm in Philippino females and males (6); 17.3 cm and 18.4 cm in Thai female and male (29). However, this dimension ranged from 159.56 ± 0.70 mm – 171.4±6.70; to 178.04 ± 0.85 mm 188.3±10.9 in Indian females and males (4,21). Additionally, the hand length was 174.22±10.75 mm (R) – 173.76±9.59 mm (L) and 192.86±10.74 mm-191.97±8.85 mm in this study. We found some differences in the mean value of hand length of Indians, Malays, Chinese, Indonesia, and Thailand with our population; having lower than Turks. From this data, our results are close to Singaporean, Philippines, and Sweden population.

The hand width was reported as 8.1 cm ve 7.2 cm in Malay males and females, respectively; whereas the same parameter was measured as 9.00 cm ve 8.00 cm in Indonesia males and females. The same parameter was declared as 9.80 cm ve 9.20 cm in Philippine males and females, while the hand width was 7.8 cm in Thai females, respectively (6,27-29). In Nigerian population the same parameter was found as 9.73 cm and 9.00 cm in Hausa males and females; 9.57 cm and 9.22 cm in males and females in Nigeria Igbo region; 9.57 cm and 9.38 cm in Nigeria Yoruba male and female population (26). In present paper, the same measurement of female subjects was measured as 73.51±3.61 mm and 72.22±4.08 mm in right and left side; whereas, this parameter of males was 81.01±2.93 mm and 80.55±4.23 mm in right and left side. Our results are different from Indonesia, Philippines, Thai and Nigeria populations; having higher than Turkish population Conversely, our results are similar to Malay males.

In Kosovan male and female subjects aged between 18-20 years, the mean value of the arm span were 1.81±0.07 m and 1.65±0.06 m, respectively. The stature measurement was less than arm span values (1.68 m) in males, whereas, in females the corresponding value were similar to height value (30). The arm span measurement was found 1.73 m and 1.64 m in Nigerian males and females, respectively. The stature value was less than arm span 0.055 m and 0.039 m in males and females, respectively (31). The corresponding measurement of Serbian females and males is 1.70 m and 1.85 m, respectively (32). In Indian females and males, the arm span was found range from 1.59 m to 1.61 m; from 1.71 m to 1.76 m, respectively (24,33). In Nepalese males and females, the same dimension was 1.59 m and 1.68 m, respectively (34). In this study, the same value was measured as 1.60±0.06 m and 1.77±0.05 m in females and males, respectively. The mean value of arm span were less than stature measurement as average 0.04 in females, whereas the mean value of arm span were close to height.

In Italian females, the palm length was found as 105.26±4.41 mm and 105.83±4.71 mm in right and left side (right handers), whereas the same value was 104.87±3.51 and 105.67±4.99 mm in right and left side (left handers). In Italian males, the corresponding value was 96.05±4.19 mm and 95.93±4.33 mm in right and left side (right handers), whereas the same dimension was 97.03±4.92 mm and 96.18±5.09 mm in right and left side (left handers) (35).
In our population, palm length was found as 97.20±5.914 mm and 97.21±5.857 mm in right and left side, respectively in female subjects. The same dimension of male subjects was measured as 108.90±7.79 mm and 108.56±7.45 mm in right and left side, respectively.

In right handers, thumb length measurement of Italian male population was given as 56.94±3.33 mm and 56.44±3.52 mm in right and left side, whereas in left hander the corresponding value was 57.33±4.59 mm and 56.33±5.05 mm in right and left side (35).

In right handers, index finger length measurement of Italian male population was declared as 71.39±3.44 mm and 71.86±3.46 mm in right and left side, whereas the same dimension was found as 71.14±5.01 mm and 72.43±4.79 mm in right and left side (left handers). In right handers, the same dimension of Italian female subjects was measured as 66.38±3.15 mm and 66.25±3.20 mm in right and left side, whereas in left handers the corresponding value was 67.50±2.88 mm and 67.83±2.64 mm in right and left side (35). In Korean female and male population the thumb length value was found 56.08±3.49 mm and 61.23±3.94 mm, whereas the index finger length of female and male Korean population was measured as 66.26±4.28 mm and 70.48±4.33 mm, respectively (36). In this paper, the thumb length (60.33±7.43 mm and 59.80±7.76 mm) and index finger length values (71.85±6.04 mm and 71.85±6.09 mm) were found in female subjects, whereas in males the thumb length (63.92±9.08 mm and 63.65±9.27 mm) and index finger length (75.51±6.59 mm and 75.11±6.04 mm) were measured, respectively. According to this data, our thumb and index finger length values are greater than Italian and Korean subjects.

In Egyptian population, the hand index was measured as 42.87±1.32 and 42.87±1.29 (female) and 41.78±1.51 and 41.79±1.44 (male) in right and left side, respectively (37). In Nigerian male and female population, the corresponding value was 44.68±0.19 and 43.29±0.19, respectively (38). In Saudi population, the same dimension was measured as 42.87±1.32 and 42.87±1.29 (female) in right and left side; 39.95±1.74 and 39.91±1.79 (male) in right and left side, respectively (39). Our results (41.95±3.56 and 42.03±2.64; 42.33±2.97 and 41.67±2.91) are different from Egyptian, Nigerian and Saudi population. In Amirshaybani et al’s study performed with Americans the mean value of total body surface area was calculated as 1.84m2 and 1.68m2 in male and females, respectively (12). Tikuisis et al reported as 2.03 m2 and 1.73 m2 in males and females, respectively (13). The corresponding value of Chinese adults was found as 1.83m2 and 1.57m2 in males and females, respectively (18). In Indians, the mean
of same value was reported as 1.59m² and 1.44m² in males and females (17). This parameter was 1.88m² and 1.64m² in males and females, respectively in Belgium (16).

In Gökern and Bozkir’s study performed with 294 healthy subjects aged between 18-25 years, the same parameter was reported as 1.90m² and 1.63m² in males and females, respectively (14). According to literature data, our results of males (1.88 m² in males) are different from Americans, Indians, Chinese, and Turkish population. The values of Americans, Indians and Chinese population are lower than our study. The value of Belgium are similar to our males’ finding. Also, our data of females (1.60 m² in females) is lower than American, Turkish and Belgium population. In a study of performed with 300 Indian adults by Agarwal and Sahu hand area was reported as 146.50 m² and 132.42 m² in males and females respectively, whereas palm area was indicated as 77.85cm² and 73.66cm² in males and females, respectively (17). Choi et al reported the hand area as 119.50 m² (19). In a performed study with Turkish population, the hand area was found as 158.34 m² and 127.87 m² in males and females, respectively; while palm area was calculated as 82.98 cm² and 63.91 cm² in males and females, respectively (14). The mean hand area [right side; 156.31 cm², males; 128.15 cm², females; left side; 154.71 cm², males; 125.56 cm², females)], and palm area [(right side; 88.30, males; 71.51, females; left side; 87.52, males; 70.24, females)] values of the present study were higher than Indian males, lower than females. Also, our findings were similar to Turkish population. In a study performed with male and female Indians of Agarwal and Sahu’s, the ratio of the HSA to BSA were found as 0.9223 and 0.9216, respectively (17). The HSA/BSA value was 0.76 and 0.73 in Chinese male and female population, respectively (18). Amirsheybani et al stated as 0.85 and 0.79 in American males and females, respectively (12). In Korean adults the corresponding value was 0.66 (19). Gökern and Bozkir declared this parameter as 0.83 and 0.78 in males and females, respectively (14). In present study, the same parameter was estimated as 0.83 (right) - 0.83 (left) and 0.80 (right) - 0.79 (left) in Turkish males and females, respectively. Due to these the reports, we found some differences in mean values of Indian and Korean populations compared with our results: Indians have greater values than us. Koreans have lower values than us. Also, Americans and Turkish population values are closer to that of the report from our results. In a study performed with male and female Indians of Agarwal and Sahu’s, the ratio of the PSA to BSA were found as 0.49 and 0.51 Indian males and females, respectively (17). In Turkish males and females aged between 18-25, the same value was estimated as 0.43 and 0.39, respectively (14). In present study, the same parameter was estimated as 0.47 (right side)-0.47 (left side) and 0.45 (right side)-0.44 (left side) in Turkish males and females, respectively. Additionally, these differences in measurements can arise from race, gender, age, genetic factors, and methodology.

As a result, we believe that the data obtained in present study can provide principal information for hand morphometry and may help the orthopaedic surgeons and rheumatologists design for having a successful surgery and minimize the related problems. Also, we think that the hand region besides the importance of ergonomics, becomes even more important in the motion of the fine motor skills, hand implantation and orthopaedic surgery for determining the value of the muscle strength should be in this area and also our study will make a significant contribution to the literature about the hand morphometry and anatomy what anthropometric measurements must be in healthy subjects in our population. Also, surface area measurements like hand, palmar and total body help to determine burns area, or extent of burn and wounds.

This study was approved by the Institutional Review Ethics Committee at Cukurova University. (Ethics Committee number: 70/10 and date 10 November, 2017).

Conflict of Interest
The authors declare that there is no financial support and there is no conflict of interest

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