Anthropometric Dimensions of Hands and Feet in Different Ages of People Living in, Iran

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Original Research

Abstract
Aim: Since the mismatch between the anthropometric dimensions of individuals and the dimensions of hand tools and shoes which leads to musculoskeletal disorders (MSDs), measuring data on anthropometric dimensions of hands and feet is essential for designing hand tools and shoes production. This study aimed to measure the anthropometric dimensions of hands and feet in different ages of men and women in Tabriz, Iran.

Method and Materials: This is a descriptive-analytical study that was conducted in 2020 on 609 peoples living in Tabriz city in Iran. In this study, two and one dimensions of foot and hand were measured manually respectively. Descriptive statistics such as percentiles, means, and standard deviation were calculated. Independent t-test and Cohen effect size were used to test the mean dimensions of hands and feet of subjects.

Finding: Mean, standard deviation and 5th, 50th and 95th percentiles values were calculated in general and in terms of gender and educational level for individuals. In all the measured dimensions, men were generally larger than women, however; there were exceptions. The mean of the measured dimensions of hand foot size between men and women was different significantly.

Conclusion: In this study, anthropometric data of hands and feet for people living in Tabriz were measured. The findings provided can be used to design hand tools and shoes productions.

Keywords: Anthropometry, Percentile, Hand and Foot Dimensions.

Introduction
According to the International Labor Organization (ILO) Work-related Musculoskeletal Diseases (WMSD) are considered one of the primary sources of occupational diseases [1-3]. One way to reduce WMSDs is to measure the anthropometric dimensions of the human body [4]. Anthropometry is one of the main elements of ergonomic studies to solve the problems of matching tasks / products with users’ characteristics [5, 6]. The use of anthropometric data in designing work environments and manufacturing products ensures that such designs meet the physical needs of end users [7]. Using anthropometric principles in designing help different people with different body dimensions, regain their physical comfort and convenience at work [8]. Anthropometric data should be collected on a continuous basis because it is required for the designing of equipment, tools, devices, and workstations [9]. Anthropometric data is used by specialists to create products that can include user satisfaction, economic success, and, most importantly, workers’ health and well-being [10]. The incompatibility of tools and machines with the characteristics of the human body will result in a variety of issues, including decreased efficiency, increased discomfort, musculoskeletal injuries, and so on [11]. For example, according to a study, more than 200,000 hand tool injuries occur each year due to tool incompatibility with the worker [12]. In general, each person’s shape and size are determined by hereditary genetic factors, diet, and lifestyle [7]. Because of differences in genetic,
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of all anthropometric dimensions of men’s hands is significantly different from women’s hands [21]. The human foot has a complex structure that includes numerous bones, joints, nerves, and muscles. Because human feet are under a lot of pressure due to their small size in comparison to the rest of the body, appropriate shoes should be worn to maintain health and determine foot comfort [22]. To design shoe models, we need access to the anthropometric dimensions of the foot so that shoe models can be made in a way that keeps users’ feet comfortable [23]. Among the studies on measuring the anthropometric dimensions of the foot, we can mention the study of Mortazavi et al., which was conducted to measure 8 dimensions of the foot and discovered a significant relationship between 85 percent of the foot dimensions [22]. Minaei et al. conducted another study in which they manually measured 21 foot dimensions and discovered that men’s feet are larger than women’s feet in all measured dimensions, and the average of all foot dimensions between men and women was different statistically significant [24]. In another study, Hajizadeh et al. measured 21 foot dimensions of right foot individuals and discovered that, in general, men’s feet are significantly larger than women’s, but some dimensions of women’s feet were larger than men’s [14]. However, because anthropometric dimensions of hands and feet can be used in the designing of various hand tools and shoes, and because anthropometric dimensions of hands and feet are difficult to obtain in Iranian society, this study aims to measure two and one dimensions of foot and hand in different age groups. The use of the study’s findings and descriptive indicators in designing and development of hand tools and shoes that fit individuals’ hands and feet will improve workers’ comfort and productivity.

Method and Materials

The current study is a descriptive-analytical...
study that was conducted in Tabriz in 2020 on 609 people ranging in age from 7 to 33 years. Inclusion criteria for the selected population included having healthy feet and hands with no abnormalities in the hands and feet, while exclusion criteria included having musculoskeletal problems caused by accidents and congenital problems. In this study, the feet and hands were measured using two and one anthropometric dimensions, respectively. Individuals were informed about the measurement process and voluntarily participation in the study to address ethical concerns. The demographic characteristics of the population studied were examined first. Calipers were used to measure the width of the subjects’ hands, and a tape measure was used to measure their height. A special measuring device was used to determine the width and length of the foot without socks or shoes. Body weight was measured using Seca scales. Individuals’ demographic and anthropometric characteristics were entered into SPSS software version 20 for data analysis. Descriptive statistics such as percentile, mean, and standard deviation were calculated during data analysis using the statistical software SPSS version 20. The difference in the mean anthropometric dimensions of the foot and hand between men and women was assessed using an independent t-test. The effect size dimensions were also calculated to assess the average difference size of foot and hand dimensions between men and women. The effect size was calculated using Cohen’s equation \[25\]. The larger the effect size, the greater the difference in means between the two comparison groups. The value of R2 is calculated as a percentage of the relevant equation to assess the effect of gender on the size of the dimensions of the foot and hand using one-way variance analysis \[5\]. The R2 value for each dimension of the foot and hand indicates what percentage of the sex factor justifies the changes in that dimension.

In the current study, each dimension of the foot and hand has definitions that must be explained first in order for the measurement process to be accurate. The distance from the radial region of the second metacarpophalangeal joint to the ulnar region of the fifth metacarpophalangeal joint is equal to the hand width, which is approximately 2.5 to 4 inch \[26\] as illustrated in Figure 1. The distance from the tip of the longest toe to the end of the heel is equal to the foot length, and the maximum width of the foot in the widest part is equal to the foot width \[27\] as shown in Figure 2.
Findings
This study included 609 people from Tabriz, 43% of whom were men and 57% of whom were women. Table 1 shows the demographic characteristics of the study population by educational stage. Table 2 displays the fifth, fifty-fifth, and ninetieth percentile values, as well as the coefficients of variation in weight, height, BMI, and measured anthropometric dimensions.

According to Table 2, the lowest and highest coefficients of variation for males in primary school are foot length and hand width, for males in middle school are hand width and foot width, and for males in university are foot length and hand width. Furthermore, the lowest and highest coefficients of variation for females in primary school are foot width and hand width, respectively, for females in middle school are foot length and hand width, and for females in high school are foot length and hand width. Table 3 displays the fifth, fifty-fifth, and ninetieth percentiles of hands and feet in men and women based on educational level.

The Female / Male ratio in Table 4 depicts...
Table 2) Different percentiles of weight, height, BMI and anthropometric dimensions of hands and feet along with the variation coefficient of dimensions in the study population (N=609)

| Anthropometric dimension | Percentile | SD   | Variation coefficient % |
|--------------------------|------------|------|-------------------------|
|                          | 5          | 50   | 95                      |
| Total population (N= 261 males and 348 females) |            |      |                         |
| Weight (kg)              | 22         | 41   | 80                      | 19.81 | 4.8 |
| Height (cm)              | 123        | 150  | 181                     | 23.27 | 3.2 |
| BMI                      | 13.75      | 18.99| 27.17                   | 4.1   | 7.6 |
| Foot length (cm)         | 18.5       | 22.5 | 27.3                    | 2.88  | 4.2 |
| Foot width (cm)          | 6.8        | 8.3  | 10                      | 1.02  | 7.8 |
| Hand width (cm)          | 5.2        | 6.5  | 8.2                     | 0.94  | 4.8 |
| Male (Primary school ) (N=94) |            |      |                         |
| Weight (kg)              | 20         | 27.50| 40.75                   | 6.54  | 22.5 |
| Height (cm)              | 122.50     | 131.50| 146.25                  | 6.83  | 5.2 |
| BMI                      | 9.42       | 14.75| 21.34                   | 3.28  | 22.4 |
| Foot length (cm)         | 18         | 20.50| 23.12                   | 1.49  | 7.3 |
| Foot width (cm)          | 7          | 8    | 9                       | 0.61  | 7.8 |
| Hand width (cm)          | 5.50       | 6.10 | 7.20                    | 0.55  | 9   |
| Male (Middle school) (N=6) |            |      |                         |
| Weight (kg)              | 25         | 30   | n/a                     | 2.96  | 9.9 |
| Height (cm)              | 129.50     | 145.50| n/a                     | 9.99  | 6.9 |
| BMI                      | 13.31      | 17.21| n/a                     | 3.27  | 18.4 |
| Foot length (cm)         | 17         | 22.05| n/a                     | 2.10  | 10  |
| Foot width (cm)          | 7          | 7.90 | n/a                     | 1.51  | 17.8 |
| Hand width (cm)          | 6          | 6.25 | n/a                     | 0.27  | 4.4 |
| Males (University) (N=161) |            |      |                         |
| Weight (kg)              | 57         | 69   | 93                      | 10.67 | 15.1 |
| Height (cm)              | 167        | 176  | 186                     | 5.41  | 3.1 |
| BMI                      | 19.49      | 26.07| 40.06                   | 6.10  | 22.2 |
| Foot length (cm)         | 24.10      | 26.10| 28.39                   | 1.30  | 5   |
| Foot width (cm)          | 8.50       | 9.50 | 10.40                   | 0.55  | 5.8 |
| Hand width (cm)          | 6.80       | 7.60 | 8.40                    | 0.51  | 6.8 |
| Female (Primary school) (N=200) |            |      |                         |
| Weight (kg)              | 20         | 29   | 43.95                   | 7.51  | 24.8 |
| Height (cm)              | 118        | 132  | 148.95                  | 8.63  | 6.5 |
| BMI                      | 10.10      | 14.48| 22.91                   | 3.72  | 24.7 |
| Foot length (cm)         | 18         | 20.30| 22.97                   | 1.91  | 9.3 |
| Foot width (cm)          | 6.50       | 7.30 | 8.40                    | 0.60  | 8.1 |
| Hand width (cm)          | 5.0        | 5.70 | 6.70                    | 0.59  | 10.3 |
| Female (Middle school) (N=137) |            |      |                         |
| Weight (kg)              | 36         | 52   | 80                      | 12.24 | 22.8 |
| Height (cm)              | 147        | 161  | 172.10                  | 6.95  | 4.3 |
| BMI                      | 14.89      | 21.97| 32.63                   | 5.71  | 25.4 |
| Foot length (cm)         | 22         | 23.80| 26                      | 1.26  | 5.3 |
| Foot width (cm)          | 7.69       | 8.50 | 9.50                    | 0.52  | 6.2 |
Continuation of Table 2

| Anthropometric dimension | Percentile | SD  | Variation coefficient % |
|--------------------------|------------|-----|--------------------------|
| Hand width (cm)          | 5          | 6.18| 7                        |
|                          | 50         | 8.31| 0.64                     |
|                          | 95         | 9.1 | 8.8                      |

Note: n/a= not available

Table 3) Different percentiles of weight, height, BMI and anthropometric dimensions of the foot and hand in the study population

| Anthropometric dimension | Percentile (men) | SD  | Percentile (women) | SD |
|--------------------------|-----------------|-----|-------------------|----|
| Hand width (cm)          | 5               | 6.20| 50                | 6.80|
|                          | 95              | 8.31| 95                | 8.8 |

Note: n/a= not available
the average ratio of the desired dimension in women to men. A ratio greater than 100 for an anthropometric dimension indicates that the average size of that dimension in the female population was greater than in the male population. According to Table

Table 4) The effect of gender on weight, height and anthropometric dimensions of hands and feet

| Anthropometric dimension | Men Average | Men SD | Female Average | Female SD | F/M % | R² % |
|--------------------------|-------------|--------|----------------|-----------|-------|------|
| Total population (261 males and 348 females) | | | | | | |
| Weight (kg) | 54.76 | 22.22 | 40.36 | 15.15 | 73.7 | 46.50 |
| Height (cm) | 159.72 | 22.18 | 144.42 | 15.84 | 90.42 | 150.96 |
| BMI | 20.28 | 4.26 | 18.67 | 3.83 | 92.06 | 20.10 |
| Foot length (cm) | 24.03 | 3.10 | 21.86 | 2.31 | 90.96 | 22.79 |
| Foot width (cm) | 8.91 | 0.97 | 7.87 | 0.80 | 88.32 | 8.32 |
| Hand width (cm) | 7.04 | 0.85 | 6.28 | 0.87 | 89.20 | 6.61 |
| Primary school (N=294) | | | | | | |
| Weight (kg) | 29.09 | 6.54 | 30.34 | 7.51 | 104.29 | 29.94 |
| Height (cm) | 132.12 | 6.83 | 132.61 | 8.63 | 100.37 | 132.45 |
| BMI | 14.70 | 3.28 | 15.05 | 3.72 | 102.38 | 14.94 |
| Foot length (cm) | 20.48 | 1.49 | 20.48 | 1.91 | 100 | 20.48 |
| Foot width (cm) | 7.91 | 0.61 | 7.38 | 0.60 | 93.29 | 7.55 |
| Hand width (cm) | 6.18 | 0.55 | 5.74 | 0.59 | 92.88 | 5.88 |
| Middle school (N=143) | | | | | | |
| Weight (kg) | 29.9 | 2.96 | 53.69 | 12.24 | 179.56 | 52.86 |
| Height (cm) | 144.75 | 9.99 | 160.41 | 6.95 | 110.81 | 159.75 |
| BMI | 17.73 | 3.27 | 22.46 | 5.71 | 126.67 | 22.30 |
| Foot length (cm) | 21.05 | 2.10 | 23.74 | 1.26 | 112.77 | 23.63 |
| Foot width (cm) | 8.48 | 1.51 | 8.53 | 0.52 | 100.58 | 8.53 |
| Hand width (cm) | 6.28 | 0.27 | 7.02 | 0.64 | 111.78 | 6.99 |
| High school (N=11) | | | | | | |
| Weight (kg) | n/a | n/a | 56.55 | 8.19 | n/a | 55.56 |
| Height (cm) | n/a | n/a | 160 | 3.68 | n/a | 160 |
| BMI | n/a | n/a | 23.13 | 5.04 | n/a | 23.13 |
| Foot length (cm) | n/a | n/a | 23.62 | 0.73 | n/a | 23.62 |
| Foot width (cm) | n/a | n/a | 8.57 | 0.68 | n/a | 8.57 |
| Hand width (cm) | n/a | n/a | 6.97 | 0.61 | n/a | 6.97 |
| University (N=161) | | | | | | |
| Weight (kg) | 70.61 | 10.67 | n/a | n/a | n/a | 70.61 |
| Height (cm) | 176.50 | 5.41 | n/a | n/a | n/a | 176.50 |
| BMI | 27.51 | 6.10 | n/a | n/a | n/a | 27.51 |
| Foot length (cm) | 26.22 | 1.30 | n/a | n/a | n/a | 26.22 |
| Foot width (cm) | 9.51 | 0.55 | n/a | n/a | n/a | 9.51 |
| Hand width (cm) | 7.57 | 0.51 | n/a | n/a | n/a | 7.57 |

Note: F/M=Female/Male, n/a= not available
The average size of men is larger than women's in all measured dimensions for the entire population, but when this ratio is examined by educational stage and gender, the average size of women's was higher in some dimensions. Gender has more effects in that dimension when the value of R2 is as close to 100 as possible. Thus, for the entire population, the height and hand width factors have the greatest and least effect from gender, respectively, but this issue varies according to educational stage.

The results of the study test regarding the mean difference of dimensions of foot and hand anthropometry in men and women, as well as the calculated effect size, are shown in Table 5. The mean difference of all factors, including foot and hand dimensions, was statistically significant (P< 0.001). The maximum and minimum effect size in hand and foot dimensions in the total population were foot width and foot length, respectively, but this issue varies according to educational stage.

### Discussion

In the current study, 609 people (261 men and 348 women) ranging in age from 7 to 33 years were measured manually in two dimensions of the foot and one dimension of the hand. The calculated percentile values for the subjects' hands and feet can be used as a source of anthropometric data for designing hand tools, shoe production, and so on. Despite the fact that advanced equipment such as 3D scanners are widely available, this study provides valuable data for various industries.
used to measure foot and hand dimensions today, the high cost of purchasing 3D scanners forces professionals to rely on manual methods \[24\]. The mean of men's and women's hand widths in this study were 70.4 and 62.8 mm, respectively, indicating a significant difference between the two genders. The fifth, fifty and ninety-fifth percentiles of hand width in primary school for men and women were 55, 61, and 72 mm for men and 50, 57, and 67 mm for women. Moreover in middle school, the findings of this study indicates that the fifth and fifty percentiles of hand width of women was greater than the fifth and fifty percentiles of men hand width, as mentioned in the SO Ismaila study \[28\]. Furthermore, the 5th and 50th percentiles of hand width in high school for women were 73 and 84 mm, respectively, and the 5th, 50th, and 95th percentiles of hand width in university men were 85, 95, and 104 mm, respectively. The age range of the study population was 20 to 59 years in a study conducted by Wonjoon Kim et al., and the mean of hand width for men and women was 75 and 83.7 mm, respectively, with a significant difference found between them \[26\]. The age range of the study population was 18 to 29 years in another study conducted by Minaei et al. and the mean foot length for men and women was 270.03 and 234.35 mm, respectively \[22\]. In the current study, the mean foot length and width for the mentioned percentiles for men and women in primary school were 180, 205, 231.2 mm and 180, 203, 229.7 mm for foot length and 70, 80, and 90 mm and 65, 73, and 84 mm for foot width, respectively, in middle school, men (5th and 50th percentiles only) and women had foot lengths of 170 and 220.5 mm and 220 and 238 mm, respectively, and foot widths of 70 and 79 mm and 76.9, 85, and 95 mm, respectively; in high school, women (only the 5th and 50th percentiles) had foot lengths of 225 and 236 mm and 73 and 84 mm, respectively, and finally, foot length and width for university men were 241, 261, and 283.9 mm and 85, 95, and 104 mm, respectively. In a study with subjects aged 18 to 29, the mean foot length for the 5th, 50th, and 95th percentiles for men and women was 248, 264, and 275 mm and 230, 250, and 270 mm, respectively, men's and women's foot widths were 79, 86, and 95 mm and 80, 90, and 100 mm, respectively \[28\]. The range of foot length in the current study's male population was 190 to 310 mm, but in the Minaei and Mortazavi studies, this range was (229.39 - 304.18) and (231-305) mm, respectively. This difference can be attributed to age and differences in the study population's characteristics. The average foot length in a study of military personnel from the United States and Sweden was 268.4 mm.
and 266.3 mm, respectively \cite{24}. Sadeghi et al. found that the average foot length in women and men was 230 and 255 mm, respectively, \cite{22}. The mean foot length of the men in that study, Minaei, and Mortazavi, is shorter than the mean of the current study, and this difference is due to ethnic differences.

The use of hand and foot anthropometric measurements in the design of hand tools and shoe production is one of the most important applications. This study, presented the values of the fifth, fiftieth, and ninety fifth percentiles for the total population, as well as by gender and educational level, which can be used to manufacture hand tools and shoes. The variations’ coefficient can be used to demonstrate attribute scatter that is independent of the absolute value of the variable in question and is also a unit of measurement \cite{24}. According to the results of the current study, the variation coefficient of weight is greater than the variation coefficient of height for the entire study population, which has been mentioned in other studies \cite{5, 24}. The width of the foot had the highest coefficient of variation among the measured dimensions for the total study population, but when this issue is examined by educational level, the maximum coefficient of variation varies for the dimensions of the hand and foot. According to one study, increasing the mean of an anthropometric dimension lowers the coefficient of variation \cite{13}.

The foot length has the highest mean and the lowest coefficient of variation in the current study. Based on the Female/Male values in this study, it can be stated that, in general, men’s were larger than women’s in all measured dimensions, which was also mentioned in the Minaei study et al \cite{24}. However, as previously stated, when this issue is examined by educational level, it appears differently, and in some cases, women’s dimensions are larger than men’s, as mentioned in another study \cite{28}. According to some studies, all dimensions measured for men were larger than those measured for women \cite{29, 30}.

The effect of gender on the measured dimensions was investigated in this study. Accordingly, gender influences foot length and width, as well as hand width, by 22.79 percent, 8.32 percent, and 6.61 percent, respectively, for the entire study population. As a result, it can be concluded that factors other than gender can influence hand and foot dimensions. The Minaei study thoroughly investigated the effect of gender on various foot dimensions \cite{24}. According to the current study result, all dimensions of the foot and hand are statistically significant different. The effect size parameter refers to the mean difference amount of the desired dimension in the two different genders. In other words, despite the statistical difference in the means of anthropometric dimensions of hands and feet between the two sexes, its degree can be determined using the calculated effect size. The effect size in this study was calculated using Cohen’s equation. According to this equation, an effect size of 0.2 to 0.3 is considered a small effect, up to 0.5 as a medium effect, and greater than 0.8 as a large effect \cite{25}. In the current study, all of the measured dimensions had an effect size greater than 0.7, but during the study, all dimensions had an effect size greater than 0.9, which is considered a large effect. The Minaei study found that the effect size of most foot dimensions was greater than 0.8, which is consistent with the current study’s findings \cite{24}

Although this study has its own strength points, there are some limitation. Among the study’s limitations, the difficult access to individuals and difficult measurement of hand and foot dimensions could be mentioned. This study was conducted in population living in city of Tabriz, so the results are limited to a specific geographical area; therefore, it is suggested that such a study be conducted in other geographical areas in the future for fully access the
anthropometric dimensions of the hands and feet among other people.

**Conclusion**

Because information about anthropometric data of hands and feet in our society is insufficient, many such studies are required to design hand tools and shoe production. The large effect sizes and significant difference in the anthropometric dimensions of the hands and feet indicate that the anthropometric dimensions of each gender and their specific geographical area should be used in the design of hand tools and shoe production. Conducting such studies in other geographical areas will aid in the completion of our country’s anthropometric database.

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**Author Contribution:** JN and VMm: designed the study. MjSh: analyzed and interpreted the data, reviewed the literature and Wrote the first and final draft of the manuscript. OA supervised all stages of the study.

**Conflict of Interests:** The authors declare that there is no conflict of interest for this study.

**Ethical Permission:** All principals of ethics were considered in the study. Participants were satisfied to be studied.

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