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

Authors

Jalil Nazari[1] *PhD*
Vahid Mirzaei Majarshin[1] *MSc*
Mohammad Javad Sheikhmozafari[2] *MSc*
Omran Ahmadi[2*] *PhD*

[1]Department of Occupational Health and Safety, Tabriz university of medical science, Tabriz, Iran.
[2]Department of Occupational Health Engineering, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran.

* Correspondence
Address: Occupational Health and safety Engineering, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran.
Tel: +98 21 82884504
Fax: +98 21 82884555
P.O.Box: 14115-331
Email: O.ahmadi@modares.ac.ir

A B S T R A C T

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 percentages, 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.

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,

racial, and nutritional structures, humans have very different body dimensions. For example, the average height of American men is 173.6 cm, while the average height of Vietnamese men is 152 cm [8]. At work, the human hand interacts with a variety of tools, and if there is a mismatch between the tool and the hand, it can cause a variety of health, safety, and functional issues, such as WMSDs in the upper limbs, tendons, limited range of motion, and reduced forces [13, 14].

Inappropriate hand tools, which put a lot of pressure on the hand, increase discomfort, and reduce job productivity, are one of the effective factors in causing such disorders on the hand [15]. For example, if the length of the tool hand is less than the width of the palm, the person will feel a lot of discomfort and a lot of pressure will be applied to the palm during long-term use [16]. Another study found that using non-electric hand tools doubled the risk of WMSDs in people [17]. The human hand has many anthropometric dimensions that can be used to design hand tools such as computer mouse, controllers, and personal protective equipments such as gloves [18]. Measuring hand dimensions is used not only in designing of hand tools, but also in designing of equipment for people with disabilities and rheumatoid arthritis patients to help them regain some of their function lost due to deformity of their hand and fingers [19]. As a result, gathering data on the anthropometry of hands and feet can be extremely beneficial in reducing musculoskeletal injuries to these organs and optimizing the design of related products [18].

In this regard, Motamedzade et al. investigated the anthropometric dimensions of hands in Iran in order to design hand tools for carpet weavers [20]. Heidari Moghadam et al. investigated the ten anthropometric dimensions of the hand and discovered that anthropometric dimensions are influenced by factors such as age, gender, and genetics [9]. Another study on 20 dominant hand dimensions conducted by Taghizadeh et al. discovered that the average

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.
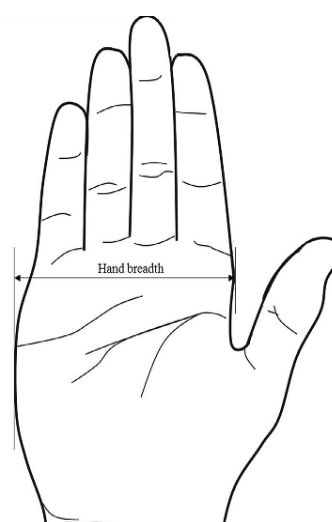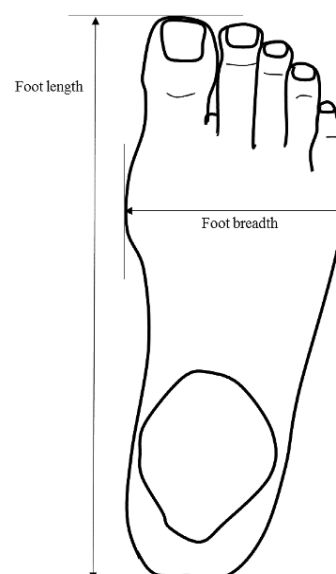

Figure 1) Anthropometric dimension of hand width

Figure 2) Anthropometric dimension of foot length and width

Table 1) Demographic characteristics of the subjects (261 males and 348 females)

Variable	Mean	SD	Min - Max
Total population (N= 261 males and 348 females)			
Age(year)	13.67	5.92	7-33
Weight (kg)	46.50	19.81	19-105
Height (cm)	150.96	20.27	113-190
BMI	19.36	1.4	10.95-32.82
Foot length (cm)	22.79	2.88	19-31
Foot width (cm)	8.32	1.02	6.2-11
hand Width (cm)	6.6	0.94	4.2-9.1
Male (Primary school) (N=94)			
Age(year)	9.01	0.945	8-11
Weight (kg)	29.09	6.54	19-61
Height (cm)	132.12	6.83	115-148
BMI	14.70	3.28	8.76-22.68
Foot length (cm)	20.48	1.49	16-25
Foot width (cm)	7.91	0.61	6.5-9.3
hand Width (cm)	6.18	0.55	5.3-9.1
Male (Middle school)(N=6)			
Age(year)	12	0	12-12
Weight (kg)	29.9	2.96	25-33
Height (cm)	144.75	9.99	130-160
BMI	17.73	3.27	13.32-21.86
Foot length (cm)	21.05	2.10	17-22.5
Foot width (cm)	8.48	1.51	7-11
hand Width (cm)	6.28	0.27	6-6.7
Males (University)(N=161)			
Age(year)	22.68	2.46	19-33
Weight (kg)	70.61	10.67	50-105
Height (cm)	176.50	5.41	165-190
BMI	27.51	6.10	16.62-49.15
Foot length (cm)	26.22	1.30	23.2-32
Foot width (cm)	9.51	0.55	8-11
hand Width (cm)	7.57	0.51	6.3-8.8
Female (Primary school) (N=200)			
Age(year)	8.80	1.27	7-11
Weight (kg)	30.34	7.51	19-62
Height (cm)	132.61	8.63	113-157
BMI	15.05	3.72	7.66-26.39
Foot length (cm)	20.48	1.91	17-31.5
Foot width (cm)	7.38	0.60	6.2-11
hand Width (cm)	5.74	0.59	4.2-9

Continuation of Table 1

Variable	Mean	SD	Min - Max
Female (Middle school) (N=137)			
Age(year)	13.37	0.65	12-14
Weight (kg)	53.69	12.24	33-90
Height (cm)	160.41	6.95	143-176
BMI	22.46	5.71	12.31-40.83
Foot length (cm)	23.74	1.26	21-29.8
Foot width (cm)	8.53	0.52	7.2-10
hand Width (cm)	7.02	0.64	5.5-8.7
Female (High school)(N=11)			
Age(year)	15	0	15-15
Weight (kg)	56.55	8.19	37-65
Height (cm)	160	3.68	153-165
BMI	23.13	5.04	16.54-31.57
Foot length (cm)	23.62	0.73	22.5-24.8
Foot width (cm)	8.57	0.68	7.3-9.7
hand Width (cm)	6.97	0.61	6.2-8.2

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, respectively. 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	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 %
	5	50	95		
Hand width (cm)	6.18	7	8.31	0.64	9.1
Female high school (11)					
Weight (kg)	37	59	n/a	8.19	14.5
Height (cm)	153	161	n/a	3.68	2.3
BMI	16.54	22.49	n/a	5.04	21.8
Foot length (cm)	22.50	23.60	n/a	0.73	3.1
Foot width (cm)	7.30	8.40	n/a	0.68	8
Hand width (cm)	6.20	6.80	n/a	0.61	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
Primary school(N=294)	5	50	95		5	50	95	
Weight (kg)	20	27.50	40.75	6.54	20	29	43.95	7.51
Height (cm)	122.50	131.50	146.25	6.83	118	132	148.95	8.63
BMI	9.42	14.75	21.34	3.28	10.10	14.48	22.91	3.72
Foot length (cm)	18	20.50	23.12	1.49	18	20.30	22.97	1.91
Foot width (cm)	7	8	9	0.61	6.50	7.30	8.40	0.60
Hand Width (cm)	5.50	6.10	7.20	0.55	5	5.70	6.70	0.59
Anthropometric dimension	**Percentile (men)**			**SD**	**Percentile (women)**			**SD**
Middle school (N=143)	5	50	95		5	50	95	
Weight (kg)	25	30	n/a	2.96	36	52	80	12.24
Height (cm)	129.50	145.50	n/a	9.99	147	161	172.10	6.95
BMI	13.31	17.21	n/a	3.27	14.89	21.97	32.63	5.71
Foot length (cm)	17	22.05	n/a	2.10	22	23.80	26	1.26
Foot width (cm)	7	7.90	n/a	1.51	7.69	8.50	9.50	0.52
Hand Width (cm)	6	6.25	n/a	0.27	6.18	7	8.31	0.64
Anthropometric dimension	**Percentile (men)**			**SD**	**Percentile (women)**			**SD**
High school (N= 11)	5	50	95		5	50	95	
Weight (kg)	n/a	n/a	n/a	n/a	37	59	n/a	8.19
Height (cm)	n/a	n/a	n/a	n/a	153	161	n/a	3.68
BMI	n/a	n/a	n/a	n/a	16.54	22.49	n/a	5.04
Foot length (cm)	n/a	n/a	n/a	n/a	22.50	23.60	n/a	0.73
Foot width (cm)	n/a	n/a	n/a	n/a	7.30	8.40	n/a	0.68
Hand width (cm)	n/a	n/a	n/a	n/a	6.20	6.80	n/a	0.61
Anthropometric dimension	**Percentile (men)**			**SD**	**Percentile (women)**			**SD**
University (N-161)	5	50	95		5	50	95	
Weight (kg)	57	69	93	10.67	n/a	n/a	n/a	n/a
Height (cm)	167	176	186	5.41	n/a	n/a	n/a	n/a
BMI	19.49	26.07	40.06	6.10	n/a	n/a	n/a	n/a
Foot length (cm)	24.10	26.10	28.39	1.30	n/a	n/a	n/a	n/a
Foot width (cm)	8.50	9.50	10.40	0.55	n/a	n/a	n/a	n/a
Hand width (cm)	6.80	7.60	8.40	0.51	n/a	n/a	n/a	n/a

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		Female		F/M %	R² %
	Average	SD	Average	SD		
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

Table 5) Comparison of the mean anthropometric dimensions of hand and foot in women and men and the calculated effect size

Anthropometric dimension (mm)	Male Mean (SD)	Female Mean (SD)	Mean difference	P	Effect size
Total population (N=261 males and 348 females)					
Foot length (mm)	240.3(31)	218.6(23.1)	21.7	0.001	0.8
Foot width (mm)	89.1(9.7)	78.7(8)	10.4	0.001	1.17
Hand width (mm)	70.4(8.5)	62.8(8.7)	7.6	0.001	0.88
Primary school (N=294)					
Foot length (mm)	204.8(14.9)	204.8(19.1)	0	0.001	0
Foot width (mm)	79.1(6.1)	73.8(6)	5.3	0.001	0.87
Hand width (mm)	61.8(5.5)	57.4(5.9)	4.4	0.001	0.77
Middle school (N=143)					
Foot length (mm)	210.5(21)	237.4(12.6)	26.9	0.001	1.6
Foot width (mm)	84.8(15.1)	85.3(5.2)	0.5	0.001	0.049
Hand width (mm)	62.8(2.7)	70.2(6.4)	7.4	0.001	1.62
High school (N=11)					
Foot length (mm)	n/a	236.2(7.3)	n/a	0.001	n/a
Foot width (mm)	n/a	85.7(6.8)	n/a	0.001	n/a
Hand width (mm)	n/a	69.7(6.1)	n/a	0.001	n/a
University (N=161)					
Foot length (mm)	262.2(13)	n/a	n/a	0.001	n/a
Foot width (mm)	95.1(5.5)	n/a	n/a	0.001	n/a
Hand width (mm)	75.5(5.1)	n/a	n/a	0.001	n/a

Note: n/a= not available

4, 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, as with the Female/Male ratio factor, this issue differs when examined separately by educational stage and gender.

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 differance 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 issues 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

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 hands 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 , 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 SO Ismaila et al., and the mean of hand width of men and women for the 5th, 50th, and 95th percentiles was 81, 95, and 105 mm for women and 88, 96, and 100 mm for men, respectively [28]. The results of the two previous studies are slightly lower than those of the current study, which could be attributed to racial and regional differences. Foot length, the most important dimension of the foot, has been measured in various anthropometric studies that shoe designers can use [24, 27].

 In the current study, the mean foot length and width for men and women in primary school were 204.8 and 79.1 mm for men and 204.8 and 73.8 mm for women, respectively; in middle school, 210.5 and 84.8 mm for men and 237.4 and 85.3 mm for women; in high

school, 236.2 and 85.7 mm for women; and in university, 262.2 and 95.1 mm for men. Minaei et al. conducted a study in which the study population ranged in age from 18 to 30 years, and the mean foot length for men and women was 270.03 and 234.35 mm, respectively [24]. In addition, Mortazavi et al. found that the average foot length for men aged 18 to 25 was 264.66 mm in their study, [22], which is slightly higher than the current study's findings. In another study, where subjects ranged in age from 20 to 59 years old, the mean length and width of the foot for men and women were 251.2 and 97.9 mm, and 227.7 and 87.9 mm, respectively [26]. 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 [24]. Sadeghi et al. found that the average foot length in women and men was 230 and 255 mm, respectively, [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 [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 [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 [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 [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 [28]. According to some studies, all dimensions measured

for men were larger than those measured for women [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 [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 [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 [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.

References

1. Sheikhmozafari MJ, Salimi F, Ahmadi O. Risk Assessment of MusculoSkeletal Disorders among workers of a housekeeping service company in Kerman, Iran.IJMPP. 2020;5(4):402-9.
2. Sheikhmozafari MJ, Alizade PM, Ahmadi O. Validation of the Persian version of the Workplace Physical-Ergonomic Conditions Evaluation (PECE) Questionnaire. IJMPP. 2021;6(3):554-61.
3. Salimi F, Sheikhmozafari MJ, Tayebisani S, Ahmadi O. Risk Assessment of Musculoskeletal Disorders Prevalence in Female Hairdressers using RULA and NERPA Techniques. IJMPP. 2021;6(3):545-53.
4. Ginting R, Nurhadi D, Malik AF. Designing a lifting tool work using SNQ and anthropometry. In IOP Conference Series: Earth and Environmental Science. 2020; 452(1): 012091. DOI:10.1088/1755-1315/452/1/012091
5. Pheasant S, Haslegrave CM. Bodyspace: Anthropometry, ergonomics, and the design of work. CRC press, 2018, 3rd Edition.
6. Gyi D, Masson A, Hignett S. Plus size and obese workers: anthropometry estimates to promote inclusive design. Ergonomics. 2019 ;62(9):1234-42.
7. Dianat I, Molenbroek J, Castellucci HI. A review of the methodology and applications of anthropometry in ergonomics and product design. Ergonomics. 2018;61(12):1696-720.
8. Kim JY, You JW, Kim MS. South Korean anthropometric data and survey methodology:'Size Korea'project. Ergonomics. 2017;60(11):1586-96.
9. Heidarimoghadam R, Shabani M, Lotfi Y, Ghasemi F, Mohammadi Y. A study of hand anthropometry dimensional on middle-aged women and male in Hamadan. Iran J Ergon. 2018; 6 (2) :46-54.
10. Salvarzi E, Choobineh A, Jahangiri M, Keshavarzi S. Facial anthropometric measurements in Iranian male workers using Digimizer version 4.1. 1.0 image analysis software: a pilot study. Int J Occup Saf Ergon. 2018 Oct 2;24(4):570-6.
11. Sadeghi F, Mazloumi A, Kazemi Z. An anthropometric data bank for the Iranian working population with ethnic diversity. Appl. Ergon. 2015; 48: 95-103.
12. Adeleye AA, Akanbi OG. Hand cumulative trauma disorders in Nigerian custom tailors: the need for redesign of manual scissors. Ergonomics, 2015. 58(8):1410-1423.
13. Viviani, C, et al. Accuracy, precision and reliability in anthropometric surveys for ergonomics purposes in adult working populations: A literature review. Int. J. Ind. Ergon. 2018. 65:1-16. doi.org/10.1016/j.ergon.2018.01.012
14. Hajaghazadeh M, Emamgholizadeh Minaei R, Allahyari T, Khalkhali H. Anthropometric Dimensions of Foot in Northwestern Iran and Comparison with Other Populations, Health Scope. 2018 ; 7(3):14063.
15. Rostamzadeh S. Saremi M, Tabatabaei S, Normative hand grip strength and prediction models for Iranian office employees. Work. 2019;62(2): 233-241.
16. Wang CY, Cai DE. Hand tool handle design based on hand measurements. MATEC Web of Conferences. 2017; 119:01044.
17. Karwowski, W. International Encyclopedia of Ergonomics and Human Factors. 2end edition, 2006; CRC press.
18. Vergara M, Agost MJ, Gracia-Ibáñez V. Dorsal and palmar aspect dimensions of hand anthropometry for designing hand tools and protections. Hum Factors Ergon Manuf. 2018; 28(1): 17-28.

19. Azeez M, Clancy C, O'Dwyer T, Lahiff C, Wilson F, Cunnane G. Benefits of exercise in patients with rheumatoid arthritis: a randomized controlled trial of a patient-specific exercise programme. Clin. Rheumatol. 2020;39(6):1783-92.

20. Motamedzade M, Choobineh A, Mououdi MA, Arghami S. Ergonomic design of carpet weaving hand tools. Int. J. Ind. Ergon.2007; 37(7):581-7.

21. Taghizade M, Mohebbi I, Khalkhali H, Ahmadi-Arablu P, Torfeh A, Hajaghazadeh M. The study of anthropometric dimensions of hand in office staffs in Urmia. Iran J Ergon. 2018; 6 (1) :1-10.

22. Mortazavi S,. Kanani M, Khavanin A, Mansourizadeh R, Mohseni M, Foot Anthropometry by Digital Photography and the importance of its application in Boot Design. Journal Mil Med. 2008. 10(1): 69-80.

23. Marconi M, Manieri S, Germani M, Raffaeli R. A digitally-enabled integrated approach to design and manufacture shoe lasts. Comput. Aided Des. 2019;16(3):593-610.

24. Emamgholizadeh Minaei R, Hajaghazadeh M, Allahyari T, Khalkhali H, Keramat M. Anthropometric Dimensions of Foot in Students. Iran J Ergon. 2016; 4 (1) :28-38.

25. Teunissen JW, Rommers N, Pion J, Cumming SP, Rössler R, D'Hondt E, et al. Accuracy of maturity prediction equations in individual elite male football players. Ann Hum Biol. 2020 ;47(4):409-16.

26. Kim W, Kim YM, Yun MH, Estimation of stature from hand and foot dimensions in a Korean population. J. Forensic Leg. Med. 2018; 55: 87-92.

27. Joza'kana'ani M, Mortazavi SB, Khawanin A, Mirzaei R, Rasulzadeh Y, Zadeh MM. Comparison of Foot Anthropocentric Measurements In Two Digital And Manual Approaches. Ilam Univ Medical Sci. 2008;16(3): 1-10.

28. Ismaila S. Anthropometric data of hand, foot and ear of university students in Nigeria. Leonardo J Sci. 2009; 15(8): 15-20.

29. Krauss I, Grau S, Mauch M, Maiwald C, Horstmann T. Sex-related differences in foot shape. Ergonomics. 2008;51(11):1693-709.

30. Hong Y, Wang L, Xu DQ, Li JX. Gender differences in foot shape: a study of Chinese young adults. Sports Biomech. 2011. 10(2): 85-97.