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Original Article

Investigation of the Relationship between Somatotypes and Hand Types in Healthy Young Individuals

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Abstract

Background: This study aimed to examine the relationship between hand types and somatotypes of healthy young individuals.

Materials: A total of 312 volunteering individuals (152 F, 160 M) from Karabük University (Karabük, Türkiye), between the ages of 17 and 35 years were included in this prospective study. The somatotypes of the individuals were measured using a previously formed Excel template based on the Heath-Carter method. Factor analysis and clustering analysis were conducted with the 17 parameters measured.

Results: The mean body mass index of female participants was 21.23±3.30 kg/m², while that of males was 23.48±3.52 kg/m². When the somatotypes of individuals were examined, 5 different groups were found to be balanced: ectomorph, endomorphic mesomorph, mesomorph endomorph, mesomorphic endomorph, and central. As a result of these factors, it was concluded that there were 4 hand types: short palm short finger, long palm long finger, wide hand long finger, narrow hand short finger. The distribution of hand types between somatotype groups, the result that endomorphic mesomorph group had long palm long finger and wide hand long finger, while balanced ectomorph group had narrow hand short finger was found to be statistically significant (x^2=55.817;df=12, P<0.05).

Conclusion: The difference between somatotypes was not only in body types, but also in hand anthropometry. We believe that the fact that these results can be used as anatomical data in product design, ergonomics, and preliminary design of interfaces for young individuals in the Turkish population will contribute to experts interested in this field.

Keywords: Somatotype; Hand shape; Anthropometry; Hand type

Introduction

Somatotype refers to the description of an individual's body type. It is a very comprehensive method based on anthropometric measurements used to describe different aspects of human physiology (1-3). It was first modified by Sheldon et al. in 1940 (4) and then by Heath and Carter in 1967 (5), and today it is the most widely used method for determining body type (1-3).

Anthropometry is related with body measurements that varies by ethnicity, sex, and age.

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Therefore, anthropometric measurements of different populations and even the results of different ages and sexes in the same population vary greatly (6, 7). These measurements increase functionality in areas where personal adaptation is important such as medicine, dentistry, personal protective equipment, and office furniture. Full adaptation ensures working safely by providing both ergonomics and work performance and decreasing injury frequency. Adaptation is not limited only to these areas; increasing adaptation in smart wearable devices should be based on extensive anthropometric measurements, especially those taken from the hand (8-10).

Today, ergonomic products have become more important with the increase in both production and consumption (11). Based on this thought, appropriate ergonomic design of products requires considering their anthropometric sizes during the design process (12).

This study aimed to examine the relationship between hand types and somatotypes of healthy young individuals. Thus, the study will show whether there is a relationship between hand types and somatotype. It will also be possible to compare hand types according to somatotype with the measurement results in this population. The production of hand-related equipment specific to the appropriate somatotype, is the most important goal that the study hopes to contribute to.

Materials and Methods

This study was approved by Karabük University Local Ethics Committee (Date: 23.09.2022, No: 2022/1065). A total of 312 (152 females and 160 males) volunteering Turkish individuals between the ages of 17 and 35 who were students at Karabük University participated in the study. Verbal and written informed consents were taken from each participant. Students who had undergone hand surgery and those who had a history of fracture and injury were not included in the study.

Measurement of somatotypes

Anthropometric data collected from the participants in line with the methods determined by International Biological Program (IBP) included measurements of height and weight, triceps, subscapular, supraspinal and thigh skinfold thickness (SFT), knee and elbow width, arm, and thigh circumference.

SFT was measured with skinfold calliper, circumference was measured with tape measure and width was measured with digital calliper. Somatotypes were measured with Heath-Carter method by using a previously formed Excel (Microsoft, USA) template (13).

Hand measurement

The left hand's image was scanned by using a digital scanner connected to a laptop. A ruler was placed on the digital scanner while scanning the hand image. The images taken were calibrated according to the ruler data in ImageJ image processing software. The parameters measured were;

- Hand width (HW): The distance between the most medial and the most lateral points of the hand at the level of metacarpophalangeal joint.
- Hand length (HL): The distance between the distal tip of the middle finger and the middle of the wrist line.
- Length of fingers 2-5 (FL2, 3, 4, 5): Each measurement was made as the distance between the distal tip of the related finger and the proximal flexion fold of the finger.
- Distance of fingers 2-5 to the wrist (DFW2, 3, 4, 5): Each measurement was made as the distance from the middle of the wrist line to the proximal flexion fold of the related finger.
- Width of metacarpophalangeal joint 1-5 (MPJ1, 2, 3, 4, 5): The distance between the most medial and the most lateral points of the flexion fold of MPJ 1-5 (Fig. 1).

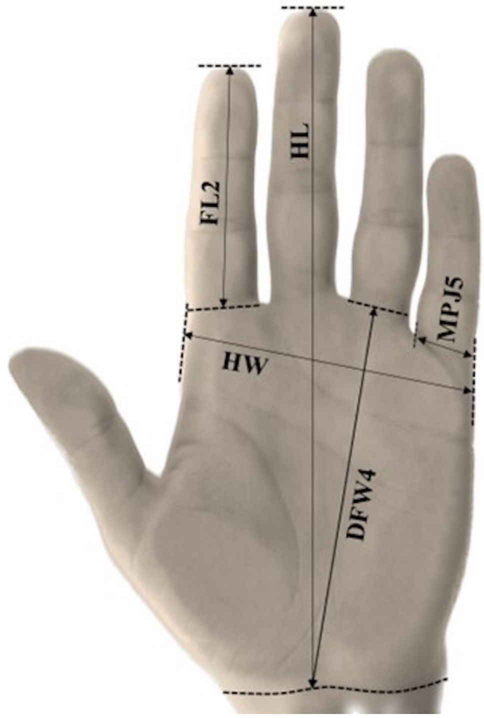

Fig. 1: Exemplification of the measured parameters (DFW4: distance of finger 4 to the wrist; FL2: length of second finger; HL: hand length; HW: hand width; MPJ5: width of metacarpophalangeal joint 5)

Statistical analysis

All data were analysed by using SPSS 22 (IBM Corp., Armonk, NY, USA), Minitab 17. Descriptive statistics (mean and standard deviation) were calculated for the value of each hand size and presented here. Anderson Darling test was performed to test whether the data set of measurements met normal distribution and One way ANOVA were used for normal distribution and Kruskal Wallis test were used not suitable for normal distribution. Somatotypes were grouped. The correlation between hand size and height was determined by using Pearson correlation coefficients and factor analysis was performed with 17 variables to determine a series of factors suitable to explain the variation in hand shape (Direct Oblimin rotation) (14). Following the factor analysis, Ward and Euclid distance method was used to measure the distance between groups and clustering analysis was conducted for factor. The hands in the study were grouped in four. A clustering analysis was conducted to determine whether the groups with similar characteristics belonged to a single category. Hand typing according to somatotype was performed with Pearson x^2 test.

Results

A total of 312 individuals, 160 (51.3%) males and 152 (48.7%) females participated in the study. The mean age of the male participants was 20.1±1.7 years, and female participants' 19.5±1.6 years. The female participants' mean body mass index (BMI) was 21.23±3.30 kg/m^2, and male participants were 23.48±3.52 kg/m^2. Statistically significant difference was found in age, height, weight, and BMI parameters regarding sex (P<0.05).

A total of five different somatotype groups were found in the individuals who participated in the study as balanced ectomorph (group 1), endomorphic mesomorph (group 2), mesomorph endomorph (group 3), mesomorphic endomorph (group 4) and central (group 5). Table 1 shows the distribution of somatotypes according to sex.

Table 1: Distribution of somatotype groups by sex

Variable		Balanced ecto-morph (Group 1)	Endomorphic meso-morph (Group 2)	Meso-morph en-domorph (Group 3)	Mesomorphic endo-morph (Group 4)	Central (Group 5)	Total
Sex	**Female**	34	35	30	29	24	152
	Male	24	69	33	17	17	160
	Total	58	104	63	46	41	312

The parameters HW, HL, DFW3, DFW4, FL3, FL4, FL5 were normally distributed in female participants ($P>0.05$), while the parameters of age, BMI, MPJ1, MPJ2, MPJ3, MPJ4, MPJ5, DFW2, DFW5, FL2 were not normally distributed ($P<0.05$).

There were no significant differences between somatotype groups in female participants in terms of the parameters of age, MPJ1, DFW2, DFW3, DFW4, DFW5, FL4, and FL5 ($P>0.05$). Significant difference was found between groups 1 and 2 in terms of MPJ2 and MPJ3 parameters ($P=0.001$). The group 1 was significantly different from 2, 3, and 5. groups in the MPJ4 parameter ($P<0.05$). The group 1 had a significant difference from the 2 and 3 groups in the MPJ5 parameter ($P<0.05$). A significant difference was also found between groups 1 and 2 in terms of HW parameter ($P=0.047$). In terms of FL2 parameter, there was significant difference between groups 1 and 3 ($P=0.005$). In HL parameter, significant difference was found between groups 1 and 2 ($P=0.034$), and in FL3 parameter, significant difference was found between groups 1 and 3 ($P=0.037$) (Table 2, 3).

Table 2: Anthropometric measurements of normally distributed parameters in female participants

Parameters (mm)	Group 1	Group 2	Group 3	Group 4	Group 5	P_{ANOVA}
HW	77.029±3.704	79.800±4.289	78.300±4.069	77.345±3.847	79.500±3.776	0.018
HL	173.559±6.373	171.114±8.757	168.967±8.223	170.897±7.374	170.750±6.448	0.200
DFW3	98.382±4.334	96.829±5.893	96.533±5.230	97.207±4.329	96.708±3.316	0.541
DFW4	94.618±4.192	93.457±5.852	92.600±4.782	93.862±4.627	93.042±3.712	0.508
FL3	75.794±3.032	74.457±4.623	72.867±4.199	74.069±4.148	74.458±4.211	0.082
FL4	69.441±3.359	68.800±4.350	67.467±4.368	68.448±4.171	68.583±4.241	0.431
FL5	55.706±3.664	55.257±3.829	54.433±3.793	54.966±3.831	55.542±3.106	0.686

(ANOVA Test, $P<0.05$, HW: hand width, HL: hand length, DFW3: distance of fingers 3 to the wrist, DFW4: distance of fingers 4. to the wrist, FL3: length of fingers 3., FL4: length of fingers 4., FL5: length of fingers 5)

Table 3: Demographic data and anthropometric measurements of non-normally distributed parameters in female participants

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	P^k
Age (year)	19 (18-22)	20 (18-35)	19 (18-22)	19 (18-22)	19 (18-23)	0.312
BMI (kg/m^2)	18.28 (16.35-20.47)	22.65 (17.98-35.75)	22.52 (19.11-28.73)	21.23 (18.90-25.46)	19.34 (17.22-21.45)	<0.001
MPJ1 (mm)	28 (25-33)	28 (25-34)	28.5 (22-32)	28 (25-32)	28 (25-32)	0.094
MPJ2 (mm)	18 (16-22)	20 (17-23)	19 (17 -24)	19 (17-22)	18.5 (17-22)	0.002
MPJ3 (mm)	17 (15-19)	18 (15-21)	17.5 (16-22)	18 (16-20)	17.5 (16-21)	0.004
MPJ4 (mm)	16 (13-18)	18 (15-21)	17 (14-22)	17 (14-20)	17 (14-19)	<0.001
MPJ5 (mm)	15 (13-18)	16 (14-18)	16 (14-19)	16 (14-17)	16 (14-17)	<0.001
DFW2 (mm)	98 (89-107)	96 (85-108)	96.5 (87-105)	97 (87-108)	96.5 (90-103)	0.493
DFW5 (mm)	87 (79-97)	84 (75-94)	85 (76-94)	87 (77-94)	86 (79-91)	0.715
FL2 (mm)	70 (62-77)	67 (60-75)	66.5 (59-75)	68 (58-77)	68.5 (61-74)	0.006

(k=Kruskal Wallis, $P<0.05$, BMI: Body Mass Index, MPJ1: width of metacarpophalangeal joint 1, MPJ2: width of metacarpophalangeal joint 2, MPJ3: width of metacarpophalangeal joint 3, MPJ4: width of metacarpophalangeal joint 4, MPJ5: width of metacarpophalangeal joint 5, DFW2: distance of fingers 2 to the wrist, DFW5: distance of fingers 5 to the wrist, FL2: length of fingers 2)

The parameters of age, BMI, MPJ1, MPJ2, MPJ3, MPJ4, MPJ5, HW, DFW4 and DFW5 were not normally distributed in male participants ($P<0.05$). HL, DFW2, DFW3, FL2, FL3, FL4 and FL5 parameters were found to be normally distributed ($P>0.05$).

There were no significant differences between somatotype groups in male participants in terms of the parameters of age, HL, DFW2, DFW3, FL2 and FL5 ($P>0.05$). According to the DFW4 parameter pairwise test results, no significant differences were found between somatotype groups ($P=0.108$). Similarly, no significant difference was found between somatotype groups in terms of DFW5 parameter pairwise test ($P=0.068$). Significant difference was found between groups 1 and 2 in terms of MPJ1 parameter ($P=0.029$). The group 1 was significantly different from 2 and 3 groups in the MPJ2 parameter ($P<0.05$). Regarding the MPJ3 parameter, group 1 had a significant difference from the 2 and 3 groups also between group 2 difference from groups 4 and 5 ($P<0.05$). In MPJ4 parameter, significant difference was found between group 2 and groups 1 and 5 ($P<0.05$), while significant difference was found between group 1 and 2, 3, and 4 groups in terms of MPJ5 parameter ($P<0.05$). In terms of HW parameter, significant difference was found between group 1 and groups 2 and 3 also group 4 and group 2 ($P<0.05$), and in terms of FL3 parameter, significant difference was found between groups 4 and 5 ($P=0.023$). Finally, significant difference was found between groups 4 and 5 in terms of FL4 parameter ($P=0.028$) (Table 4, 5).

Table 4: Anthropometric measurements of normally distributed parameters in male participants

Parameters (mm)	Group 1	Group 2	Group 3	Group 4	Group 5	P^{ANOVA}
HL	178.15±8.72	181.62±11.68	177.80±11.73	175.73±10.23	179.24±12.41	0.093
DFW2	100.06±4.79	102.91±7.33	100.69±6.96	99.26±5.89	100.60±6.81	0.050
DFW3	100.72±4.95	103.48±7.25	101.25±6.94	99.95±5.82	101.24±7.01	0.078
FL2	71.12±3.98	71.33±5.04	69.52±5.53	69.26±4.85	71.60±5.31	0.075
FL3	78.06±4.62	78.66±5.58	77.06±5.95	76.13±5.36	78.65±6.51	0.028
FL4	71.96±4.98	73.38±5.67	71.58±5.96	70.58±5.12	72.90±6.68	0.040
FL5	58.24±4.89	59.55±5.21	58.25±5.34	57.19±5.11	59.29±5.64	0.116

(ANOVA Test, $P<0.05$, HL: hand length, DFW2: distance of fingers 2 to the wrist, DFW3: distance of fingers 3 to the wrist, FL2: length of fingers 2, FL3: length of fingers 3, FL4: length of fingers 4, FL5: length of fingers 5)

Table 5: Demographic data and anthropometric measurements of non-normally distributed parameters in male participants

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	p^k
Age (year)	19	20	20	19	20	0.507
	17-22	17-35	18-24	18-24	18-23	
BMI (kg/m²)	18.53	24.51	23.09	22.20	19.72	<0.001
	16.35-21.43	17.98-37.03	19.11-31.67	18.90-26.55	17.22-22.25	
MPJ1 (mm)	45.07	31.0	30.0	29.0	29.0	0.018
	25.0-34.0	24.0-37.0	22.0-35.0	25.0-35.0	25.0-34.0	
MPJ2 (mm)	18.0	21.0	19.0	19.5	20.0	<0.001
	16.0-23.0	17.0-25.0	17.0-24.0	17.0-22.0	17.0-22.0	
MPJ3 (mm)	17.0	19.0	18.0	18.0	18.0	<0.001
	15.0-19.0	15.0-24.0	16.0-22.0	16.0-20.0	16.0-21.0	
MPJ4 (mm)	16.0	18.0	17.0	17.0	17.0	<0.001
	13.0-21.0	15.0-22.0	14.0-22.0	14.0-20.0	14.0-20.0	
MPJ5 (mm)	15.0	17.0	17.0	16,5	16.0	<0.001
	13.0-18.0	14.0-20.0	14.0-19.0	14.0-19.0	13.0-18.0	
HW (mm)	80.0	87.0	83.0	80.0	82.0	<0.001
	69.0-97.0	71.0-99.0	70.0-95.0	67.0-90.0	73.0-94.0	
DFW4 (mm)	96.0	101.0	97.0	95.5	96.0	0.108
	86.0-107.0	81.0-117.0	83.0-113.0	85.0-107.0	87.0-112.0	
DFW5 (mm)	88.5	94.0	90.0	88.0	88.0	0.068
	79.0-100.0	75.0-104.0	76.0-103.0	77.0-98.0	79.0-107.0	

(k=Kruskal Wallis, $P<0.05$, BMI: Body Mass Index, MPJ1: width of metacarpophalangeal joint 1, MPJ2: width of metacarpophalangeal joint 2, MPJ3: width of metacarpophalangeal joint 3, MPJ4: width of metacarpophalangeal joint 4, MPJ5: width of metacarpophalangeal joint 5, HW: hand width, DFW4: distance of fingers 4 to the wrist, DFW5: distance of fingers 5 to the wrist)

Factor Analysis

Kaiser-Meyer-Olkin value was found as .933. Barlett test of sphericity results (x^2=8323,015; *P*<0.001) showed that the data found were significant at (*P*<0.001). Direct Oblimin technique was used as rotation technique. The number of factors was determined according to Kaiser Rule. Factor analysis revealed a 3-factor structure. The values of factors are shown in the table below. Total explanatory power of the factors was 84.43%. Factor 1 was called finger length; factor 2 was called hand width, factor 3 was called hand length. In addition, height and weight were included in factor parameters so that they would not affect the result (Supplementary Table; not published).

Factor scores were found by using factor analysis and standardized to a normal distribution (with a mean-variance of 0 and 1) that facilitated interpreting the hand shape and these were later used to make a cluster analysis. For example, if the factor 1 mean score of the participant is higher than 0, this means that the subject has a size larger than the mean in variables related with hand width. On the other hand, if the participant has a negative score for factor 1, it means that the participant has a size smaller than the mean in variables related with hand width. Thus, these factor scores are used to group participants who have similar hand measurements through clustering analysis. The appropriate group size was calculated by selecting four clusters by deriving a dendrogram and applying Ward's method of using Euclidean distance. By using ANOVA, it was confirmed that these four groups were significantly different from one another (*P*<0.05) (Table 6). Four different hand types were found according to analysis results (Fig. 2).

Table 6: Cluster mean factor scores for four types of hands

Variable	Cluster mean factor scores			
Hand types	Factor 1: finger length	Factor 2: hand breadth	Factor 3: palm length	Relative frequency (%)
Type 1: short palm short finger	-1.129	-0.659	1.209	26.0
Type 2: long palm and finger	1.340	0.721	-1.242	20.5
Type 3: wide hand long finger	0.161	1.198	-0.278	17.6
Type 4: narrow hand and short finger	-0.028	-0.523	-0.028	35.9

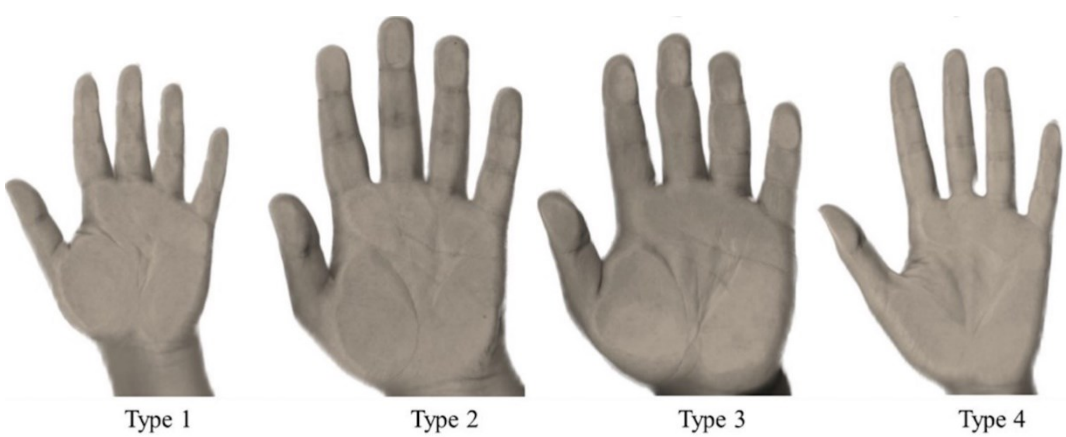

Fig. 2: Type 1: short palm short finger, Type 2: long palm and finger, Type 3: wide hand long finger, Type 4: narrow hand and short finger

While no significant difference was found between groups as a result of the distribution between hand types in terms of somatotype groups, the result that both type 2 and type 3 were in group 2 and type 4 was in group 1 was found to be significant (x^2=55.817;df=12, P<0.05) (Table 7).

Table 7: Distribution of somatotype groups within the four hand types

Hand types		Somototype groups					Total
		Group 1	Group 2	Group 3	Group 4	Group 5	
1	Count	15[a]	18[a]	19[a]	16[a]	13[a]	81
2	Count	5[a]	29[b]	14[a,b]	5[a,b]	11[a,b]	64
3	Count	1[a]	33[b]	11[b,c]	7[a,b,c]	3[a,c]	55
4	Count	37[a]	24[b]	19[b]	18[a,b]	14[b]	112
Total	Count	58	104	63	46	41	312

Each subscript letter denotes a subset of somototype groups categories whose column proportions do not differ significantly from each other at the 0.05 level.

Discussion

Five different somatotype groups were found in 312 individuals included in the study as balanced ectomorph in 58, endomorphic mesomorph in 104, mesomorph endomorph in 63, mesomorphic endomorph in 46, and central in 41. As a result of the analyses, the participants were grouped in four with 81 in 'short palm short finger', 64 in 'long palm long finger', 55 in 'wide hand long finger' and 112 in 'narrow hand short finger'. It was found that the most dominant somatotype was endomorphic mesomorph, while the most dominant hand type was narrow hand short finger. It was found that there were individuals with long palm long finger and wide hand long finger in endomorphic mesomorph group, while there were individuals with narrow hand short finger in balanced ectomorph group.

In a study conducted in literature on big South Korean individuals, females were grouped in four as 'large torso and below-average shoulder width', 'wide shoulder and below-average lower body', 'small torso and large lower body' and 'small figure'; while males were also grouped in four as 'large everyway', 'small figure but above-average legs', 'large torso surface' and 'torso surface'. Park & Park did not perform somatotype analysis but found body types by using various anthropometric measurements (15). In the present study and studies conducted in the literature, it can be seen that somatotype analysis can be conducted on athletes and healthy individuals using the Heath-Carter method (2, 16, 17). Somatotype evaluation method Heath-Carter was preferred in the present study since is the most up-to-date evaluation method with which the body is classified according to anthropometric measurements and interpreted with quantitative data (18).

The most common body type in the present study was endomorphic mesomorph. There are studies in literature in which endomorphic mesomorph body type is dominant (13, 19). In their study, Yang et al. found that their sample had predominantly mesomorphic endomorph body type (20). Chiu et al. found that mesomorphy was dominant in the somatotype study (21). In a study conducted on Indian male boxers, it was found that lightweight boxers had ectomorphic mesomorph body type, middle weight boxers had balanced mesomorph body type and heavy weight boxers had endomorphic mesomorph body type (22). In the somatotype study they conducted on 191 participants, Seçgin et al.

found the most dominant body type as mesomorph endomorph with 111 participants (17). We believe these somatotype differences are due to population, sports and nutrition differences.

In a study conducted in the literature, hand shape was calculated according to hand width/hand length formula and hand shapes were grouped in three types: long and narrow, average looking or relatively square (23). In another study, cluster analysis was performed depending on the factors obtained from various parameters measured from the hand. Hand typing was classified in four types as 'Spacious hand and short finger', 'Short palm but above average finger', 'Long palm and finger' and 'Narrow hand and short finger' (14). In another study conducted on Korean population, 4 different hand types were found as in the classification of Jee and Yun (11). Another study conducted on Turkish population calculated hand types according to Krogman Index (24). In a study on hands conducted for smart wearable technology, the hand was examined in four types: uphill, downhill, mountain and horizon (9). In the present study, the classification most suitable for the population was made as 'short palm short finger', 'long palm long finger', 'wide hand long finger' and 'narrow hand short finger'. Hand types were shown because of the clustering analysis conducted with the factors created by using anthropometric measurements of the hand and height and weight parameters. It is thought that after excluding the effect of weight and height, anthropometric measurements, in other words quantitative assessments, gave the most suitable results.

Kretschmer evaluated hand types according to body shape and made three classifications: leptosome type-long and slender, athletic type-balanced, and pyknic type- a short and wide dorsum with conically formed fingers. In the present study, it was found that the endomorphic mesomorph group included individuals with long palm long finger and wide hand long finger, while balanced ectomorph group included individuals with narrow hand short fingers. The study with closest results to the present study was conducted by Kretschmer (25). However, esthetical classification limited Kretschmer's study. Our literature review shows that our study is the first one examining the relationship between hand type and somatotype groups. This unique approach between somatotype analysis and hand type evaluation enables us to understand the potential connections between body components and hand morphology. The strengths of the study include the large number of participants, the use of comprehensive anthropometric measurements and effective use of Heath-Carter method in somatotype analysis.

Conclusion

The most dominant somatotype was endomorphic mesomorph, while the most dominant hand type was narrow hand short finger. It was found that endomorphic mesomorph group included individuals with long palm long finger and wide hand long finger, while balanced ectomorph group included individuals with narrow hand short finger. No similar studies were found in the literature review. Although this limits our study's discussion, we believe it will prepare a basis for future studies. This study will provide data about hand anthropometry that will be useful in designing hand tools for Turkish people and in choosing tools with suitable sizes to be imported from industrialized countries to be used in industrial businesses in Turkey. The results of anthropometric measurements and hand types in this study can be used in ergonomic product design, especially for the young Turkish people, who are potential buyers.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Availability of supplementary data

All supplementary data accessible via sending email to the corresponding author based on reasonable application.

Conflicts of interest

The authors declare no competing interests.

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