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ORIGINAL ARTICLE

Investigating Hand Anthropometric Dimensions- A Case Study on Office Personnel and Car Mechanics

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ABSTRACT

The present study was aimed to distinguish the effects of work type on hand dimensions and investigate the relationship between anthropometric dimensions and occupation. Methods: The participants included 91 males in two groups, namely 51 manual labor and 40 office employees. The anthropometric data of 12 hand anthropometric dimensions were collected. A simple random method was applied to identify samples. All data were analyzed using SPSS version 18. Results: All the measurements unless manual workers grip diameter were significantly greater than office personnel. The hand perimeter had the greatest value among the 12 measured dimensions while the thickness of the side little finger was the smallest one. In four dimensions, namely width of four fingers together from the central hinge; diameter of thumb to face; diameter of the index finger to face; hand thickness from index finger revealed the availability of a significant difference between manual labor jobs and office workers. Moreover, no significant relation was observed between weight and stature with hand dimension, which represents the correlation between occupation and the four dimensions. Conclusion: The results of this study showed a significant difference between occupational groups in terms of the four dimensions. Therefore, it is suggested that tool designers should consider this finding in their designing process.

KEYWORDS: Hand Dimensions, Occupation, Tool Design, Car Repairman, Employees

INTRODUCTION

In spite of the propagation of mechanized and automatized processes, a great part of business activities is currently performed by human beings and a major part of manual works is still done with hand tools. In this regard, an accurate plan is necessary to avoid musculoskeletal perturbations such as Carpal Tunnel Syndrome (CTS), Hand–Arm Shake Syndrome, Tendonitis, etc. Evaluating the hand tool knobs are particularly important besides its ergonomics and operationality. If this factor did not take into account, it would result in job-related musculoskeletal disturbances which impose different costs such as administrative, ineffectiveness, and injures [1-2].

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Hand anthropometry is regarded as a required input for tool design in such a way that it can enhance task productivity and workers' health.

In a study conducted by Rafael, workers systematically used the tools with dimensions that did not sufficiently fit their hands and that might have imposed unnecessary mechanical loads to the users. A continuous design or re-design of manual tools is needed to improve the usability of manual tools [3]. To do so, a plan of ergonomic products, which estimates anthropometric variation and user priority, is required to harmonize the final users and products [4]. The results of a study revealed that the Chinese people had relatively long and flatted hands compared to the Japanese. These data can be beneficial to improve plan of products [5].

Since manual anthropometry is a primary input to design tools, it can be used to define the percentiles of labor hands [6]. The high intensity reiterated trauma disturbance is the main reason for the wasted labor in many manual industries. In fact, iterated risk agents consist of repeated and powerful actions, certain positions, mechanical stress, low temperatures, gloves, and shake. The risk factors are determined with manually occupational analysis methods. These factors are controlled by task's re-attributing, balancing instruments, choosing the plan of the following tool, relocating labor, choosing the proper conservation of hand, and reducing the exposure of hand with low temperatures and shake [7].

The force direction and number of movements of hand, wrist, forearm, and shoulders have a direct relationship with disturbances due to the weak plan and broad usage of the manual instruments. In fact, it causes the emergence of intensified wrist force and ulnar deviation under local pressure in the hand which lies in an improper situation of shoulder, neck, and repeated moving [8]. The manual materials controlling tasks are prevalent in the majority of industrial occupations where the function of such tasks exposes laborers to different biomechanical risks [9]. CTS is the most important and common side entrapment competed anthropometric in the upper limb [10].

A few studies have evaluated the strength parameters. Therefore, it is of particular for the ergonomic and optimization of tools to minimize musculoskeletal disturbances and avoid possible damages to the workers working on farms [11]. The body anthropometric dimensions have an important role to identify man-machine interactions. The proficiency of human–machine interaction and the final inconvenience have various effects on using the instruments and machinery in mounds [12]. MSDs can be seen in Iranian industries like knitting and tire craft, sugar-producing companies, assembly line laborers, shut flow TV (CCTV), and petrochemical industry of some disturbances fluctuate from 54% to 78% [13-17].

The results of Chandna's study in Northern parts of India showed that this area has higher measurement body dimensions than other areas of the country. Hence, it is required to purify and evaluate the plane of present tools based upon ergonomic considerations previously introduced in this area [18]. Prior to producing a hand tool, it is recommended to consider ergonomic measures [19]. Hand anthropometric diversities between the male population of several countries and the sample study should be considered in order to model hand tools [20].

According to the above-mentioned statements, there may be a relationship between manual jobs and hand anthropometry size. Manual tasks are generally done by hands, there may be several modes arising from such changes in anthropometric measurements. Evidently, anthropometric measurements are necessary for producing high efficient tools. The aim of this study was to investigate the effect of work type on the dimensions of the hand between office employees and car mechanics.

MATERIALS AND METHODS

In the current study, a car mechanic and office employee were selected to investigate their hand anthropometric dimensions. Ninety-one male adults were selected as the participants and divided into two groups, i.e. 51 manual laborers (car mechanic) and 40 office staff (university office employee). A simple random method was applied to identify samples. Individuals were selected from the administrative staff who did not have any heavy manual activity (working with tools) in the last year. In this study, all 12 hand dimensions commonly used in previous studies were measured and have been presented in Figure 1 and Table 1 [3-20-21]. Calipers were used to measure the length, breadth, and thickness of hands and fingers with an accuracy of 0.01 mm. Tapes were used to measure the circumference of hands, and ergonomics dukes were used to measure the grip diameter. Digital scales and a stadiometer were used to measure the body weight and stature.

Table 1. Definition of hand dimensions

Hand dimensions	Definition
1. Hand length	Distance from the middle of inter stylion to the tip of middle finger
2. Palm length	Distance from the middle of inter stylion to the proximal flexion crease of the middle finger
3. Palm width	Meta-carpal joint exterior to the interior of the joint Metatarsophalangeal
4. Thickness of side little finger	The upper part of the meta-carpal of the little finger to the underside little fingers metacarpal
5. Width of four fingers together from the central hinge	Index finger proximal joints to the proximal joint of the little finger
6. Thumb Opponens muscle thickness	The most prominent part of Opponensplasty muscle-extensor polliciongus tendon
7. Thickness of abductor muscle of little finger	The most prominent part of adductor muscles- the little fingers metacarpal bone
8. Diameter of thumb to face	Trapezium- the last part of small fingers metacarpal
9. Diameter of index finger to face	The first part of Metacarpal- the end of Triquetrum
10. Hand perimeter	Around the upper part of Metacarpal bones- exterior part of thumb the upper proximal in the closed position of hand
11. Grip diameter	Connecting the tip of the middle finger and thumb
12. Hand thickness from index finger	The upper part of the meta-carpal joint of the index finger to the underside of metacarpal

Descriptive statistics including mean, standard deviation, and various percentiles were calculated for each hand dimension. Moreover, the normal distribution of measurement data was assessed using the Kolmogorov–Smirnov test. *t-test was also run to compare the difference between two groups in terms of the measurements of manual labor and office job.* All the data were then analysed via SPSS version 18.

The objectives of the research were first explained to all participants and informed consent was obtained from them. Everyone was also free to resign from participation whenever they like.

RESULTS

In this study, 91 individuals have participated. The demographic data of the subjects have been shown in Table 2. According to the results of Table 2, the work experience of manual laborers was larger than office workers.

The significance level of the independent t-test was obtained equal to 0.109, which shows that the null hypothesis is accepted as the p-value is greater than 0.05. In other words, there was no significant difference between manual and office work groups in terms of BMI.

Table 2. Participants' demographic data

	Manual labor				Office job			
	Mean	SD	Range	%	Mean	SD	Range	%
Age (year)	36.6	1.3	23-59	-	33.5	1.2	25-52	-
Height (cm)	175.29	7.42	160-198	-	177.34	8.236	160- 194	-
Weight (kg)	76.37	10.724	60-95	-	81.88	13.445	54-110	-
Work experience	17.75	7.528	7-35	-	11.5	6.969	4-30	-
Occupation	-	-	-	56	-	-	-	44

The mean and standard deviation of hand measurements of manual and office workers has been presented in Table 3. All measurements pertaining to the manual workers of the sample group were significantly greater than those for the office job workers except for grip diameter. The hand perimeter was the greatest value among 12 measured dimensions, whereas the thickness of the side little finger was the smallest one.

Table 3. Descriptive statistics of manual and office job workers

Hand dimensions	*n*	*M*	*SD*	*SEM*
1 Hand length				
Manual	51	195.47	7.809	1.093
Office job	40	192.30	10.188	1.611
2 Palm length				
Manual	51	111.69	4.443	.622
Office job	40	111.45	6.308	.997
3 Palm width				
Manual	51	88.73	4.040	.566
Office job	40	87.02	4.594	.726
4 Thickness of the side little finger				
Manual	51	26.10	2.081	.291
Office job	40	25.38	2.350	.372
5 Width of four fingers together from the central hinge				
Manual	51	83.22	3.529	.494
Office job	40	79.88	4.398	.695
6 Thumb Opponents muscle thickness				
Manual	51	42.82	4.412	.618
Office job	40	41.85	4.086	.646
7 Thickness of the abductor muscle of little finger				
Manual	51	38.33	2.754	.386
Office job	40	37.10	3.296	.521
8 Diameter of thumb to face				
Manual	51	116.63	5.265	.737
Office job	40	114.08	6.669	1.055
9 Diameter of the index finger to the face				
Manual	51	125.20	4.716	.660
Office job	40	122.80	6.001	.949
10 Hand perimeter				
Manual	51	298.86	40.447	5.664
Office job	40	293.00	18.173	2.873
11 Grip diameter				
Manual	51	49.61	7.116	.996
Office job	40	49.70	7.884	1.247
12 Hand thickness from the index finger				
Manual	51	28.88	1.705	.239
Office job	40	27.78	2.259	.357

Table 4 shows a significant difference between the manual labor and office job worker in four dimensions. Moreover, no relation was observed between weight and stature with hand dimension. This result represents the correlation between occupation and four dimensions.

Table 4. Independent samples test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	% Diff	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Year	Equal variances assumed	3.864	.052	1.747	89	.084		1.790	-.429	6.684
	Equal variances not assumed			1.793	88.904	.076	3.127	1.745	-.339	6.594
1 Hand length	Equal variances assumed	2.157	.145	1.681	89	.096	3.171	1.886	-.577	6.918
	Equal variances not assumed			1.628	71.393	.108	3.171	1.947	-.711	7.052
2 Palm length	Equal variances assumed	4.521	.036	.209	89	.835	.236	1.128	-2.005	2.478
	Equal variances not assumed			.201	67.304	.841	.236	1.176	-2.110	2.582
3 Palm width	Equal variances assumed	1.354	.248	1.876	89	.064	1.700	.906	-.100	3.501
	Equal variances not assumed			1.847	78.220	.069	1.700	.921	-.132	3.533
4 Thickness of the side little finger	Equal variances assumed	.190	.664	1.554	89	.124	.723	.465	-.201	1.647
	Equal variances not assumed			1.531	78.547	.130	.723	.472	-.217	1.663
5 Width of four fingers together from the central hinge	Equal variances assumed	1.153	.286	4.021	89	.000	3.341	.831	1.690	4.991
	Equal variances not assumed			3.916	73.676	.000	3.341	.853	1.641	5.041
6 Thumb Opponens muscle thickness	Equal variances assumed	.001	.975	1.079	89	.284	.974	.902	-.819	2.766
	Equal variances not assumed			1.089	86.514	.279	.974	.894	-.803	2.750
7 Thickness	Equal	2.163	.145	1.944	89	.055	1.233	.634	-.027	2.494

of the abductor muscle of little finger	variances assumed									
	Equal variances not assumed			1.902	75.712	.061	1.233	.648	-.058	2.525
8 Diameter of thumb to face	Equal variances assumed	3.382	.069	2.041	89	.044	2.552	1.251	.067	5.037
	Equal variances not assumed			1.984	72.862	.051	2.552	1.287	-.012	5.117
9 Diameter of the index finger to the face	Equal variances assumed	2.791	.098	2.134	89	.036	2.396	1.123	.165	4.628
	Equal variances not assumed			2.073	72.640	.042	2.396	1.156	.092	4.700
10 Hand perimeter	Equal variances assumed	.059	.809	.851	89	.397	5.863	6.889	-7.825	19.550
	Equal variances not assumed			.923	72.863	.359	5.863	6.351	-6.795	18.520
11 Grip diameter	Equal variances assumed	.009	.926	-.058	89	.954	-.092	1.576	-3.224	3.040
	Equal variances not assumed			-.058	79.458	.954	-.092	1.596	-3.269	3.084
12 Hand thickness from the index finger	Equal variances assumed	2.385	.126	2.666	89	.009	1.107	.415	.282	1.933
	Equal variances not assumed			2.578	70.632	.012	1.107	.430	.251	1.964

Table 5 presents the relationship among the measured dimensions of manual labor. Most of the values show a significant relationship among the dimensions. For example, an increase in palm width results in length and palm length in both hands increase. However, the thickness of the side little finger had no correlation with the hand length.

Table 5. Pearson correlation coefficient between the dimensions

Correlation*	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.854	1										
3	0.493	0.350	1									
4	0.375	0.302	0.577	1								
5	0.499	0.386	0.702	0.606	1							
6	0.108	0.140	0.285	0.287	0.266	1						
7	0.276	0.164	0.428	0.499	0.480	0.454	1					
8	0.708	0.659	0.618	0.435	0.597	0.331	0.370	1				
9	0.790	0.728	0.510	0.358	0.510	0.203	0.246	0.690	1			
10	0.308	0.256	0.403	0.364	0.399	0.120	0.165	0.365	0.388	1		
11	0.320	0.343	0.152	0.160	0.022	-0.014	-0.137	0.152	0.219	0.055	1	
12	0.254	0.147	0.507	0.679	0.541	0.276	0.429	0.381	0.276	0.220	0.071	1

* Hand dimensions (Table 1)

The logistic regression analysis was carried out to determine the impact of each independent variable on the dependent variable and the pertaining results have been presented in Table 6. It was revealed that the four dimensions, including the width of four fingers together from the central hinge, the diameter of thumb to face, the diameter of the index finger to face, and hand thickness from index finger could predict changes in the dependent variable.

Table 6. Logistic regression for measurement correlation

Variables	score	Diff	sig
1. Hand length	2.801	1	.094
2. Palm length	.045	1	.832
3. Palm width	3.462	1	.063
4. Thickness of the side little finger	2.404	1	.121
5. Width of four fingers together from the central hinge	13.991	1	.00
6. Thumb Opponens muscle thickness	1.175	1	.278
7. Thickness of the abductor muscle of little finger	3.707	1	.054
8. Diameter of thumb to face	4.068	1	.044
9. Diameter of the index finger to the face	4.428	1	.035
10. Hand perimeter	.735	1	.391
11. Grip diameter	.003	1	.953
12. Hand thickness from the index finger	6.729	1	.009
Overall statistics	23.752	12	.022

Omnibus test results indicate the evaluation of the entire logistic regression model. The effect of the independent variables on the dependent variable was examined and the p-value was obtained significantly smaller than 0.05. Therefore, it can be concluded that hand dimensions have changed due to the type of job (manual labor) and the type of job affects hand dimensions.

Table 7. Classification table [a]

	Observed	Predicted		
		Occupation		Percentage correct
		Manual labor	office job	
Step1	Manual labor Occupation	42	9	82.4
	Office job	13	27	67.5
	Overall percentage			75.8

[a] *The cut-off value equals .500*

The results of Table 8 indicate the role of each variable in the logistic regression model and is the most important table in interpreting the results, the significance, and the effect of each variable on the dependent variable.

Table 8. Variables in the equation

	B	***SE***	**Wald**	**Diff**	**Sig**	**Exp(B)**	**95% C.I for EXP(B)**	
							Lower	Upper
Hand length	-.095	.72	1.720	1	.190	.910	.790	1.048
Palm length	.304	.118	6.601	1	.010	1.355	1.075	1.708
Palm width	.175	.103	2.890	1	.089	1.192	.974	1.458
Thickness of the side little finger	.140	.184	.581	1	.446	1.150	.803	1.648
Width of four fingers together from the central hinge	-.350	.116	9.105	1	.003	.704	.561	.884
Thumb Opponens muscle thickness	-.012	.070	.029	1	.886	.988	.862	1.133
Thickness of the abductor muscle of little finger	.008	.105	.006	1	.940	1.008	.820	1.239
Diameter of thumb to face	-.043	.072	.361	1	.548	.957	.831	1.103
Diameter of the index finger to the face	-.104	.086	1.448	1	.229	.901	.761	1.067
Hand perimeter	.005	.010	.265	1	.607	1.005	.986	1.025
Grip diameter	-.031	.034	.830	1	.362	.969	.906	1.037
Hand thickness from the index finger	-.207	.174	1.415	1	.234	.813	.579	1.143
Constant	17.682	7.278	5.903	1	.015	47784674.76		

DISCUSSION

This study investigated 12 hand anthropometric dimensions among 91 subjects which were divided into two occupation groups. The outcomes of the current study may provide useful information to new designs/design modifications for hand tools, hand apparel, tools and protective equipment items, and other practical applications. The mean and standard deviation of the two occupation groups showed that most values of hand anthropometric dimensions were higher in the manual labor groups compared to office job employees. It can be concluded based on the results that there are few important remarks which should be emphasized here. In the United States, it has been estimated that there are over 260,000 hand tool injuries each year and hand tools mismatches may have contributed to these injuries to some extent [22].

Recent trends in globalization and free trade agreements have forced the majority of industrialized developing countries to open their doors to exporting tools and equipment from industrialized countries. However, most of these tools have been designed based upon the anthropometric data of the industrialized countries rather than those of the importing country [23].

Furthermore, human environment should be designed without pressure and stress. The main problem for an ideal design is the physical difference among the subjects; thus, anthropometric data can be used in a product design. Otherwise, it may lead to the waste of human and financial resources and time indirectly through work-related diseases [2-24]. Physical differences must be considered in the design and post-production evaluation of equipment [25]. In the study of Chandra, the hand index for male industrial workers of India estimated where 1540 male industrial workers with an age range of 18 to 62 years were studied. In that study, it was observed that hand length with 186.52 (mm) and hand breadth with 84.29 (mm) were smaller than the dimensions in the present study [20]. Sajit Kumar's investigation on agricultural workers' hand anthropometry showed that there was a significant difference amongst age groups; occupation groups; and different countries' hand length (175.1mm), palm length (97.2), and handbreadth (82.3) were smaller than those in the present study, while the mean values of hand thickness (28.1) and grip diameter (52.3) were larger than those in the repairman hand dimension [26].

Workers who are using hand-force tools expose their upper extremity to biomechanical stress and strain. Previous studies have indicated that tool design may play a significant role in the development of work-related disorders of hands and forearms. Therefore, design, evaluation, selection, and use of hand-powered tools are major concerns of the professionals in the field of ergonomics. Among the other design parameters, the grip span size of a hand-force tool has been hypothesized to be a critical factor contributing not only to the CTD risk factors but also to the workers' performance [27].

The anthropometric data pertaining to East Indian farm workers showed that the mean value of hand circumference was 19.2 mm, which is smaller than the mechanics' size in the present study [28]. All the following hand dimensions in the present study were larger than L.P.Gite and B.G study results. The Indian farmworkers' hand dimension for tool design showed that hand length, handbreadth, hand thickness, palm length, and grip diameter (inside) dimensions had mean values of 18.3, 8.3, 2.8, 10.3, and 4.1 mm, respectively [29].

Hands are the most frequently used body parts. Each hand is composed of 27 bones and 15 joints and contains more pieces of measurement information than any of the other body parts [21]. Hand dimension differences should be considered for Iranian workers in designing tools. Okunribido measured 18 hand landmarks on 37 Nigerian farmworkers and found a significant difference between them and other regions. For example, the proximal phalange lengths of the middle finger and the little finger were significantly smaller than those of their counterparts in Hong Kong, the United States, and Europe [30]. In the Shyamal study, volleyball grip strength was evaluated and it was observed that a significant difference exists between the length, width, and grip strength [31]. This point should be taken into account because a lot of tools used in Iran are made in other countries. It is noteworthy that such a difference in these tools may lead to hand disorders.

Hsiao's evaluated firefighter's hand anthropometry and structural glove sizing showed that the 197.6 mm hand length, 113.8 mm palm length, and

97.2 mm handbreadth, all of which are larger compared to our mechanic sample in Iran.

In Chandra's study, thirty-seven hand anthropometric characteristics relating to 878 male industrial workers working in thirty-eight industries of Haryana state of India were analysed and all dimensions were obtained larger than those in the present study [32].

CONCLUSION

In the present study, four hand anthropometric dimension differences between two occupational groups was significant in such a way that dimensions were higher in the manual labor group than those in the office job group. Hence, it is suggested that tool designers should consider this finding in their designing process. Also, the results obtained from Iranian hand dimensions can be used for tool design. In this research, the time and resource constraints were among the limitations. It is recommended that further research with larger data pools be carried out in the future to illuminate the current issue more than ever.

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