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Precise Evaluation of Anthropometric 2D Software Processing of Hand in Comparison with Direct Method

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ABSTRACT

Various studies carried out on different photo anthropometry, but each one had some deficiencies which during the years they have been resolved. The objective of this paper is to test the efficiency of two-dimensional image processing software in photo anthropometry of hand. In this applied research, 204 office workers and industrial workers were selected. Their hands were measured by manual with photo anthropometric methods. In this study, designing the “Hand Photo Anthropometry Set,” we tried to fix the angle and distance of the camera in all of the photos. Thus, some of the common mistakes in photo anthropometric method got controlled. The taken photos were analyzed by Digimizer software, version 4.1.1.0 and Digital Caliper (Model: Mitutoyo Corp., Tokyo, Japan) was used via manual method. *t*-test statistical test on data revealed that there is no significant difference between the manual and photo anthropometric results ($P > 0.05$) and the correlation coefficients for hand dimensions are similar in both methods illustrated in the range of 0.71-0.95. The statistical analyses showed that photo anthropometry can be replaced with manual methods. Furthermore, it can provide a great help to develop an anthropometric database for work gloves manufacturers. Since the hand anthropometry is a necessary input for tool design, this survey can be used to determine the percentiles of workers’ hands.

Key words: *Digital photography, ergonomics, hand, manual anthropometry, photo anthropometry*

INTRODUCTION

Various studies conducted on different photo anthropometry, but each one included some deficiencies and during the years, which were resolved.[1,2] The anthropometry studies can be divided into three categories: (1) Manual anthropometry, (2) two-dimensional (2D) photography and (3) three-dimensional (3D) photography. A review in literature shows that these methods have adequate precision[3] and of course each one has some advantages and disadvantages.

The direct anthropometry is done by the caliper and tape measure.[4,5] The examiner should possess adequate skill.[6] During the measurement some errors may occur, due to pressure of measuring tools on soft-tissues.[5,7] Now-a-days, most of the anthropometry studies are carried out by imaging and computer software analysis and we know modern advanced methods, such as 3D scanning are very expensive.

The science of image processing has resulted special attractions to anthropometry and has expended its applications in various areas, specially forensics, anthropology, clothing industry, designing work space, designing manual tools, etc.[8,9] In medical science, the first accurate anthropometry was done on a human body and dipping the limbs was used to determine the volume of the body, which may not give correct values due to changes after death.[6,10]

The anthropometry of the face is also used in medical sciences, dental sciences, face cosmetic surgeries and hence forth[11,12] and also for determining the face characteristics like checking the patient condition before the cosmetic surgeries. Since the measurement from photo is much simpler some spots may be covered and remain hidden by the skin and adipose tissue that need to be touched.[13] These places can be located before photography.

Despite the high costs, a significant difference between the 3D scanning techniques and manual methods may be identified. In a study, Han *et al*. compared the results of traditional and 3D scanning and found that the values round the body have the most difference, which has increased with the increase of body mass index.[14]

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Meunier and Yin simultaneously used two cameras and 2D image processing software and measured six different dimensions of the body including around the neck, around the chest, around the buttock, around the loin, height and length of the sleeve. They came to this conclusion that linear measurements like height are more accurate than peripheral measurements and this method can replace with overall traditional methods.[15]

From the standpoint of biomechanics, there is a direct relationship between musculoskeletal injuries and occupational risk factors and working with unsuitable hand tools can exacerbate these symptoms.[16,17] In a study performed on Colombian floriculture workers, showed that the hand size in the present study population appears to be significantly different from those of other populations' hand size. And there is not much consistency between their hand size and their hand tools; therefore, this matter can lead to serious injuries to hand.[18] Thus, with respect to the importance of ergonomics of tools, existence of an anthropometry database is essential in every society and this data should be up-to-date. As the size of some body parts may alter during years.[19] Hence, developing simple and quicker anthropometry methods would encourage researchers to gather this data. According to the survey, most of the Iranian anthropometric studies have been manual. And considering that the design tools should be based on the physical dimensions of user, consequently, providing bank of Iranian population is essential. However, due to the difficulty of manual methods so far scattered information is provided in the context of Iranian population. Unfortunately, most of the industrial designers are forced to use anthropometric data of European or American countries; it'll cause the maladjustment between the device and the user. Hence, the purpose of this study is to compare the accuracy of 2D image processing software with the direct method and present its results to ergonomic specialist, designers and producers.

MATERIALS AND METHODS

In this applied research, 204 office workers and industrial workers were selected. Their hands were measured by manual with photo anthropometric methods. People with bodybuilding background, deformations and swollen hands were excluded from the research. A total of 76% of participants were men and 24% of them were women. Nearly 91.7% of them were left-hand and 8.3% were right-hand. 68.6% had industrial jobs and 31.4% had office jobs. The other demographic information is summarized in Table 1. In this study, 14 dimensions of the hand were measured with both manual method digital caliper and 2D photo anthropometry method as described in Figure 1. The measured dimensions of the hand were selected based on National Aeronautics and Space Administration recommendation.[20]

Digital caliper (Model: Mitutoyo Corp., Tokyo, Japan) was used in manual method. Digital caliper resolution was 0.01 mm and its precision was 0.01 mm.

In anthropometric method, four pictures were taken from people's hand by a Sony DSC-W35, 7.2 Mega pixels digital camera as shown in Figure 1. In order to maintain the distance between the hand and camera, "Photo anthropometry set" (designed by the researcher) was used [Figure 2]. An on-screen ruler was also used as stage which their hands could be placed on it. This set was designed to measure also the other dimensions of hand such as internal and external diameter of grip for future.

Then, images were analyzed by Digimizer version 4.1.1.0 software. Digimizer [Figure 3] is a very flexible and simple software package, which is very useful for analyzing the

Table 1: Demographic characteristic of participants

	Min	Max	Average	SD
Age (year)	23	49	34.6	6.2
Weight (kg)	47	121	75.1	16.2
Height (cm)	153	194	174	8.7
BMI (%)	17	38	24.6	4.3
Experience (year)	1	27	9.7	6.2

SD – Standard deviation; BMI – Body mass index

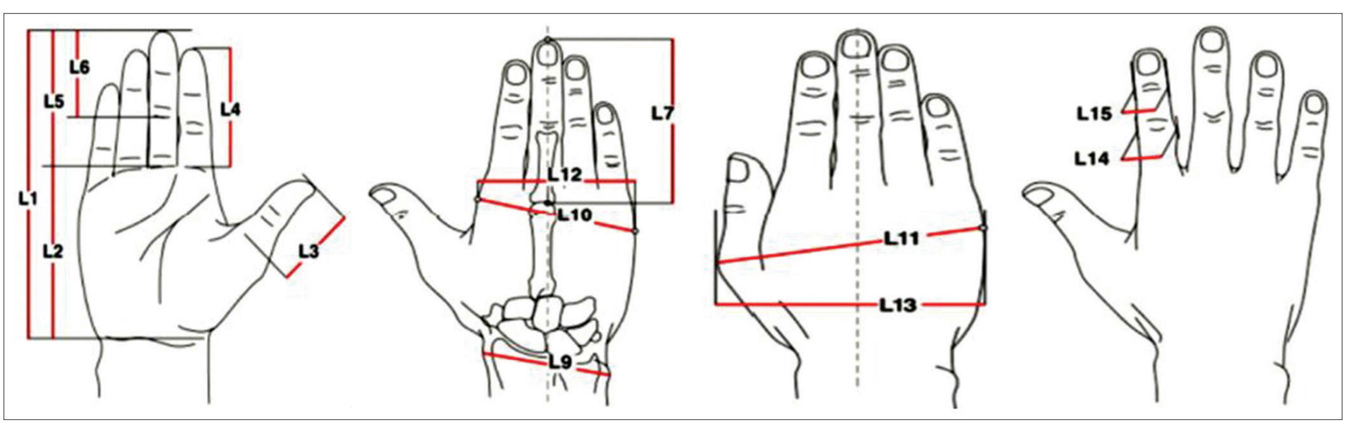

Figure 1: Measured dimensions of the hand

images. This software was compatible with windows XP and Vista and it was based on counting the pixels, per unit of length and values entered into the right table. Then, after opening the image in the software, using the ruler next to hand, the number of pixels/unit of length was defined and then by drawing a line between the desired points, we obtained the distance between them. The table with the sizes was compatible to Microsoft Office Excel. In this way, the error while entering the numbers into analyses software like Excel or SPSS was resolved and a lot of time saved.

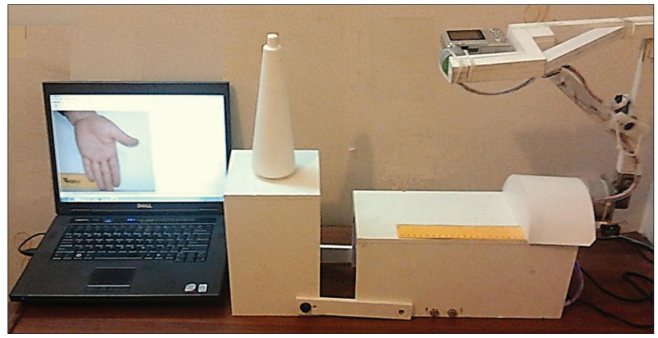

Figure 2: Hand photo anthropometry set

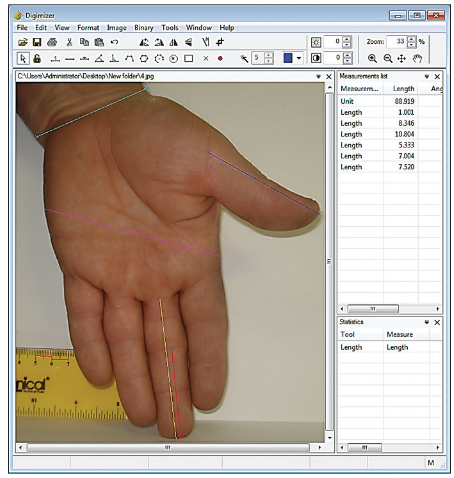

Figure 3: Image analyzing software for hand images

FINDINGS

The *t*-test shows [Table 2] no significant difference between the two manual and photo anthropometry methods ($P > 0.05$). For example, the average of length of hand in photography method is 19.68 ± 2.08 cm and in manual method it is 19.56 ± 2.23 cm; is not a significant difference using *t*-test statistical exam ($P = 0.085$).

Correlation coefficients between hand dimensions in the two methods are the same shown in the range of 0.71-0.95 [Table 3]. The correlation between hand dimensions (L1, P1) and palm dimensions (L2, P2) is shown in a scatter plot [Figure 4].

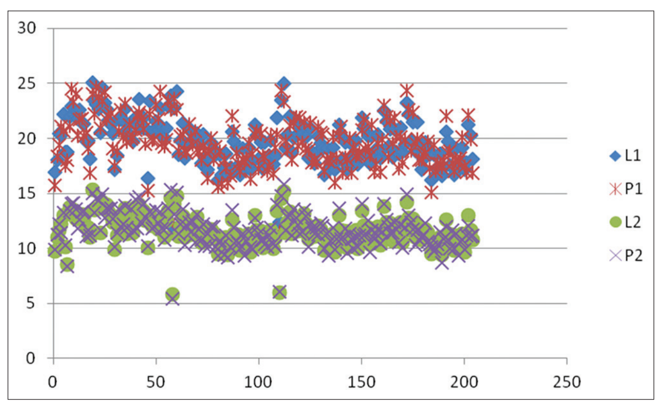

Figure 4: The scatter plot between dimensions of length of hand (L1, P1) and dimensions of palm (L2, P2)

DISCUSSION AND CONCLUSION

Digimizaer version 4.1.1.0 was used determine the actual dimensions of objects in images. And its application for hand anthropometry was used in this research, for the very first time. The findings imply that the average of hand dimensions, has no significant difference in the two methods ($P > 0.05$), in other words, the dimensions of the hand are the same in each method. In this study, designing "hand anthropometry set", we tried to fix the angle and distance of the camera in all images. Thus, some common errors in photo anthropometry method prevented to occur.

Manual anthropometry is a simple, low cost, time consuming method and needs the cooperation of the individual who is being tested and at the end, it provides a list consisting numbers for us. However, this method may not be feasible to perform for some patients in medical centers. Hence, advanced equipment could be very effective in indirect anthropometry.[21]

Hung *et al*. designed an anthropometry computer system and the results of their study demonstrated that some peripheral dimensions like around the neck has a significant difference in manual method, but linear dimensions like height of arm had a high degree of accuracy. They found out that the reasons for this difference were because of missing some key spots in the image and also the weak contrast between the individual's clothes and their background.[22]

Ozkul *et al*. also used software to determine the angles and proportions of patient's face before and after face surgeries. As the basis of this software is the proportion between the two parts, thus he could not determine the height of an individual part or the distance between two parts (e.g. eyes).[3] Although, this study showed that the length of a particular member is easy to determine.

Table 2: Descriptive indicators of dimensions in two manual and photo anthropometry methods

Dimensions	Anthropometry method	Mean±SD (min-max)	Significant (2-tailed)
L1-height of the hand	Image 2D	19.68±2.08 (12-25)	0.085
	Manual	19.56±2.23 (11.5-24.7)	
L2-height of palm	Image 2D	11.61±1.39 (5.8-15.3)	0.142
	Manual	11.66±1.54 (5.4-15.8)	
L3-height of thumb	Image 2D	6.94±0.95 (5.1-9.7)	0.055
	Manual	6.87±1.02 (5-9.7)	
L4-height of index finger	Image 2D	7.44±0.88 (5.7-10.1)	0.498
	Manual	7.46±0.99 (5.5-10.5)	
L5-height of middle finger	Image 2D	8.05±0.94 (4-10.4)	0.58
	Manual	7.99±1.01 (3.7-10.3)	
L6-height of second and third knuckles of middle finger	Image 2D	5.10±0.67 (2.3-8.9)	0.168
	Manual	5.13±0.73 (2.1-9.2)	
L7-height of middle finger (posterior)	Image 2D	11.07±1.04 (8.7-14.8)	0.815
	Manual	11.06±1.34 (1.8-15.5)	
L9-width of wrist	Image 2D	6.76±1.02 (5.3-9.3)	0.061
	Manual	6.61±1.03 (4.7-9.5)	
L10-width of palm	Image 2D	9.51±1.11 (7.5-13.4)	0.645
	Manual	9.49±1.22 (4.4-12.9)	
L11-maximum width of palm	Image 2D	10.95±1.44 (8.5-15.5)	0.761
	Manual	10.96±1.6 (3.9-16.3)	
L12-width of palm (vertical)	Image 2D	9.18±1.13 (7.2-12.5)	0.064
	Manual	8.91±1.21 (6.7-12.6)	
L13-maximum length of palm (vertical)	Image 2D	10.71±1.32 (8.4-14.2)	0.358
	Manual	10.74±1.39 (8.3-15.2)	
L14-width of middle finger knuckle	Image 2D	2.37±0.3 (1.8-3.2)	0.204
	Manual	2.30±0.44 (1.7-6.7)	
L15-width of middle finger knuckle	Image 2D	1.94±0.28 (1.2-2.7)	0.086
	Manual	1.99±0.28 (1.5-2.9)	

SD – Standard deviation

Table 3: Level of correlation between measured dimensions in the two methods

Variable	Correlation	Significant
L1 and P1	0.90	<0.0001
L2 and P2	0.94	<0.0001
L3 and P3	0.94	<0.0001
L4 and P4	0.93	<0.0001
L5 and P5	0.94	<0.0001
L6 and P6	0.95	<0.0001
L7 and P7	0.80	<0.0001
L8 and P8	0.94	<0.0001
L9 and P9	0.88	<0.0001
L10 and P10	0.91	<0.0001
L11 and P11	0.93	<0.0001
L12 and P12	0.93	<0.0001
L13 and P13	0.71	<0.0001
L14 and P14	0.92	<0.0001
L15 and P15	0.90	<0.0001

In another survey, the measurement of foot's dimensions is studied in two methods: Digital photography and manual photography. The results showed that the measured size of the foot is the same in both ways.[23]

In a similar research, some of the body's linear dimensions were measured by an aluminum frame as scale and also with computer software. The average error in this method is about 2.5 mm.[2] The important point in photo anthropometric is to evaluate the appropriate scale. In the study which was done by Das and Kozey, two colored ropes were used as scale in body's length and width and made a meaningful error in our measurement.[1] However in this study, number of pixels in length unit was used as scale.

In anthropometry method, it was observed that because it was less time consuming and also because there wasn't any body contact with measuring tools, people were more willing to cooperate. In this method, a photo archive was developed that could be reviewed in the future.

Among the capabilities of this software, ability to edit images, ability to set the contrast and brightness, ability to change the background image, ability to change images to grayscale mode, ability to define the unit of measurement even in Nanoscale, measure angles, determine the center of segment, reduce image noises and exporting Excel files for quicker statistical analyses, can be named.

The dimensions under study in this research were linear and in comparison to manual methods had adequate accuracy. And this study can be a start of reviewing the accuracy of this software in measuring peripheral dimensions of the body, such as around the wrist, chest and so forth. With respect to the widespread use of different kinds of safety gloves, this study can be used for determine the percentiles of the hands for efficient sizing of safety gloves. This study can also be a preface for more investigations for the development of an anthropometry database.[24-33]

The statistical analyses showed that photo anthropometry can be used instead of manual methods. Furthermore, since the hand anthropometry is a necessary input for tool design, this survey can be used for determining the percentiles of workers' hands.

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