3D Hand Anthropometry of Korean Teenager's and Comparison with Manual Method

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Abstract. The requirements of wearing products fitting comfort was continuously increasing and considerable attentions had been paid for a long time. The assessment of the physical dimensions of the human hand provided a metric description to establish human-machine compatibility. Higher accuracy in hand anthropometric measurements could be achieved with the aids of an image analysis system. Scanning of hand surfaces either 2D or 3D was an alternative method for manual measurements. Three-dimensional anthropometry may lead to significant improvement in fitting comfort of wearing products. The purpose of this study was to measure 3D hand anthropometry and compared it with manual methods. For that purpose, 10 hand measurements of the right hand (lengths, breadths, and circumference of hand and fingers) were taken from 1,700 middle and high school students by age ranged from 13 to 19 years old. The hand was measured by manual (using anthropometric sliding, spreading calipers and measuring tape) and using a high-resolution 3D hand scanner (NEXHAND H-100, Knitech, South Korea) with the scanning accuracy ± 0.5 mm. From the scanned data, the hand measurements were extracted using scanning software (Enhand, Knitech, South Korea). Mean and standard deviation for each hand measurements were calculated. T-test statistical test on the data revealed that there was no significant difference between the manual and 3D hand measurements ($p > 0.05$). Therefore, 3D anthropometry can be replaced with manual methods. The data gathered may be used for ergo-design applications of hand tools and devices. And also it can provide a great help to develop a hand anthropometry database for hand wearing products.

1 Introduction

Anthropometric data are one of significant factors in designing machines and devices. Incorporating anthropometric data would yield more effective designs, ones that are

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more user friendly, safer, and enable higher performance and productivity. The assessment of the human hand physical dimensions provides a metric description to establish human-machine compatibility [1, 2, 3]. To protect hands from the hazardous work environments workers are commonly used the gloves [4]. The experts in the certain sports used the custom-made gloves to their personal specification requirements. Pressure therapy gloves were mainly found in the area of pressure therapy, those gloves are designed to apply acceptable pressure to hand and fingers with the purpose to increase the rate of scar maturation, prevent contracture formation, and enhance cosmetic appearance without impairing circulation [5, 6, 7, 8]. There are many types of gloves available in the market to protect against a wide variety of hazards. An accurate and effective measurement of hand anthropometric dimensions is crucial to optimize the effectiveness and practical use of the gloves [4]. There are two hand measurement methods namely direct and indirect. Direct measurement method used the tools such as flexible measuring tape, calipers, martin anthropometry device, measuring boards and rulers are traditionally used to obtain hand dimensions [9]. The indirect methods such as three-dimensional (3D) image analyses have been widely adopted for taking body dimensions in the design of various products including medical, garments, safety instruments, etc., [10, 11, 12, 13, 14]. Along with the 3D image analysis, multi-camera photogrammetric systems based on two-dimensional (2D) images for body measuring have been developed in various studies [15, 16].

The objective of the present study was Korean teenagers' hand anthropometric measurements by using indirect method using 3D scanner and compare against the direct measurement method. This research work aims to provide a useful reference for the development of hand anthropometry database.

2 Method

2.1 Participants

Ten measurements (lengths, breadths, and circumference of hand and fingers) of the right hand from 1,700 middle and high school students were measured and their age ranged from 13 to 19 years old. Table 1 showed participants demographic information.

Table 1. Demographic information for participants

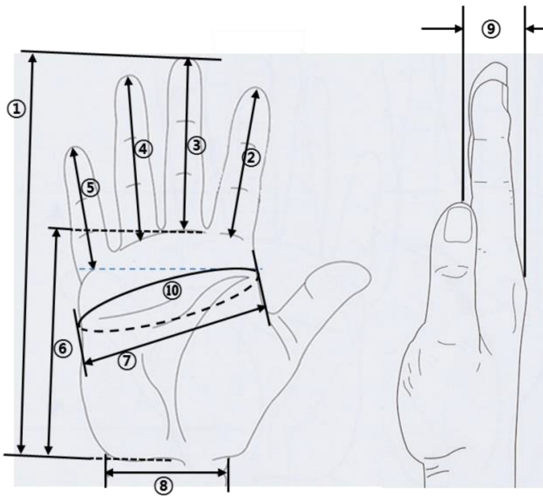
	Height (mm)	Weight (kg)	BMI
N = 1,700	1593.37±52.26	52.72±8.26	20.73±2.88

2.2 Methodology of Measurement

The instruments used for the manual measurements were the anthropometric sliding and spreading calipers, and measuring tape (martin anthropometer). The instrument used for the indirect measurements was a high-resolution 3D hand scanner (NEXHAND H-100, Knitech, South Korea) with the scanning accuracy ± 0.5 mm. The 3D scanner generates a 3D digital hand, and then computer software (Enhand, Knitech, South Korea) measures 3D hand dimensions from the digital hand (Fig. 1). The generated 3D digital hand with its several dimensions can be directly applied to design of product shape. Mean and standard deviation for each hand measurement were calculated and compared.

Fig. 1. Measurement tools used (a: Martin anthropometer, b: NEXHAND H-100 hand 3D scanner)

The selected hand dimensions measured from the direct and indirect methods were showed in Fig. 2



	Measured Items
①	Hand length
②	Index finger Length
③	Medius finger length
④	Ring finger length
⑤	Little finger length
⑥	Palm length perpendicular
⑦	Hand breadth with thumb
⑧	Hand breadth with wrist
⑨	Hand thickness
⑩	Hand circumference

Fig. 2. Hand items measured from the direct and indirect methods

3 Results and Discussion

The t-test was performed to compare the significance between the direct and indirect measurement methods (Table 2) for the measured items. The t-test results showed that there were no significant differences between two measurement methods for whole items measured.

Table 2. Right Hand Anthropometric Measurements Comparison between Direct and Indirect Method using T-Test

Measured Items	Mean (SD) in mm		p-value
Hand length	D	169.21 ± 7.30	0.182
	I	168.93 ± 4.36	
Index finger Length	D	65.32 ± 3.61	0.655
	I	64.90 ± 1.61	
Medius finger length	D	72.75 ± 3.59	0.846
	I	72.54 ± 1.57	
Ring finger length	D	68.01 ± 3.88	0.246
	I	68.05 ± 2.14	
Little finger length	D	53.63 ± 3.98	0.54
	I	53.13 ± 1.28	
Palm length perpendicular	D	97.05 ± 5.09	0.854
	I	97.02 ± 3.15	
Hand breadth with thumb	D	76.91 ± 3.69	0.68
	I	75.84 ± 2.54	
Hand breadth with wrist	D	52.08 ± 3.16	0.15
	I	51.87 ± 2.58	
Hand thickness	D	26.29 ± 2.15	0.14
	I	26.14 ± 1.24	
Hand circumference	D	177.73 ± 9.0	0.94
	I	1776.24 ± 2.1	

D: Direct measurement method, I: Indirect measurement method.

Garrett, 1971 [9] performed the direct measurement using traditionally available tools to make the glove design and pattern development. However, the direct measurements are time consuming; the accuracy of the measurement depends on the person who is measuring those dimensions. Another important point need to be highlighted that using direct measurement methods there are limited number of hand dimensions can be measured. Nevertheless, the 3D hand scanned data contains numerous hand dimensions. From the 3D scanned data, many dimensions can be extracted using custom build software tools for example Rapidform. Also the repeatability of the indirect measurement is higher than the direct measurement method [4]. However, there are still in many developed countries both measurement methods are employed to construct national anthropometry database. The existence of an anthropometry database is essential in every society and this data should be up-to-date. As the size of the some body parts may alter during years [16]. With the indirect measurement methods it would be easier to update the anthropometry database.

4 Conclusion

The study performed Korean teenagers' hand anthropometric measurements by indirect measurement method using 3D hand scanner and compared the dimensions against the direct measurement method. The findings of this study imply that the average of hand dimensions has no significant difference in the two methods ($p > 0.05$). The statistical analyses showed that indirect measurement methods (using 3D scanner) can be replaced with direct measurement methods. It can provide an extended help to develop an anthropometric database for gloves manufactures and also to develop national anthropometric database.

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