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An anthropometric survey of Korean hand and hand shape types

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ABSTRACT

Some tools or interfaces designed not to fit the size of individuals make users experience discomfort and lower productivity. Previous studies on hands tend to focus only on measuring lengths of various hand parts and reporting the distribution of these measurements. In order to overcome this, we aim to distinguish major factors that determine hand shapes and categorize the hand shapes of Koreans. 321 people (167 males and 154 females) enrolled as subjects of this study by their own will. 21 hand dimensions including length, breadth, and circumference of the hand were measured. T-value and correlation coefficients were compared to identify the difference of measurement values and the relation between hand measurements and heights. Factor and cluster analysis was conducted to identify hand shape types of Korean. Descriptive statistics of Korean hand dimension were presented. 78.3% of the variance of hand shape was explained by 3 major factors (factor 1: hand breadth, factor 2: palm length, factor 3: finger length). We also distinguished 4 hand shape types and found that wide hand and short finger type (type 1) was the most common in males, but narrow hand and short finger type was the most common in females. Korean males and females had wider hands and shorter fingers than the people of 8 other nations. We expect products and interfaces to be designed based on these understandings on the characteristics of Korean hands that the result of our study suggests.

1. Introduction

People control machines in everyday life by interacting with interfaces that have been designed, and they also use various hand tools to carry out the corresponding tasks. Frequently, tools or interfaces are not designed to conform to the size of the user's hands, and in such cases, users can experience discomfort that eventually results in a decrease in productivity (Aghazadeh and Mital, 1987; Karunanithi et al., 2001; Goonetilleke, 1998; Rok Chang et al., 1999). Modern industry has become increasingly prosperous due to international trade, and many companies are now manufacturing more and more products for worldwide consumption (Okunribido, 2000). However, it will be difficult to produce goods that will satisfy consumers in any given nation if information on the size of their bodies is not thoroughly investigated (Xiao et al., 2005). Thus, anthropometry, which is used to obtain the exact size of diverse body parts, has recently become more and more important for product manufacturing and various other service fields (Goonetilleke et al., 1997; Witana et al., 2006).

Our hands are two of the most frequently used body parts. They are composed of 27 bones and 15 joints each and contain more measurement information than any of the other body parts. Certain products, such as hand tools, should be designed based on these measurements. Many previous studies have focused on the importance of mapping and measuring the human hand, and several prior studies have measured the dimensions of the hand. For example, Davies measured 28 hand landmarks on 92 Europeans, compared the hand sizes of different ethnic groups, and found that the hand parts of European females were, on the whole, significantly smaller than those of their West Indian counterparts (Davies et al., 1980). Of the various parts, the width at the tip of middle finger exhibited the greatest difference across different ethnic groups.

Okunribido measured 18 hand landmarks on 37 Nigerian farmworkers (Okunribido, 2000) and found a significant difference with other regions. For example, the proximal phalange length of the middle finger and the little finger was significantly smaller than that of their counterparts in Hong Kong, United States and Europe. In addition, the depth of the little finger and the middle finger in Nigerian females was reported to be about 25% thicker than those of their Hong Kong counterparts. However, the cause for these differences has not been thoroughly investigated.

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Imrhan measured the hand dimensions of 40 Bangladeshi males (Imrhan et al., 2006), and these dimensions were then compared to those of Mexican and Vietnamese males (Imrhan and Contreras, 2005). Most of the hand dimensions of the Bangladeshi men were significantly smaller than those of the Mexican men, with the most significant difference being the depth at the proximal joint of the little finger. Prado-lu measured the head, chest, foot and hand size of workers from the Philippines and reported the hand length, breadth, and circumference as well as the wrist circumference (Del Prado-Lu, 2007). Mandahawi measured the landmarks on the hands of 235 Jordanian people. The percentile for the dimensions of each hand part for the 235 Jordanians are presented and compared to those of their Bangladeshi, Nigerian, and Vietnamese counterparts (Mandahawi et al., 2008). In the depth-related hand parts, the dimensions for the Jordanian males were significantly larger than those for the Hong Kong males, and Jordanian women had a significantly greater size in terms of the finger breadth and depth-related variables than their UK counterparts.

Instead of only measuring size, many case studies have also derived the shape of different body parts. Clerke measured the hand dimensions of 232 Australians teenagers, and then used the hand width and length ratio to identify three hand shape types (long, average, square) (Clerke et al., 2005). Fallahi defined the hand shape as the ratio of the hand width to the hand length and then found a difference in the grip strength that depended on the shape of the subjects' hands (Fallahi and Jadidian, 2011). Park identified five factors to describe the body shape of the obese Koreans, and the factor scores were used to classify their body shapes into four types (Park and Park, 2013). Kouchi analyzed the hand dimensions of Japanese subjects in order to obtain a representative Japanese hand model. She conducted a factor analysis and identified 7 factors that explain the variability in the hand size to then derive digital 3D hand model from the boundary conditions of the hand dimensions (Kouchi et al., 2005).

A number of studies have used body size measure to provide guidelines for hand tools. Kwon identified three key hand dimensions to design gloves (length, circumference, and breadth) from among 70 different dimensions. He concluded that greater size options should be provided for males due to the greater variability in the size of the male hand (Chae et al., 2004). Ki reported on five hand measurements that represent the characteristics of Korean hands (Sang ho and Doyoung, 2012), including hand length, middle finger length, hand circumference, hand breadth and hand thickness. He also used regression analysis to provide details on the hand part dimensions corresponding to the length of people's hands. This study was intended to provide a main reference point to produce gloves and hand tools for Korean users. Chang proposed garden tools (shovel, rake, and hoe) to suit a user as a result of ergonomic studies on tool handles (Rok Chang et al., 1999). In addition, many studies on hand tool guidelines have also been conducted (Tichauer and Gage, 1977; Meagher, 1987). These studies have argued that incorrect hand tools may result in cumulative disorders, so to increase user satisfaction, the design of hand tools should provide more diversity in sizing options than the standard “one size fits all” approach that is currently used.

Previous studies on Korean hands tend to focus only on measuring the length and breadth of the hand, and the distribution of these measurements was then reported. Thus, most companies have selected only the hand length and breadth as relevant metrics to design gloves and user interfaces. Most of the time, companies design such products based on the average of these measurements and do not take into account for the distinct hand shapes within the Korean population because there are few studies providing such guidelines. In this study, we include various data on the hand dimensions of both Korean males and females, including variables related to the breadth and circumference of various hand parts. Statistical methods are then used to distinguish the major factors that determine the hand shapes and to categorize the hand shapes that are found within the Korean population. Ultimately, we expect the results of our study to be used as baseline data to design and develop products related to hands.

2. Method

2.1. Subjects

This study uses anthropometric data from the Korean Hand Measurement Project, led by the Korean Agency for Technology and Standards. 167 males and 154 females enrolled in this study of their own will, and a small stipend was provided to each participant as compensation for their involvement in this study. All 321 subjects had no history of hand or spine related disorders, were of the same race, born and raised in Korea, and were evenly distributed in terms of their occupation (office/manufacturing), and age. The demographics of the subjects are shown in Table 1.

2.2. Measurement

In this study, all 27 hand dimensions that were common among previous studies were measured, as defined in Fig. 1 and Table 2 (García-Cáceres et al., 2012; Hall et al., 2007; Cakit et al., 2014). Digital calipers were used to measure the length, breadth and thickness of the hands and fingers to an accuracy of 0.01 mm, and tape measures were used to measure the circumference of the hands and finger joints. Digital scales and a stadiometer were used to measure the body weight and stature. The individuals that were employed to conduct these measurements were provided with 18 h of training in an anthropometric measurement.

2.3. Data analysis

All of the data were analyzed using MS EXCEL and SPSS 21. Descriptive statistics (including the mean, standard deviation and various percentiles) for the value of each hand dimension were calculated and are presented herein. A Kolmogorov–Smirnov test was conducted to test whether the data set of the measurements conformed to a normal distribution, and eight variables for males and two variables for females were found not to show normality. A T-test was used to compare the differences in the measurements for the males and females. The relationship between the hand measurement and the stature was identified by using Pearson correlation coefficients, and a factor analysis was carried out with 27 variables in order to determine a suitable set of factors to explain the variability in the hand shape (Varimax rotation). The change in the slope of the scree plot indicated that three factors were suitable to this end, and after the factor analysis, the Ward and Euclidian

Table 1
Subject characteristics.

	Male			Female		
	Mean	SD	Range	Mean	SD	Range
Age (year)	42.5	13.2	20–70	46.5	16.4	20–83
Stature (cm)	169.5	6.3	153–188	155.5	7.4	137–174
Weight (kg)	70.6	10.4	45–101	55.4	8.5	40–90

Gender	Age					Region		Occupation	
	20's	30's	40's	50′	>60's	Urban	Rural	Office job	Production
Male	20.4%	20.4%	20.4%	19.2%	19.8%	69%	31%	59%	41%
Female	20.1%	20.1%	20.1%	19.6%	20.1%	58%	48%	55%	45%