

Anthropometric Measurement of the Hands of Chinese Children

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Abstract. This paper presents the results of a nationwide anthropometric survey conducted on children in China. Eight hand anthropometric dimensions were measured from 20,000 children with age ranged from 4 to 17 years old. Mean values, standard deviations, and the 5th, 95th percentile for each dimension were estimated. The dimension difference between age, gender and difference between Chinese and Japanese were analyzed. It was found that the mean values of the dimensions showed a gradual increase by age. The dimensions had no significant difference between genders for the children from 4 to 12, but the difference became significant for the children from 13 to 17. Comparison between Chinese and Japanese children showed that Chinese children tended to have relatively longer and broader hands than Japanese children. These data, previously lacking in China, can benefit the children's products design.

Keywords: Hand; anthropometric measurement; Chinese children.

1 Introduction

Anthropometric data are essential for the correct design of various facilities. Without such data, the designs can not fit people properly. This is especially true for children. The comfort and functional utility of the workspace, equipments and products which designed based on the anthropometric data are related with children's health and safety. Many anthropometric studies had been undertaken to determine the size of children [1][2][3][4]. In china, a nationwide anthropometric survey project for children from 4 to 17 was completed from 2005 to 2008. This survey measured more than 100 anthropometric dimensions, including body size as well as head, foot and hand size. The hand anthropometric data for the children are presented in this paper. The purpose is to determine hand dimensions in different age groups to facilitate the design of such products as toys, gloves and other components in their daily life.

2 Methods

2.1 Subjects

China is a vast country with an area of over 96 million square kilometers. Children in different regions have large difference in body development status and body shape. To

make the anthropometric survey more representative, a stratified cluster sampling method was used to determine the distribution of the samples.

The whole country was divided into six geographical areas, which was in accordance with the adult anthropometric survey in 1988[5]: north and northeast area, central and western area, the lower reaches of the Changjiang River area, the middle reaches of the Changjiang River area, Guangdong-Guangxi-Fujian area, Yunnan-Guizhou-Sichuan area. From the statistical point of view, the people within each area have similar body shape and body size, but body shape and size for the people in different areas are different with other.

The sample size in each area was determined based on the distribution of children's population reported by China National Bureau of Statistics [6]. One or two cities in each area were selected and some kindergartens, primary schools and high schools were taken from these cities. Within each kindergarten, primary school or high school selected, a number of classes were taken and all the children in which were measured until the number of children desired in per age group was met.

According to Report on the Physical Fitness and Health Surveillance of Chinese School Students (2000) [7] and Report on the Second National Physical Fitness Surveillance (2000) [8], the children were subdivided into five age groups: preschool (4-6), lower primary (7-10), upper primary (11-12), middle school (13-15), high school (16-17). In this survey, for example, 10 years old means ones whose age is from 9.5 to 10.5 years old. The sample size in each age group was distributed according to the children's body development status. The sample size of preschool age group may be smaller. Within lower primary and middle school age group, sample size should be increased, and for upper primary and high school age group the sample size can be reduced appropriately.

Based on this sampling plan, body dimension data were obtained from more than 20,000 children in ten provinces distributed in the six geographical areas.

2.2 Dimension Measurements

Instead of traditional Martin type anthropometer, a two-dimensional color scanner was adopted for hand anthropometric survey. The ratio of image size with the real hand size was 1:1 with a resolution of 150. They were kept in BMP format. The advantages of such system are that it would be much faster than Martin method of collecting hand data and it is applicable for a large-scale anthropometric survey. And it would provide a permanent record from which any measurement dimensions can be taken as needed.

To achieve a greater scientific uniformity, measurements were always carried out on the right hand. Every subject was scanned with two hand postures. The first was with four fingers closing together and the thumb naturally outreached, putting on the scanning plane lightly. The second was with the five fingers outreached as far as possible, putting on the scanning plane lightly. After each scanning, a view to the scanning results was required to prevent the scanning failure caused by finger shifting.

In each area, before starting the survey the measurement team was specially trained in anthropometric techniques and checked for consistency in their procedures to ensure the data reliability. The parents or teachers were asked to fill a form including their

child's name, sex, birth date and place, nationality, the school and grade, etc. The whole survey was completed in a period of about two years.

2.3 Data Processing and Statistical Analysis

Hand Dimension Calculating Computer Software was developed. This programme allows the user to select anatomical points on both hand images on screen by means of a cursor. Once the points in each image have been identified, the programme can calculate hand length and breadth dimensions automatically. In this paper, eight anthropometric measurement dimensions were taken: hand length, hand breadth at metacarpals, palm length perpendicular, index finger length, thumb length, middle finger length, index finger breadth (proximal) and index finger breadth (distal). Except thumb length and middle finger length, the definitions of other six hand dimensions were taken from ISO 7250:2004[9].

The dimension values obtained were categorized according to sex and age groups and abnormality data examination was conducted. The extreme outliers and unreasonable results were identified and eliminated carefully by using 3σ test, peak value test and logical value test. The Statistical Package for the Social Sciences (SPSS) for Windows version 16.0 was used in the following statistical analysis. The descriptive statistics, including arithmetic means (M), standard deviations (SD), and percentiles (5th and 95th) of the above measurements were calculated for both boys and girls.

3 Results

The statistical data of eight hand anthropometric dimensions are presented in table 1-6, including the number of subjects, gender (boys and girls) and age (4 to 17 years old). Estimates of mean, standard deviation (SD) and the 5th, 95th percentile are included. All dimensions are reported in mm.

4 Discussion

4.1 Differences between Age Groups

From table 1 to 6, it can be found that all mean values for the eight dimensions increase gradually by age. Because hand length and breadth are the basis to establish hand sizing system [10], hand length and breadth are further analyzed to show the difference between age groups. Table 6 and table 7 show the interclass increase value and relative odds ratio of the mean values. Both length and breadth show a trend for significant dimension increase by age in boys and girls and there are clear differences between the five age groups. For boys, the difference of hand length between (4-6) and (7-10) age group is 20.1mm. From (7-10) to (11-12), the length of boys increased by 16.8mm, and from (11-12) to (13-15) the increase value is 18.1mm. Also for girls, the increase of mean values of hand length are 20.7mm, 18.6mm, 7.8mm and 0.9mm respectively for the age group from (4-6) to (16-17) .

Table 1. The statistical values of hand anthropometric dimensions (4–6 years old)

Dimensions(mm)	Boys(N=1138)				Girls(N=1140)			
	M	SD	P5	P95	M	SD	P5	P95
Hand length	124.1	9.3	110.1	138.7	122.0	8.4	108.2	136.5
Hand breadth at metacarpals	58.4	4.0	52.3	64.7	56.5	3.7	50.7	62.6
Palm length perpendicular	71.0	5.6	62.7	80.4	69.3	5.2	61.0	78.2
Index finger length	48.2	4.0	42.2	55.1	48.0	3.8	41.6	53.9
Thumb length	39.2	3.7	33.9	45.2	38.5	3.5	32.9	44.3
Middle finger length	53.8	4.5	47.2	61.3	53.6	4.1	47.0	60.5
Index finger breadth, proximal	14.3	1.4	12.1	16.5	13.8	1.3	11.7	16.0
Index finger breadth, distal	12.7	1.3	10.8	14.9	12.3	1.2	10.5	14.5

Table 2. The statistical values of hand anthropometric dimensions (7–10 years old)

Dimensions(mm)	Boys(N=2239)				Girls(N=2115)			
	M	SD	P5	P95	M	SD	P5	P95
Hand length	144.2	9.9	128.7	161.9	142.7	10.5	126.3	161.2
Hand breadth at metacarpals	65.5	4.5	58.5	73.2	63.4	4.3	56.6	71.1
Palm length perpendicular	82.3	6.0	72.8	92.8	80.7	6.2	70.8	91.8
Index finger length	56.0	4.4	49.0	63.8	56.2	4.6	48.9	64.2
Thumb length	45.9	4.0	39.9	52.9	45.9	4.3	39.1	53.4
Middle finger length	62.4	4.8	54.9	70.8	62.6	5.0	54.9	71.5
Index finger breadth, proximal	15.7	1.3	13.6	18.0	15.1	1.3	13.1	17.4
Index finger breadth, distal	14.1	1.2	12.2	16.3	13.6	1.1	11.9	15.7

Table 6 and 7 also reveal that for both boys and girls, there is a stage in which the hands have a relatively fast growth rate. For boys, it is in the 4 to 15 years old, but for girls it is the 4 to 12 years old. When the boy grows up to 15, girls to 12, the hand growth rate slows down. According to the Report on the Physical Fitness and Health Surveillance of Chinese School Students (2000), children have a sudden increase in youth period. During this period, their physical size has an obvious change. In that report, the periods are 12-14 and 10-12 for the boys and girls. It can be found that there is a certain degree of correlation between the hand dimension changes and age group. This exact relationship may be verified through future research.

Table 3. The statistical values of hand anthropometric dimensions (11–12 years old)

Dimensions(mm)	Boys(N=2098)				Girls(N=2019)			
	M	SD	P5	P95	M	SD	P5	P95
Hand length	161.0	10.9	144.6	180.7	161.3	9.3	145.9	176.5
Hand breadth at metacarpals	71.8	5.1	64.3	81.1	70.0	4.1	63.5	76.9
Palm length perpendicular	91.8	6.5	81.6	103.6	90.9	5.6	81.5	100.1
Index finger length	62.3	4.7	55.0	70.6	63.5	4.5	56.3	71.0
Thumb length	51.7	4.4	45.0	59.6	52.3	4.0	45.9	59.2
Middle finger length	69.6	5.3	61.7	79.3	70.9	4.8	62.9	78.8
Index finger breadth, proximal	17.0	1.5	14.6	19.5	16.4	1.4	14.3	18.7
Index finger breadth, distal	15.1	1.3	13.1	17.5	14.8	1.3	12.8	17.0

Table 4. The statistical values of hand anthropometric dimensions (13–15 years old)

Dimensions(mm)	Boys(N=2942)				Girls(N=2795)			
	M	SD	P5	P95	M	SD	P5	P95
Hand length	179.1	10.9	159.6	196.1	169.1	7.8	156.4	181.7
Hand breadth at metacarpals	79.5	5.2	70.5	87.8	73.0	3.7	67.1	79.2
Palm length perpendicular	101.6	6.5	90.4	112.1	95.2	5.0	87.2	103.5
Index finger length	69.3	5.1	60.7	77.5	66.8	4.0	60.5	73.2
Thumb length	57.5	4.6	49.9	64.9	54.4	3.6	48.6	60.6
Middle finger length	77.7	5.5	68.2	86.6	74.2	4.2	67.5	81.3
Index finger breadth, proximal	18.6	1.7	15.7	21.3	17.3	1.4	15.2	19.6
Index finger breadth, distal	16.4	1.5	14.0	18.8	15.4	1.2	13.4	17.5

4.2 Gender Differences

The differences between boys and girls can be obtained in table 1 to 6. In table 1 to 3 most of the boys' dimensions have a litter higher than girls', but the differences are not obvious. The differences of mean values range from -1.3mm (index finger length and middle finger length in 11-12 age group) to 2.1mm (hand length in 4-6 age group and hand breadth in 7-10 age group). In table 4 and 5, the gender differences have become significant. In the age group of (13-15), the mean differences range from 1.0mm (index finger breadth, distal) to 10.0mm (hand length).The differences keep increasing in the 16-17 age group by a range from 1.3mm (index finger breadth, distal) to 14.7 mm (hand length).

Table 5. The statistical values of hand anthropometric dimensions (16–17 years old)

Dimensions(mm)	Boys(N=1840)				Girls(N=1910)			
	M	SD	P5	P95	M	SD	P5	P95
Hand length	184.7	8.9	170.2	198.8	170.0	8.0	157.2	183.2
Hand breadth at metacarpals	82.0	4.4	75.2	89.2	73.4	3.6	67.4	79.4
Palm length perpendicular	105.0	5.8	95.7	114.9	96.0	5.1	88.2	104.5
Index finger length	71.7	4.2	65.1	78.6	67.0	3.9	60.5	73.8
Thumb length	59.2	4.0	52.8	66.2	54.4	3.8	48.2	60.6
Middle finger length	80.2	4.6	72.6	87.5	74.4	4.3	67.5	81.7
Index finger breadth, proximal	19.2	1.5	16.8	21.5	17.6	1.3	15.5	19.7
Index finger breadth, distal	16.8	1.4	14.7	19.2	15.6	1.2	13.7	17.6

Table 6. Mean value increase of hand length and breadth in different age groups (for boys)

Age group	Hand length		Hand breadth at metacarpals	
	Interclass increase (mm)	Relative odds ratio (%)	Interclass increase (mm)	Relative odds ratio (%)
(4-6) to (7-10)	20.1	116.2	7.1	121.2
(7-10) to (11-12)	16.8	111.7	6.3	109.6
(11-12) to (13-15)	18.1	111.2	7.7	110.7
(13-15) to (16-17)	5.6	103.1	2.5	103.1

Table 7. Mean value increase of hand length and breadth in different age groups (for girls)

Age group	Hand length		Hand breadth at metacarpals	
	Interclass increase (mm)	Relative odds ratio (%)	Interclass increase (mm)	Relative odds ratio (%)
(4-6) to (7-10)	20.7	117.0	6.9	112.2
(7-10) to (11-12)	18.6	113.0	6.6	110.4
(11-12) to (13-15)	7.8	104.8	3.0	104.3
(13-15) to (16-17)	0.9	100.5	0.4	100.5

The significance of the differences between boys and girls was also examined by Mollission's method [11] [12] across age groups. The formula is as followed:

$$S = \frac{A_1 - A_{11}}{S_{A11}} \times 100 \quad (1)$$

A_1 — Arithmetic mean of boys in each age group;

A_{11} — Arithmetic mean of girls in each age group;

S_{A11} — Standard deviation of girls in each age group;

Differences between the means of boys and girls are expressed in each measurement by percentage deviation. When the indicator of mean deviation is positive, then the value of the mean of boys is bigger than the mean of girls. The situation is reversed when the indicator is negative. If the result exceeds 100, then it shows that there is a significance difference between the two groups.

The indicator of mean deviation was calculated. The results showed that from 4 to 12, no significant differences were found between boys and girls in all the eight hand dimensions. In (13-15) age group, the differences were significant in the hand length, hand breadth and the palm length. In the (16-17) age group, all the eight dimensions had significant difference between boys and girls, especially the hand length, breadth and palm length.

The results showed that the hand dimensions have very little differences between boys and girls for the children from 4-12 years old, which may imply that it was not necessary to consider gender difference in the design of some hand related products for children younger than 12 years old. But for children older than 12 years old, the difference should be taken into consideration.

4.3 Differences between Chinese and Japanese Children

China and Japan are both in the eastern of Asia, with similar ethnic characteristics and cultural traditions. It is meaningful to find out whether there are significant differences in body dimensions of the children in these two groups.

Table 8. Comparison of mean values between China and Japan in four age groups (boys)

Dimensions(mm)	(7-10)		(11-12)		(13-15)		(16-17)	
	China	Japan	China	Japan	China	Japan	China	Japan
Hand length	144.2	141.6	161.0	157.0	179.1	175.8	184.7	182.6
Hand breadth at metacarpals	65.5	61.7	71.8	68.5	79.5	76.1	82.0	79.2
Palm length perpendicular	82.3	80.2	91.8	88.4	101.6	99.3	105.0	103.5
Index finger length	56.0	54.1	62.3	60.4	69.3	67.5	71.7	69.8
Thumb length	45.9	46.0	51.7	51.5	57.5	58.0	59.2	60.2
Middle finger length	62.4	61.4	69.6	68.6	77.7	76.5	80.2	79.2
Index finger breadth, proximal	15.7	16.1	17.0	17.3	18.6	18.7	19.2	19.8
Index finger breadth, distal	14.1	14.0	15.1	15.0	16.4	16.2	16.8	17.3

Table 9. Comparison of mean values between China and Japan in four age groups(girls)

Dimensions(mm)	(7-10)		(11-12)		(13-15)		(16-17)	
	China	Japan	China	Japan	China	Japan	China	Japan
Hand length	142.7	140.9	161.3	158.8	169.1	167.5	170.0	167.7
Hand breadth at metacarpals	63.4	60.4	70.0	67.5	73.0	70.1	73.4	70.8
Palm length perpendicular	80.7	79.5	90.9	89.1	95.2	94.0	96.0	94.3
Index finger length	56.2	54.3	63.5	61.9	66.8	65.9	67.0	65.6
Thumb length	45.9	45.4	52.3	51.5	54.4	54.3	54.4	55.3
Middle finger length	62.6	61.5	70.9	69.6	74.2	73.4	74.4	73.4
Index finger breadth, proximal	15.1	15.5	16.4	16.9	17.3	17.6	17.6	17.8
Index finger breadth, distal	13.6	13.5	14.8	14.6	15.4	15.1	15.6	15.3

The Japanese data were collected during 1992 to 1994 by the Institute of Human Engineering for Quality of Life (HQL). More than 5,000 children from 7 to 17 years old were included in the survey. Because there's no hand data for children from 4 to 6 in Japan, only the hand mean values in four age groups are displayed in table 8 and 9.

It is found that both Chinese boys and girls have greater values in hand length, hand breadth palm length in the four age groups. It appears that Chinese children have longer and broader hands than Japanese children. As to the three finger length dimensions, most of the Chinese children have a relatively higher value than Japanese children. Only one finger breath dimension was compared and it showed that Japanese children had wider 2nd joint and narrower 1st joint than Chinese children. Whether there are differences between other fingers' breadth, more data should be extracted from the Chinese children hand images.

5 Conclusion

This study was conducted to provide hand anthropometric information of Chinese children from 4 to 17 years old, which could be used for the ergonomic design of workspace and products. A total of eight hand anthropometric dimensions extracted from 20,000 children are listed in the forms of mean, standard deviation and percentile values. The differences among age groups, between boys and girls groups, and between Chinese and Japanese are discussed. The results showed that the differences between the age groups were significant. In (13-15) age group, the gender difference was significant in the hand length, hand breadth and the palm length and in the (16-17) age group; all the eight dimensions had significant difference between boys and girls. Chinese children had longer and broader hands than Japanese children, whereas Japanese children had wider 2nd joint and narrower 1st joint than Chinese children. In

this study, the hand dimensions were extracted from 2-D images. The thickness and girth data about hands and fingers have not been obtained. Nevertheless, this survey provides the first hand anthropometric database of Chinese children.

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