Human Dimensions of Chinese Minors

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Abstract. This paper presents the preliminary statistical results of the latest national anthropometric survey of the minors in China mainland. About 20,000 minors (9666 males and 9699 females) were recruited from six geographical areas in China. These subjects were divided into five age groups. Body weight plus totally 134 static dimensions were selected for measurement. Non-contact three-dimensional (3D) scanning technology was used in this survey while manual measuring and two-dimensional (2D) imaging measurement were used as the subsidiary methods. There is no significant difference on body height between genders at the significance level of 0.05 when the subjects are less than 12 years old. The 5th, 50th and 95th percentile values for nineteen selected dimensions were addressed. This work provides the first national wide anthropometric database of the minors in China mainland and will inevitable benefit the products design for the potential users.

Keywords: Anthropometric, minors, three dimension, survey.

1 Introduction

Anthropometric data are essential for the ergonomic design of numerous products, facilities and work places. Great efforts have been made through many countries and areas in establishing an anthropometric database for different population groups such as students, farmers and workers etc [1-2]. However, there is no enough 3D anthropometric data of Chinese in spite of the fast development of its economy and the expansion of the biggest labor market. Most products sold in China market are designed according to the body data of European and American, and they are not conforming to the Chinese bodily form. Though there are a large number of minors in China mainland, anthropometric data related with the minors have either been lacking or are quite obsolete. This has resulted in many problems related with functional utility of the classroom, the furniture, and the clothes relevant for the minors' health, safety and comfort [3-4]. A national anthropometric survey of the minors has been recently completed in China mainland. This survey, conducted from 2005 to 2008, is regarded as the most comprehensive, influencing and high-technique anthropometric project in China since the last national anthropometric survey was finished in 1986. Great anthropometric changes have taken place during the past decades with the rapid

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progress of the economical level and the living standards of the Chinese people. It is reported that secular changes of the anthropometric values have arisen continuously e.g., as demonstrated in the general trend of increasing stature [5]. As for the minors, notable anthropometric difference can be recognized compared with their ancestors' counterparts.

Anthropometric measuring technique has also made big advancement in the last years. Traditional univariate anthropometrical measurements could not satisfy the fitting requirements of products [6-7], while 3D laser surface imaging technology has the ability to digitize the surface information of the subjects as a 3D point cloud with high density [7-11]. Three dimensional scanning technologies is one of the most important methods for the digitalization of the objects and environment in the real world [12]. It is more and more popular and has attracted great attention of the anthropometry. Three dimensional anthropometric measurements have been used in various fields such as workplace design [13-14], sizing for clothes [6], and protective wear for motorcycle riders [15]. At present, more and more 3D scanning projects are launched in many countries [14, 16-18]. Three dimensional scanning techniques have been applied more and more widely and have the possibility to substitute for the traditional manual measuring method.

The objective of this paper was to present the preliminary anthropometric data results for the minors in China mainland. The remainder of this paper is organized as follows. In Section 2, we introduce the method. Section 3 reports the results. Some discussions are given in Section 4. Finally, Section 5 summarizes this study.

2 Method

2.1 Subjects

About 20,000 subjects (9,666 males and 9,699 females) participated in this survey. The population database has ages ranging from four to seventeen years old. The children were classified into five age groups: preschool (4-6 ages), junior primary school (7-10 ages), senior primary school (11-12 ages), junior high school (13-15 ages), and senior high school (16-17 ages). The criterion of age stratifying is based on ISO15535: 2003 General requirements for establishing anthropometric databases [19]. The population database includes 2,117 pre-school students, 4,263 junior primary school students, 3,930 senior primary school students, 5,527 junior high school students, and 3,527 senior high school students. The subjects were recruited from six geographical areas in China: the northeast-north China, the central and western China, the lower reach of Yangtze River, the middle reach of Yangtze River, the south-east and the south-west China. The sample size in each area was determined based on the distribution of children's population reported by China National Bureau of Statistics [20]. One or two cities in each area were selected and some kindergartens, elementary schools and high schools were chosen from these cities. The distribution of the sample size among different regions and age groups can be seen in Table 1 and 2,

respectively. The parents or teachers of the minors filled the subjects' name, sex, birth date and place, nationality, the school name and grade, etc [5]. The whole measuring process was in accordance with ethics regulation.

Table 1. Distribution of sample size among regions

Region	Gender	
	Male	Female
Lower reach of Yangtze River	1804	1738
Middle reach of Yangtze River	1797	1804
Northeast-north China	1734	1805
South-east China	975	941
South-west China	1704	1773
Central and western China	1652	1638
Total	9666	9699

Table 2. Distribution of sample size among age groups

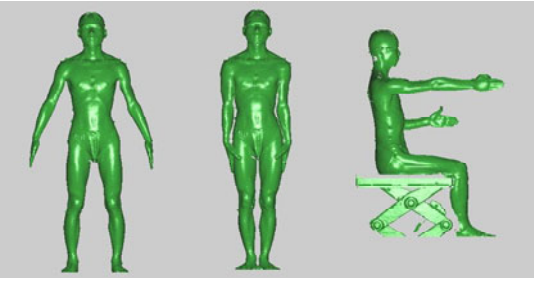
Age	Male	Female	Total
4-6	1043	1074	2117
7-10	2113	2150	4263
11-12	1988	1942	3930
13-15	2795	2732	5527
16-17	1727	1800	3527
Total	9666	9699	1700

2.2 Measuring Apparatus and Procedure

The following instruments were used for the measurements: weighing scales, a Human Solutions Vitus 3D full body measuring equipment, a Human Solutions 3D head measuring equipment, a Human Solutions 3D foot measuring equipment, Martin type anthropometers and self-produced adjustable chairs. 3D body scanning measuring technique was primarily used in this survey, while weight, stature and middle fingertip height over head are measured manually. Hand dimensions were measured by ordinary 2D scanners. During the measuring process, the male subjects wore shorts, while the female wore underwear. As shown in Fig. 1, the subject wore a uniform tight white-colored cap to avoid the light absorption of the hair; otherwise there will be outliers and holes on the scanned head data. Since some anatomy landmarks can not be recognized by computer software, twenty-one landmarks were stuck on the skin of the subjects to help distinguish these points more easily.

Fig. 1. White-colored elastic cap worn during scanning [21]

There were three postures during body scanning in this survey, i.e., standing posture Ⅰ, standing posture Ⅱ, and sitting posture, as shown in Fig. 2, respectively.



(a)Standing posture I (b)Standing posture II (c)Sitting posture

Fig. 2. Postures for body scanning

2.3 Measurements

Body weight plus totally 134 static dimensions were selected for measurements. Sixty-nine of the static dimensions were related to the standing posture and twenty-three to the sitting posture. The other forty-two were measurements of specific body segments, i.e., 15 head dimensions, 23 hand dimensions and 4 foot dimensions. The dimensions measured were all named according to International Standard, ISO 7250: Basic Human Body Measurements for Technological Design [22].

3 Results

Some principles based on the expertise accepted through common practice in traditional anthropometry to ensure the data effectiveness were used to detect the outliers caused by equipment errors while taking the measurements, and to reduce both inter- and intra-investigator variability to a minimum. The statistical software

SPSS 16.0 was used for analysis. An ANOVA test with a significance level of 0.05 was used to test the gender effect on stature among different age groups. Results are listed as shown in Table 3. It can be seen that there is no significant difference between genders within the age group of 4-12 years old at the significance level of 0.05. However, there is significant difference between genders within the age group over 12 years at the significance level of 0.05. This coincides with the common sense. Chinese female minors usually grow into their adolescence period after they get 12 years old. Once getting into this period, significant physiology phenomenon and anthropometric characteristics will take place on the female minors. Therefore it is not necessary to separate female from male when presenting the descriptive statistics of height for the subjects younger than 12 years.

Table 3. Descriptive statistics of height for male and female participants

Age	Gender	N	M.	Std.	Minimum	Maximum	p-value[a]
4-12	Male	4942	1332	150	1785	934	0.15
	Female	4810	1328	160	1768	922	
13-15	Male	2656	1617	88	1862	1327	0.00
	Female	2628	1564	61	1754	1067	
16-17	Male	1617	1695	63	1901	1280	0.00
	Female	1675	1581	55	1812	1403	

[a] *p*-Values indicate significance of difference between genders within each age group.

Descriptive statistics - 5th, 50th and 95th percentile - were generated for female and male subjects, respectively within each age group. The statistical results are presented through table 4-6. The nineteen most commonly applied anthropometric measurements for the minors are presented here. Tables 4 presents the anthropometric mean values of 5th, 50th and 95th stature percentile group for both genders aging no more than 12 years. Tables 5 and 6 present the anthropometric mean values of 5th, 50th and 95th stature percentile group for male and female subjects for the two age groups, i.e., 13-15 and 15-17years, respectively.

4 Discussions

Great efforts have been made to conduct data pre-processing, statistical analysis, and establishment of sizing systems once the anthropometric survey was finished. This paper only presents the preliminary statistical analysis results of this survey, mainly addresses the 5%, 50% and 95% percentiles of dimensions for each stature percentile group. It is common in ergonomics to use percentiles, for instance the 5th, 50th and 95th. However, it is not suitable for multidimensional issues [23-24]. Strictly speaking, the percentiles presented in this paper are more suitable for one dimensional design problems, such as defining the subway handrails and not suitable for multidimensional issues such as designing a vehicle cockpit [23]. For these kinds of ergonomic design problems other statistical approaches should be taken into consideration such as the anthropometric data integrated into digital human modeling software where multidimensional design tools are available [24].

Table 4. Anthropometric mean values of 5th, 50th and 95th stature percentile group for both genders (age ≤12)

Anthropometric dimensions[a]	Age group								
	4-6 years			7-10 years			11-12 years		
	percentile								
	5%ile	50 %ile	95%ile	5%ile	50 %ile	95%ile	5%ile	50 %ile	95%ile
1.stature	996	1107	1222	1172	1302	1450	1345	1468	1601
2.chest circumference	535	580	637	592	649	772	684	736	815
3.weight	152	190	250	205	272	410	304	382	504
4.hip breadth	199	213	238	220	246	288	256	281	312
5.hip circumference	552	592	659	607	682	800	714	778	865
6.waist circumference	486	512	562	508	566	677	591	632	693
7.abdominal circumference	499	532	584	529	594	717	614	663	732
8..shoulder breadth	228	246	266	258	285	317	299	319	345
9.neck circumference	247	254	266	252	268	297	276	289	311
10.cervical height	801	899	998	956	1075	1213	1125	1234	1357
11.upperarm length	175	199	221	210	238	265	250	272	298
12.forearm length	129	145	164	158	179	199	186	204	224
13.iliocristale height, sitting	129	146	161	155	173	192	181	198	211
14.inner ankle height	44	49	54	51	57	64	59	64	70
15.body depth	171	184	199	179	199	231	200	215	232
16.eye height	882	993	1098	1054	1183	1327	1230	1350	1479
17.maximum body breadth	289	303	329	305	336	391	351	376	417
18.shoulder height	756	853	951	910	1027	1155	1074	1179	1294
19. iliospinale anterius height	502	569	640	614	702	796	735	809	887

[a] Weight is given in kg; all other values are given in mm.

Table 5. Anthropometric mean values of 5th, 50th and 95th stature percentile group for male (age >12)

Anthropometric dimensions [a]	Age group					
	13-15 years			16-17 years		
	percentile					
	5%ile	50 %ile	95%ile	5%ile	50 %ile	95%ile
1.stature	1457	1623	1749	1596	1696	1793
2.chest circumference	722	820	875	848	868	881
3.weight	351	518	621	531	588	649
4.hip breadth	269	312	334	319	328	342
5.hip circumference	743	860	914	882	908	935
6.waist circumference	602	687	715	697	716	733
7.abdominal circumference	630	721	753	729	750	773
8..shoulder breadth	320	360	380	376	383	394
9.neck circumference	281	324	339	335	347	349
10.cervical height	1225	1378	1488	1357	1442	1532
11.upperarm length	273	304	327	300	321	336
12.forearm length	203	226	249	220	235	252
13.iliocristale height, sitting	194	215	229	217	221	233
14.inner ankle height	64	72	77	70	75	79
15.body depth	215	233	241	235	242	247
16.eye height	1341	1504	1624	1482	1576	1665
17.maximum body breadth	367	422	450	432	446	456
18.shoulder height	1168	1311	1423	1287	1374	1458
19. iliospinale anterius height	810	894	965	868	925	986

[a] Weight is given in kg; all other values are given in mm

Table 6. Anthropometric mean values of 5th, 50th and 95th stature percentile group for female (age >12)

Anthropometric dimensions [a]	Age group					
	13-15 years			16-17 years		
	percentile					
	5%ile	50 %ile	95%ile	5%ile	50 %ile	95%ile
1.stature	1465	1566	1663	1490	1580	1677
2.chest circumference	786	821	843	839	846	855
3.weight	412	489	561	463	510	573
4.hip breadth	305	323	342	322	334	346
5.hip circumference	835	884	928	876	905	936
6.waist circumference	655	681	709	680	703	702
7.abdominal circumference	690	725	760	717	750	758
8..shoulder breadth	331	345	360	339	352	359
9.neck circumference	292	304	316	301	308	313
10.cervical height	1228	1323	1410	1258	1338	1429
11.upperarm length	272	292	313	276	294	313
12.forearm length	201	215	228	203	216	233
13.iliocristale height, sitting	202	217	227	205	217	225
14.inner ankle height	64	69	73	66	70	74
15.body depth	221	234	239	231	239	241
16.eye height	1346	1446	1541	1377	1462	1557
17.maximum body breadth	389	412	429	409	421	429
18.shoulder height	1177	1262	1351	1202	1276	1364
19. iliospinale anterius height	795	856	919	806	855	918

[a] Weight is given in kg; all other values are given in mm

Anthropometric data has applications in establishment of sizing systems, development of digital manikins, aviation, virtual maintenance and assembly, clinical diagnostics, cosmetic surgery, forensics, arts and other fields. As the first national wide anthropometric survey in China, this work have attracted great interests from various fields, either in the academia or the industry. At present, five national standards for the minors in China, i.e., body dimensions standard, hand sizing standard, foot sizing standard, garment sizing standard and head sizing standard, will be revised based on the data and statistical results of this work.

5 Conclusions

Anthropometric data of the minors are very important in products design, but they have been lacking or obsolete in China mainland for a long period. The minors in China are a tremendous group of potential customers with high consumption power for all the manufacturers in domestic or from abroad. The body dimensions of Chinese minors have changed greatly compared with their ancestors counterparts two decades ago. The anthropometric data for the minors in China will bring great benefits to the industry and academia.

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