ANTHROPOMETRICAL DIFFERENCES BETWEEN CHINESE AND GERMANS

Gong B. Shan, Klaus Nicol,
Westfälische Wilhelms-Universität, Münster, Germany

KEY WORDS: anthropometrical parameters, Chinese, Germans, modeling

INTRODUCTION: It is known that anthropometrical data differ with gender, race and age. In practice, researchers often use the statistical data obtained from previous studies (Hanavan, Zatsiorsky) for biomechanical modeling in sports. Accuracy is reduced by racially unsuitable data. Knowing the racial differences and statistical error can help scientists to achieve a reasonable compromise between the accuracy of the estimates and the time required to complete the measurements. The purposes of this study were first to determine anthropometrical differences between young Chinese (a group of Asians) and young Germans (a group of Caucasians) and second to supply systematic statistical data for Chinese which are not found in the literature at present.

METHODS: A method developed by Shan (1993, 1995) was utilized in this study. The method is as follows: I.) measure the characteristic profiles of a human body (Figure 1); II.) reconstruct the body surface in the computer with the help of the

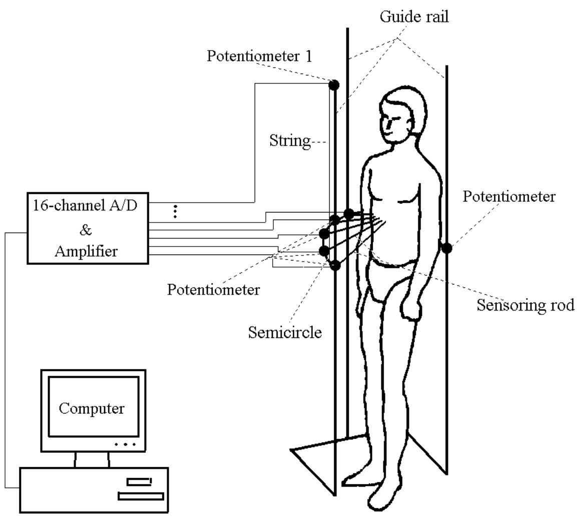

Figure 1. The measuring system

measured profiles and AutoCad (Figure 2), get a large amount of 3D-body-surface-points; III.) subdivide the body into thousands of tiny columns with the help of 3D-points and calculate the anthropometrical data, such as segmental masses, centers of mass, radii of gyration and moments of inertia. A reconstructed body segment is shown in Figure 3. The determination of the body segments is based on Zatsiorsky's 16-segment-model (1983).

Sixty subjects with a mean age of 28.1 took part in this study. The subjects are 15 female Germans, 15 female Chinese, 15 male Germans and 15 male Chinese. The average body weight and height of the subjects are 56.9 kg and 1.66 m for the Chinese, 71.1 kg and 1.75 m for the Germans. In order to find the differences between the two groups, the relative comparisons (segmental mass: % of body weight; segmental length: % of body height) were applied. Furthermore, 792 correlation and regression analyses of body weight and/or height as independent variables were made in order to compare the accuracy of the estimations.

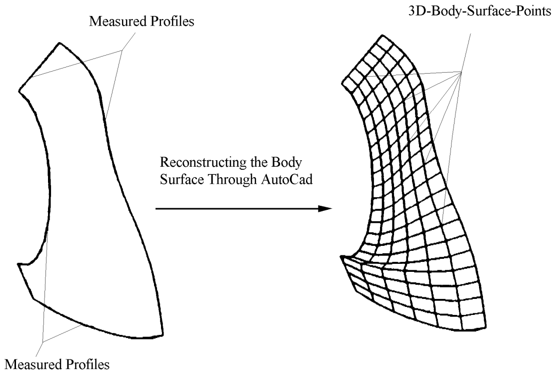

Figure 2. Getting 3D-body-surface-points

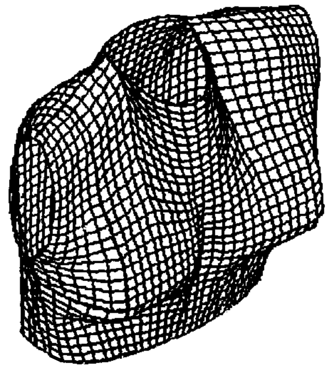

Figure 3.

RESULTS: The mean values of relative segmental mass and length of the groups are shown in Table 1. Statistically significant differences were found for the masses of head and leg, as well as for the lengths of trunk, leg and arm. For the same body weight and height: the head of a Chinese is 2.6% (male 3.0%, female 2.3%) heavier than that of a German, and the leg of a German is 1.7% (male 1.6%, female 1.8%) heavier than that of a Chinese, the trunk of a Chinese is 1.8% (male 1.9%, female 1.7%) longer than that of a German, the leg and arm of a German are 1.8% and 1.6% longer than those of a Chinese, respectively. According to these statistical results, Chinese have generally bigger heads, longer trunks and shorter legs and arm in comparison with Germans. An astonishing result is also found in this study: for the normal Chinese the head is heavier than the arms. This especially applies for Chinese women.

The results of the correlation and regression analyses show that the segmental masses are better estimated by body weight ($r=0.6 - 0.8$, $p<0.1$) than by body height ($r=0.2 - 0.6$, $p>0.1$) or by body weight and height. Although the r value is slightly increased when using multiple independent variables, the p values of some segments become larger than 0.1. That means that estimated segment masses become more unreliable in comparison with using single independent variables. Segmental lengths can also be estimated more accurately by using single independent variables (body height). A high correlation ($r=0.7 - 0.85$) between the principal moment of inertia and body weight & height was found in the study. Therefore It is advised to estimate the segmental moment of inertia using multiple independent variables. The statistical analysis in this study also shows that there are poor correlations between segmental radii of gyration and body weight or/and height (r=0.1 - 0.5, p>0.2). It would be better to use statistical mean values from the literature.

		Head		Trunk		Leg		Arm	
		Ch.	Ge.	Ch.	Ge.	Ch.	Ge.	Ch.	Ge.
Segmental mass (%)									
Total	Mean value	9.91	7.41	43.59	43.58	38.09	40.40	8.41	8.61
	SD	1.10	0.68	2.39	2.34	2.05	2.09	1.22	1.22
	T-Test (p)	0. 00		0. 99		0. 00		0. 53	
Men	Mean value	10.08	7.42	42.54	43.30	38.22	40.03	9.16	9.25
	SD	1.11	0.68	2.11	2.12	2.18	1.96	1.21	1.30
	T-Test (p)	0. 00		0. 34		0. 02		0. 84	
Women	Mean value	9.74	7.41	44.63	43.86	37.96	40.77	7.66	7.96
	SD	1.10	0.71	2.24	2.59	1.98	2.22	0.65	0.72
	T-Test (p)	0. 00		0. 39		0. 00		0. 24	
Segmental length (%)									
Total	Mean value	14.49	14.34	39.86	38.23	47.72	49.42	39.84	41.47
	SD	0.95	0.73	1.40	1.45	1.32	1.47	1.55	1.07
	T-Test (p)	0. 52		0. 00		0. 00		0. 00	
Men	Mean value	14.26	13.99	39.53	37.92	48.15	49.83	40.46	41.43
	SD	0.97	0.54	1.18	1.33	1.10	1.37	1.67	1.22
	T-Test (p)	0. 34		0. 00		0. 00		0. 08	
Women	Mean value	14.71	14.70	40.19	38.54	47.29	49.01	39.21	41.51
	SD	0.91	0.73	1.57	1.54	1.43	1.49	1.17	0.94
	T-Test (p)	0. 98		0. 01		0. 00		0. 00	

Tab. 1 Comparison of the anthropometrical difference between Chinese & Germans

At present there are still no regressions for estimating Chinese anthropometrical data in the literature. It is known that the proper regressions for estimation are necessary. For this purpose the regressions of Chinese will be provided in this report. Due to the paper length limitation, only the regressions for segmental masses, lengths and principal moments of inertia about the transverse axis are listed below.

Tab.2 Regressions for estimating segmental masses ($\mathbf{m_s = a_0 + b_0 m_{bw}}$), bw: body weight

	Men				Women			
Segment	a_0	b_0	r	p	a_0	b_0	r	p
Head	1.7687	0.0714	0.60	*	3.0032	0.0368	0.68	**
UPT	-2.1656	0.2269	0.84	**	-5.4077	0.3173	0.84	**
MPT	0.2979	0.1222	0.56	*	-2.0756	0.1621	0.69	**
LPT	-1.7835	0.1369	0.70	**	1.0341	0.0970	0.63	*
Hip	-1.1237	0.1393	0.77	**	0.5897	0.1081	0.90	**
Shank	2.0405	0.0214	0.47	*	0.8847	0.0389	0.72	*
Foot	0.6044	0.0052	0.26	ns	0.3441	0.0062	0.67	**
Upper arm	-0.5346	0.0329	0.70	**	-0.2021	0.0250	0.77	**
Forearm	0.1567	0.0132	0.60	*	0.1199	0.0107	0.73	**
Hand	-0.2164	0.0095	0.64	*	0.0043	0.0042	0.61	*

UPT: Upper part of the torso. MPT: Middle part of the torso. LPT: Lower part of the torso. **: p<=0.01.
*: 0.01<p<=0.1. ns: not significant (p>0.1). units: mass(kg), length(cm), inertia(kg*cm²).

Tab. 3 Regressions for estimating segmental lengths ($\mathbf{L_s = a_0 + b_0L_{bh}}$), bh: body height

	Men				Women			
Segment	a_0	b_0	r	p	a_0	b_0	r	p
Head	-28.8457	0.3117	0.84	**	6.8812	0.1037	0.32	ns
UPT	-15.0174	0.2534	0.68	**	-42.1902	0.4394	0.61	*
MPT	-3.9492	0.1258	0.35	ns	9.7949	0.0222	0.06	ns
LPT	34.5871	-0.0754	0.26	ns	24.8505	-0.0131	0.03	ns
Hip	-2.6398	0.2607	0.65	**	-15.1752	0.3398	0.64	**
Shank	-0.9912	0.2420	0.74	**	-5.3253	0.2608	0.65	**
Foot	7.7098	0.1001	0.53	*	9.6337	0.0801	0.43	*
Upper arm	-9.4893	0.2036	0.61	*	2.4007	0.1326	0.43	*
Forearm	-7.3803	0.1916	0.77	**	-0.3685	0.1409	0.44	*
Hand	10.1473	0.0490	0.23	ns	-4.9259	0.1363	0.66	**

Tab.4 Regressions for estimating principal moments of inertia about transverse axis ($\mathbf{I_s = a_0 + b_0m_{bw}+c_0L_{bh}}$)

	Men						Women					
Segment	a_0	b_0	c_0	r	p_1	p_2	a_0	b_0	c_0	r	p_1	p_2
Head	-1678.43	1.687	11.705	0.87	ns	**	-361.667	2.8743	3.0911	0.77	*	ns
UPT	-1373.68	22.698	4.9119	0.78	*	ns	-3504.45	40.4365	14.473	0.84	**	ns
MPT	10.8635	8.9104	-0.8799	0.42	ns	ns	586.370	11.7577	-6.138	0.76	**	ns
LPT	1129.89	16.588	-10.225	0.80	**	*	21.6414	8.5334	-0.7875	0.68	*	ns
Hip	-1290.90	31.160	3.0357	0.71	*	ns	-618.228	24.070	1.6129	0.82	**	ns
Shank	-979.73	-0.3152	7.8753	0.84	ns	**	-1422.36	0.6513	10.215	0.81	ns	**
Foot	-77.948	-0.1996	0.6604	0.57	ns	*	10.724	0.2341	-0.0626	0.72	*	ns
Upper arm	-129.986	2.0270	0.5399	0.64	*	ns	-88.8865	1.0444	0.560	0.68	*	ns
Forearm	-138.192	0.3950	0.9375	0.68	ns	*	-76.4670	0.3403	0.5230	0.80	*	*
Hand	-12.0898	0.1438	0.0487	0.73	*	ns	-11.4968	0.0572	0.0696	0.78	*	ns

CONCLUSIONS: This study showed that anthropometrical models should consider racial differences to optimize the accuracy of calculations. For the estimation of segmental masses and lengths, a single parameter leads to suitable results.

REFERENCES:

Hanavan, E. P. (1964). A Mathematical Model of the Human Body. Dayton, OH: Wright-Patterson Air Force Base, AMRL-TR-64-102.

Shan, G. B. (1993). A Low Costing Method for Measuring Anthropometrical Data. In *XIVth Congress of the International Society of Biomechanics* (pp. 1230-1231).

Shan, G. B., Nicol, K. (1995). Method for Obtaining Anthropometrical Data. In *XVth Congress of the International Society of Biomechanics* (pp. 832-833). Jyväskylä.

Zatsiorsky, V. et al (1983). The Mass and Inertia Characteristics of the Main Segments of the Human Body. In *Biomechanics VIII-B (Proceedings of the Eighth International Congress of Biomechanics)* (pp. 1152-1159). Nagoya.