Measurement and Analysis of Anthropometric Parameters of Young Male Vehicle Drivers

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Abstract. In this study, anthropometric data of 1243 vehicle drivers were sampled and the their age was from 17 to 34 years and averaged 21.85±2.82years. 76 anthropometric static parameters and 11 functional parameters were studied. The 76 static parameters were measured with the Non-contact 3d human boy scanners of VITUS SMART XXL systems while the 11 functional parameters were measured manually with Martin measuring scale. The correlation and fitting formulas of body height, sitting height and other parameters were measured and obtained. We also contrasted measured data with data form GJB 1835-1993. The present analysis showed that the correlation between sizes of body length and sitting height was significant. Sizes of body length and enclosing size and width direction were all increased compared to those in the 1980s. The present results were consistent with other researchers' current research results. The measured data could be an important basis for the data of young male anthropometric parameters and edition of relative standard and design of specific equipment.

Keywords: Anthropometric parameters, Anthropometry, Correlation analysis, Ergonomics.

1 Introduction

Anthropometric measurement method is used to study human body physical features, and acquire the relevant data. Accurate anthropometric data is the basis of engineering system equipment design, space layout, man-machine interface and task design, and also the foundation of human database and all kinds of human body mode.[1][2]. The content of anthropometric measurements includes morphological, physiological measurement and motion measurement. It is a measurement and analysis of anthropometric measurement to the basic human body scale (including contour diameter), surface area, volume and weight measurement, et al, while the measurement mainly focused on static body size.

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At present, the anthropometric data of Chinese adult mainly comes from GB10000-1988, GB/T 13547-1992 and GJB 1835-1993[3-5]. The data of GB10000-1988 was published in 1988 and it is a nationwide and a large sample measurement. Anthropometric parameters of GJB 1835-1993 measured in 1983 came from armored force. Because of the timeliness characteristics of anthropometric data, the data mentioned above cann't satisfied with the engineering design. According to the investigation and analysis of labor science and social medicine, there is difference in both body figure and growth of different occupation.

According to the investigation and analysis of labor science and social medicine, there is difference in both body figure and growth of different occupation. Especially for some group people, due to long-term professional activities or preference, some body parts have changed the shape because of some special exercise and their body shape is different to the average of people. Therefore, when make a design for a particular career, if conditions permit, it is best to sample from this type of group people to have a anthropometric measurement. For example, in order to make improvement to aircraft cockpit size and layout, and the pilot's life protection and saving equipment, China conducted a series of human body size measurements of air force male pilots which will be a basis of product design[6-9].

Driving is one of the most common work, the requirements to anthropometric data is especially urgent for armored vehicles in the design of man-machine interface. Therefore, this study conducted the measurement and analysis to the youth anthropometric size in a large sample. The results can provide important basis for data accumulation and update of human body, revision of the relevant standards.

2 Method

2.1 Anthropometric Parameters

According to the GB/T 5703-1999, GB10000-1988, GJB 1835-1993 and requirements of armored vehicles and equipment design, the static anthropometric size measurement and functional size of human body were determined in this study which include 76 static anthropometric parameters and 11 functional size parameters(Table 1).

2.2 Anthropometric Method

The overall 76 static anthropometric parameters were measured with VITUS SMART XXL systems which is a non-contact human body 3 d scanner. The system can make a quick and high precise measurement [10][11]. All participants wore uniform measurement cap and put hair within the measuring cap. They wore tight and light color brief with no lace, no obvious fold, and the trousers didn't exceed the umbilical point. If the participants' wears didn't conform to the requirements, they should change one-time measurement trousers that provided by measurement team. They couldn't wear a watch, jewelry and glasses. They were in the environment which its temperature was 20~25℃, noise was 40~50db, atmospheric pressure was the same as the ground. The functional anthropometric parameters were measured with Martin scale.

Table 1. Measured items of anthropometric parameters

	Parameters category	Number	Parameters name
Static parameters	Head parts	7	total head height, auricular height, maximum head breadth, ear to ear breadth, head circum ference, sagittal arc, head length.
	Standing posture	30	stature, eye height, bitragion height, gnathion height, crotch height, shoulder height, upperarm length, forearm length, et al.
	Sitting posture	18	sitting height, eye height sitting, acromion height sitting, elbow height,sitting, Popliteal fossa height sitting, knee height sitting, et al.
	Hand and foot parts	21	hand length, hand breadth at metacarpale, foot length, foot breadth, finger Ⅲ length, finger Ⅳ length, et al.
Functional parameters	Standing posture	5	functional arms span, arms span, middle fingertip height over head, functional upward reach with both arms, akimodo.
	Sitting posture	6	maximum arm reach from back sitting, maximum arm lift length sitting, forearm-hand length, functional forearm-hand length, maximum lower extremity reach sitting, functional maximum arm lift length sitting.

2.3 Participant

The participants were 1243 armored soliders whose age was from 17~34(averaged: 21.85±2.82). The number of effective sample was 1222 and their data was analyzed.

2.4 Data Processing

All measured anthropometric data was analyzed with spss15.0 software. The descriptive statistics was made which include mean value, variance, and percentiles. Also cluster and fitting to the parameters were made.

3 Results and Analysis

3.1 Correlation Analysis

According to the measuring direction and part, anthropometric parameters were divided into six categories: the vertical axis size, which is the height direction size; the transverse axis dimension, that is, the width size; the longitudinal axis dimension, also the thickness direction; the enclosing size; the head and face size; hand and feet size.

It is generally believed that there is certain association between body shape size and stature and weight. Therefore, the correlation analysis was made between body

Table 2. Correlation of stature and sitting height and vertical dimension(R^2)

Parameters	Stature	Sitting height
Knee height sitting	0.894	0.664
Eye height sitting	0.842	0.940
Popliteal fossa height sitting,	0.845	0.569
Maximum arm reach from back sitting	0.791	0.642
Shoulder to elbow length, sitting	0.793	0.627
Forearm-hand length	0.823	0.345
Shoulder height,sitting	0.728	0.824
Cervical height,sitting	0.504	0.556
Maximum arm lift length sitting	0.630	0.515
Functional maximum arm lift length sitting	0.600	0.503
Functional upward reach with both arms	0.694	0.469
Middle fingertip height, over head	0.693	0.468
Functional forearm-hand length	0.487	0.299
Maximum lower extremity reach sitting	0.600	0.324
Lower extremity length	0.981	0.381
Thigh length	0.764	0.559
Leg length	0.766	0.526
Length of upper extremity	0.877	0.685
Upperarm length	0.758	0.572
Forearm length	0.656	0.493
Eye height	0.992	0.865
Gnathion height	0.983	0.851
Bitragion height	0.992	0.861
Crotch height	0.874	0.608
Shoulder height	0.973	0.825
Lower leg-foot length	0.710	0.496
Spinal height	0.981	0.831
Malleolus height	0.293	0.274

shape size and stature, weight, and sitting height. The results showed that there was high correlation between the height direction size and stature and sitting height. The correlation coefficient with stature was generally larger than with sitting height($p<0.01$) (Table 2).

The body size of width was positively correlated with height and sitting height ($p<0.05$). The correlation coefficient was in the range of 0.310 ~ 0.674 which is lower than it was between body size in height direction and stature and height sitting. The body size in thickness direction was positively correlated with height and sitting height($p<0.05$).t he correlation coefficient between body depth sitting and stature was 0.821. The correlation coefficient between back from knee and stare was 0.711. The correlation coefficient of the rest items was between0.101 ~ 0.598. The body size of enclosing was positively correlated with height and sitting height ($p<0.05$). The correlation coefficient was in the range of 0.174 ~ 0.619. The head and face size was positively correlated with height and sitting height ($p<0.05$). The correlation coefficient was in the range of 0.110~0.601. Among hand and feet size, hand girth, foot length, and foot width was positively correlated with height and sitting height. The correlation coefficient was in the range of 0.134~0.301. The size of the rest parameters was not significant correlative with height and sitting height.

3.2 Fitting Analysis

Linear fitting was made between the parameters that the correlation coefficient was larger than 0.7 and height and sitting height. The fitting result was compared to the part of the relative study[10]. The comparison results were shown in table 3 and table 4.

Table 3. Analysis linear correlation between main human dimensions and height(H)

Number	Parameters	Linear relationship with H	Document fitting
1	Knee height sitting	0.332H - 43.646	
2	Eye height sitting	0.410H + 110.937	
3	Popliteal fossa height sitting,	0.272H – 48.032	
4	Maximum arm reach from back sitting	0.450H + 69.30	
5	Shoulder to elbow length, sitting	0.207H – 5.525	
6	Forearm-hand length	0.259H + 11.072	
7	Shoulder height,sitting	0.306H + 82.610	
8	Lower extremity length	0.517H + 10.075	
9	Thigh length	0.308H – 29.351	0.232H
10	Leg length	0.256H – 53.659	0.247H
11	Length of upper extremity	0.434H + 5.612	
12	Upperarm length	0.188H + 2.531	0.172H
13	Forearm length	0.148H – 17.563	0.109H
14	Eye height	0.936H – 10.434	
15	Gnathion height	0.888H – 46.435	
16	Bitragion height	0.945H – 39.173	
17	Crotch height	0.501H – 116.562	
18	Shoulder height	0.831H – 38.761	
19	Lower leg-foot length	0.272H – 38.354	
20	Spinal height	0.517H – 7.925	
21	Body depth,sitting	0.297H – 28.609	
22	Back from knee	0.367H – 17.826	

Table 4. Linear correlations between main human dimensions and sitting height(H1)

Number	Parameters	Linear relationship with H1
1	Eye height sitting	0.410H + 110.937
2	Shoulder height,sitting	0.306H + 82.610
12	Upperarm length	0.188H + 2.531
14	Eye height	0.936H – 10.434
15	Gnathion height	0.888H – 46.435
16	Bitragion height	0.945H – 39.173
18	Shoulder height	0.831H – 38.761
20	Spinal height	0.517H – 7.925

3.3 Contrast with GJB1835-1993

The anthropometric data could be compared to the corresponding parts of GJB1935-1993. The comparison results was shown in table 5.

Table 5. Comparson between measured data and from GJB1835-1993(P50)(mm)

Number	Parameters	GJB1835-1993	This study
1	Stature	1680	1699.2
2	Sitting height	903	927.9
3	Knee height sitting	496	504.6
4	Eye height sitting	801	808.7
5	Shoulder to elbow length, sitting	345	346.6
6	Maximum arm reach from back sitting	814	834.0
7	Forearm-hand length	448	452.4
8	Lower extremity length	851	888.4
9	Thigh length	497	494.7
10	Leg length	369	382.6
11	Upperarm length	302	321.3
12	Gnathion height	1453	1461.7
13	Bitragion height	1551	1568.4
14	Crotch height	780	734.0
15	Shoulder height	1369	1374.2
16	Lower leg-foot length	418	421.5
17	Maximum lower extremity reach sitting	972	1001.0
18	Functional forearm-hand length	344	332.0
19	Spinal height	942	870.4
20	Akimodo	879	894.0
21	Akimbo span	411	402.0
22	Hip breadth, sitting	320	344.3
23	Cervical height, sitting	653	644.6
24	Body depth, sitting	469	475.3
25	Dorsoventral distance	179	198.1
26	Elbow height, sitting	258	270.8
27	Elbow to elbow breadth, sitting	411	401.4
28	Back from knee	561	604.8
29	Thigh depth	140	144.4
30	Chest circumference	877	921.4
31	Shoulder breadth	373	396.1
32	Chest breadth	275	314.0
33	Eye height	1569	1579.9
34	Total head height	226	238.2
35	Maximum head breadth	154	163.9
36	Ear to ear breadth	192	191.4
37	Head length	188	194.2
38	Auricular height	127	133.6
39	Hand length	186	186.1
40	Hand breadth	88	90.1
41	Foot length	253	257.0
42	Foot breadth	103	105.0
43	Forearm length	241	234.7

It could be seen form table 5 that stature, height sitting, body depth sitting, etc all have increased in vary degree compared to the corresponding part of 1980s, while thigh length, functional forearm-hand length, elbow to elbow breadth of sitting, etc all have decreased. The differences was due to the increased nutrition intake which caused the corresponding changes of the body size and it was a normal phenomenon.

4 Discussion

It could be seen from the correlation analysis that the anthropometric data of the height direction was closely correlated with the data of stature and sitting height. Affected by some other factors, anthropometric data of body width size, the size of body thickness, the enclosing size, the head and face size, hand and feet size was not closely correlated with stature and sitting height.

Parameters which were highly correlated with stature and sitting height were extracted to make linear fitting and a series of fitting equation were obtained. The calculated trend of the fitting equation was consistent with the current experience formula [11]. When the direct measuring data could not be obtained, anthropometric size could be calculated by fitting equation.

Compared with GJB1835-1993, P50 of stature of this study was 1699mm which increased 19mm and the stature showed an increased trend. It said in researcher's study that the stature of male pilots measured from 1974 to 1977 was 1693mm and it was 1711mm measured in 2000[12]. It increased 18mm and the increasing trend was consistent. The weight of P50 of this study was 61.9kg while it was 60.8kg in GJB1835-1993. it increased 1.1kg and showed an increasing trend which was consistent with the other document[12].

Compared with GJB1835-1993, the size of human vertical axis in this study, such as Lower extremity length, eye height, shoulder height, Lower leg-foot length, sitting height, sitting eye height, and sitting knee height ect all increased in vary degree. It reflected not only the overall increase trend of human stature, but also reflected the change trend of proportions. Among the enclosing size, Chest circumference increased by 44.4mm, and the other parameters were not measured in GJB 1835-1993. The body's width size also increased in a vary degree.

Among the functional parameters of this study, 4 items were measured in GJB1835-1993 and only maximum lower extremity reach of sitting changed more. The reason was that the maximum lower extremity reach sitting of this study have increased obviously.

5 Conclusion

A large sample of Chinese young male was made to anthropometry in this study. The analysis showed that the human body size in vertical axis direction was significantly correlated with stature and sitting height. Some formulas were fitted in this study and The result agreeded with the relevant studies.

Anthropometric data of this measurement in body length, enclosing size, and width size increased obviously compared with the corresponding data of 1980s which agreeded with the air force pilot of the changing trend of anthropometric data.

Thirty seven items static anthropometric parameters and seven items functional anthropometric parameters that have not been measured in GJB1835-1993 were included in this measurement which provided a supplement to the basic data of the same group people.

The anthropometric data of this study was a important reference for accumulation and update of Chinese young males' basic data, reversion of relevant standards, and design of specific equipment.

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