Original Article

An Objective Measure to Evaluate Actual Body Shape among Children and Adolescents in China*

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Abstract

Objective The purpose of this study was to explore an objective measure to assess actual body shape of children and adolescents in China.

Methods Based on the Chinese National Survey on Student's Constitution and Health (CNSSCH) in 2005, 210 927 children and adolescents' (7-18 years) body height, body weight, chest circumference, sitting height, chest circumference-height ratio, chest circumference-sitting height ratio, chest circumference-low limb ratio, and sitting height-low limb ratio measurements were used to develop an objective measure by using transformation variables and explored factor analysis (EFA). Discrimination power of the objective measure was evaluated based on BMI reference and Receiver Operating Characteristic curves (ROC).

Results The objective measure included four dimensions scores: transverse dimension (TD) indicating weight and chest circumference; length dimension (LD) indicating height and sitting height; transverse-length ratio dimension (TLD) indicating chest circumference-height ratio, chest circumference-sitting height and chest circumference-low limb ratio; proportion dimension (PD) indicating sitting height-low limb ratio. The whole dimension (WD) indicating the whole body shape was showed by the average of four dimensions scores. Four dimensions and WD scores were approximately 80 in children and adolescents with normal weight, and higher than those of overweight, obesity, and underweight (all *P*-values <0.001). Areas under ROC of overweight and obesity compared with normal weight ranged from 0.88 to 1.00 for scores of TD, TLD, and WD.

Conclusion The objective measure which included four dimensions was explored, and TD, TLD, and WD had significant discrimination power.

Key words: Objective measure; Body shape; Children and adolescents

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INTRODUCTION

Body dissatisfaction of children and adolescents is very important for their growth and development, and more attention has been paid to it in the world. Several cross-sectional studies have shown that children and adolescents have a high prevalence of body dissatisfaction[1-3]. For example, the mild and moderate dissatisfaction rate in Chinese children and adolescents is 36.4% and 23.5%, respectively[4]. In addition, body dissatisfaction is associated with self-compassion, self-esteem, depression, and eating disorders[5-9].

At present, the measures of body image scales and figural scales, are generally used to assess body dissatisfaction, such as the Body Shape Questionnaire (BSQ), Offer self-image questionnaire (OSIQ), subscale of the EDI-2 questionnaire, Collins' Child Figure, Ma figural stimuli, and so on[3-4,10-15]. Most of the body image scales are set up based on different body parts including height, weight, chest circumference, body proportions, waist, hips, thighs, stomach, face, body build, and shoulders, and so on[16-17], which required participants to rate their satisfaction with different body parts to assess their body shapes. The figural scales on body dissatisfaction are composed of a series of frontal images ranging from thin to fat, and individuals are typically asked to select the image that best represents their current and ideal body size to assess whether they are satisfied with their body.

All measures for assessing body dissatisfaction are participants' self-reports based on their satisfaction with different body parts or body shapes. Thus those measures may cause potential response biases[11], and that should include multidimensional structures (height, chest circumference, sitting height, upper-down body ratio, and so on). In studies on body dissatisfaction, the standardized and objective adolescents' body shape measure needs to be used[18] to help participants know whether their actual body shapes are normal, perfect, or poor, which is very important for positively evaluating body satisfaction, preventing body distortion, and improving the behaviors and psychological state related with body dissatisfaction. The studies have shown potential biases based in the body mass index (BMI)[19-20], however, BMI is the main biological determinant of body dissatisfaction which only assesses body distortion on weight. It is difficult to perfectly evaluate actual body shape for different body parts[21]. No objective measures to assess children and adolescents' actual body shapes have been conducted. The purpose of the current study was to explore and develop the objective measure to evaluate actual body shape based on body parameters related with body dissatisfaction.

MATERIAL AND METHODS

Participants

The data used in current study were from Chinese National Survey on Student's Constitution and Health (CNSSCH) in 2005, a total of 210 927 children and adolescents aged 7-18 years, including 102 045 girls (48.38%) and 108 882 boys (51.62%), were surveyed. Students were randomly selected from primary, middle, and high schools by stratified cluster sampling in 30 provinces of China. The detailed sampling procedures had been previously described[22-26]. The body height, body weight, sitting height, and chest circumference of the students were measured in CNSSCH. According to the 'Reference Norm for Screening Overweight and Obesity in Chinese Children and Adolescents' developed by the Working Group on Obesity in China (WGOC) in 2005[27] and 'Reference Norm for Screening Underweight in Chinese Children and Adolescents'[28], 85th percentile ≤BMI <95th percentile, BMI ≥95th percentile, BMI <15th percentile for each sex and age were defined as overweight, obesity and underweight, respectively. A total of 159 938 students were with normal body weight (72 940 boys and 86 998 girls), who were used to develop the objective measure. 4 142 boys and 2 259 girls were obese, 10 737 boys and 8 700 girls were overweight, 14 226 boys and 10 625 girls were underweight.

Measures of Body Parameters

In CNSSCH, children and adolescents were measured in the context of wearing no shoes by trained staff, and they were required to follow a standard procedure[24]. Body weight was measured to the nearest 0.1 kg by using lever scales. Body height and sitting height were measured to the nearest 0.1 cm by using metal column height measuring stands. Chest circumference was measured using Nylon tape to the nearest 0.1 cm.

Procedure of Developing the Objective Measure

Step 1 Derivative variables were calculated,

including chest circumference-height ratio (CCHR; chest circumference/height), chest circumference-sitting height ratio (CCSR; chest circumference/ sitting height), chest circumference-low limb ratio [CCLR; chest circumference/(height-sitting height)], sitting height-low limb ratio [SLR; sitting height/ (height-sitting height)] and body mass index (BMI; weight/height^2).

Step 2 The original and derivative variables were transformed into the standardized variables (Z') for each age and sex groups with the method named absolute value of deviate from mean (ADM; $[(x-\overline{x})^2]^{1/2}$); the transformation formula (Equation 1) was $z'=\alpha'[(x-\overline{x})^2]^{1/2}+b'$ (z' was the standardized variable; x was original or derivative variable for each age and sex; $\overline{x}$ was mean of original or derivative variable for each age and sex; α' and b' were the transformation coefficients of the equation for each age and sex). When $x=\overline{x}$, it was made $z'=10$, and when $x=\overline{x}\pm 2.58$ s, it was made $z'=6$ (s was the standard deviation of the original or the derivate variable for each age and sex) to calculate coefficients α' and value b'.

Step 3 All standardized variables (z') were transformed into latent dimension variables (z'') for each sex by using varimax orthogonal rotation of explored factor analysis (EFA); the transformation formula (Equation 2) was $z''=\sum\alpha''\times z'$ [z' was the first standardized variable; α'' was factor load of standardized variable z', which was calculated through the method of varimax orthogonal rotation of explored factor analysis (EFA)].

Step 4 The latent dimension variables (z'') were transformed again into the standardized latent dimension variable through the formula (Equation 3) $C=\alpha'''z''+b'''$ (C was the standardized latent dimension variable to evaluate actual body shape from different dimensions, z'' was the latent dimension variable in the step 3; α''' and b''' were the transformation coefficients of the equation). When $z'''=z'''+2.58$ s, it was made $C=100$, and when $z'''=z'''-2.58$ s, it was made $C=60$ (s was standard deviation of latent dimension variable) to calculate coefficient α''' and b'''. All transformation coefficients were summarized to get the formula (Equation 4) $C=\sum\alpha[(x-\overline{x})^2]^{1/2}+b$ to evaluate body shape among children and adolescents in each age and sex groups. Then the variable (C_0) was got for evaluating whole body shape by using the formula (Equation 5) $C_0=\sum C/k$, (C was standardized latent dimension variable; k was the number of latent dimension variable).

Step 5 Discrimination power of the objective measure was evaluated by using BMI reference and receiver operating characteristic curve (ROC) and the difference of body scores among normal weight, underweight, overweight and obesity was analyzed.

Statistical Analysis

The data were analyzed by using the IBM SPSS 20 for windows. Means and standard deviations were used to describe quantitative data. Explored factor analysis (EFA) was conducted to calculate latent variables using the principal component method to extract factors, and varimax orthogonal rotation was used to obtain factor loads in step 3 of the procedure for the objective measure. All participants aged 7-18 years were divided into four groups (normal weight, underweight, overweight, and obesity) according to BMI references (85th percentile ≤BMI <95th percentile, BMI ≥95th percentile, BMI <15th percentile for each sex and age groups were defined as overweight, obese and underweight, respectively), and an equal number of participants in four groups were randomly selected. Receiver Operating Characteristic curves (ROC) and differences of actual body shape scores among four groups were analyzed to evaluate the discrimination power of the objective measure. Differences in body shape scores among four groups (normal weight, underweight, overweight and obesity) were tested by using one-way analysis of variance (ANOVA), and the differences between any two groups were tested by using the least significant difference (LSD) t test. $P<0.05$ was set as the significant level.

RESULTS

Descriptive Data

In this study, children's sample sizes in each age and sex groups were always more than 5 592, ranging from the smallest group of 5 592 in boys aged 12 years to the biggest group of 8 404 in girls aged 18 years. Figure 1 indicates the age and gender specific trends of body parameters. The trends of body height, body weight, chest circumference (CC), sitting height (SH), chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR) in boys and girls increased with age, and there were significant differences between boys and girls. The differences in values of body height, body weight, sitting height were similar between boys and girls aged <13 years, but were higher in boys than in

girls aged >13 years. The difference in chest circumference was significant between boys and girls aged >14 years. CCHR was higher in boys than in girls aged <11 years, and CCSR values were similar in boys and girls aged <13 years. The trends of CCLR and SLR with age were in an 'U' like shape, and CCLR was higher in boys than in girls aged <11 years, SLR was higher in boys than in girls aged >10 years.

The Objective Measure of Body Shape

Eight body parameters were transformed into standardized variables for each age and sex, according to the Equation 2 ($z'=\alpha'[(x-\bar{x})^2]^{1/2}+b'$) whilst generating an objective measure. Table 1 shows coefficients (α') of the transform equation of eight body parameters for each sex and age, and that all *b'* values for each body parameter were 10. Average scores±standard deviation (SD) of standardized body height, body weight, chest circumference (CC), sitting height (SH), chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR), chest circumference-low limb height ratio (CCLR) and sitting height-low limb height ratio (SLR) were 8.77±0.94, 8.75±0.92, 8.77±0.95, 8.78±0.95, 8.79±0.97, 8.8±0.98, 8.79±0.97, and 8.83±1.01, respectively, in boys and were 8.78±0.93, 8.75±0.92, 8.77±0.94, 8.78±0.95, 8.77±0.95, 8.78±0.96, 8.78±0.95, and 8.82±1.01, respectively, in girls.

The explored factor analysis (EFA) was conducted to transform eight standardized variables into latent dimension variables for each sex group. The number of latent dimension variables was defined according to the Eigen values greater than 1, or cumulative variance greater than 80%. Table 2 shows factor loads of EFA. Eight standardized variables were explained by four latent dimension variables (z''_1, z''_2, z''_3, z''_4). Cumulative variances of four latent dimension variables in boys and girls were 85.79% and 85.65%, respectively. Latent dimension variable 1 (z''_1) which mainly indicates CCHR (z'_5), CCLR (z'_7), and CCSR (z'_6) was defined as transverse-length dimension (TLD); latent dimension variable 2 (z''_2) which mainly indicates height (z'_1) and sitting height (z'_4) was defined as length dimension (LD); latent dimension variable 3 (z''_3) which mainly indicates chest circumference (z'_3) and weight (z'_2) was defined as transverse dimension (TD); latent dimension variable 4 (z''_4) which mainly indicates SLR (z'_8) was defined as proportion dimension (PD). Factor loads of EFA were regarded as weight coefficient (α'') for calculating four latent dimension variables (z''_1, z''_2, z''_3, z''_4). Standardized variable (z') values were put into the equation 2 ($z''=\sum\alpha'' \times z'$) to calculate latent variables values TLD (z''_1), LD (z''_2), TD (z''_3), and PD (z''_4). Then, the latent dimension variables were transformed into standardized latent dimension variables to evaluate actual body shape from each dimension using the equation 3 ($C=\alpha'''z''+b'''$). Table 3 shows values of α''' and b'''.

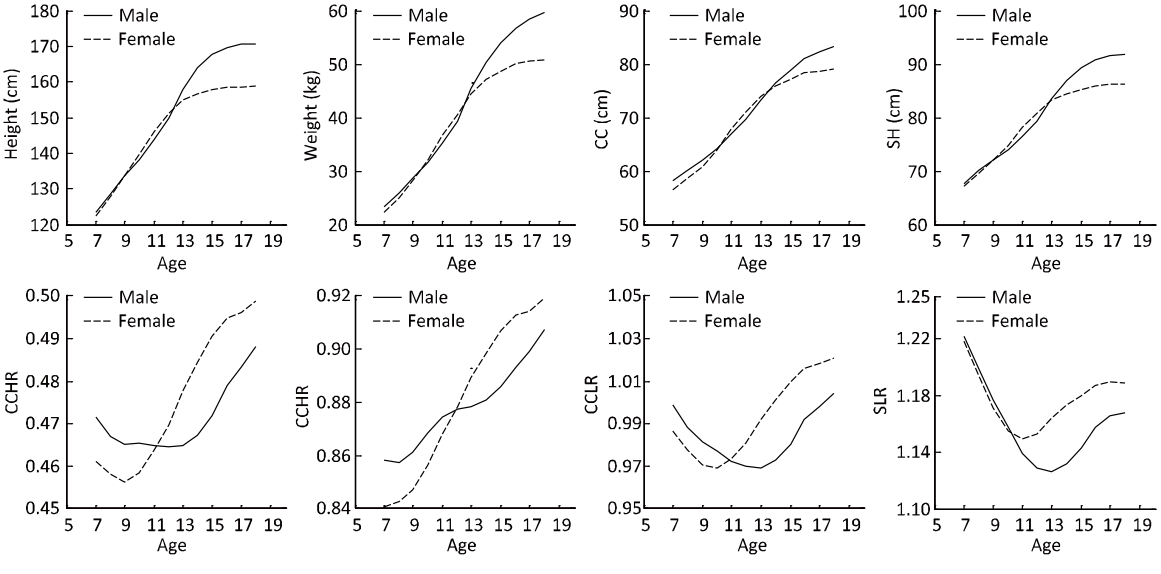

Figure 1. Trends of body parameters with age among boys and girls aged 7-18 years in China. Chest circumference, Sitting height, Chest circumference-height ratio, Chest circumference-sitting height ratio, Chest circumference-low limb ratio, Sitting height-low limb ratio was abbreviated as CC, SH, CCHR, CCSR, CCLR, SLR, respectively.

Table 1. Coefficients of the Equations of Transforming Original or Derivate Variables into the Standardized Variables (z')

Gender	Age	α'_1	α'_2	α'_3	α'_4	α'_5	α'_6	α'_7	α'_8
Male	7	-0.2684	-0.5470	-0.5394	-0.5023	-72.1144	-38.6590	-24.7935	-23.5064
	8	-0.2606	-0.4632	-0.4894	-0.5071	-71.8631	-38.3340	-25.4865	-24.8810
	9	-0.2535	-0.3960	-0.4351	-0.4949	-69.6124	-36.3051	-25.6725	-25.6380
	10	-0.2422	-0.3438	-0.3936	-0.4910	-66.1546	-34.6722	-25.0172	-26.2724
	11	-0.2141	-0.2859	-0.3545	-0.4322	-63.1906	-32.0771	-24.9300	-26.3942
	12	-0.1868	-0.2419	-0.3216	-0.3580	-62.3301	-31.8604	-24.8710	-27.5282
	13	-0.1809	-0.2195	-0.3029	-0.3262	-60.7071	-30.6304	-24.0467	-25.5371
	14	-0.1993	-0.2176	-0.3140	-0.3453	-62.7162	-32.4551	-23.9435	-25.4617
	15	-0.2284	-0.2310	-0.3307	-0.3990	-62.9407	-32.2473	-23.9051	-25.1452
	16	-0.2448	-0.2418	-0.3421	-0.4340	-61.2533	-31.7140	-23.2830	-25.0459
	17	-0.2448	-0.2398	-0.3456	-0.4434	-62.1337	-32.1533	-23.2203	-24.2309
	18	-0.2499	-0.2455	-0.3556	-0.4536	-63.2457	-32.4241	-23.8428	-25.0009
Female	7	-0.2715	-0.5677	-0.5431	-0.5218	-72.1798	-38.3336	-25.0958	-23.3545
	8	-0.2588	-0.4597	-0.4596	-0.5083	-68.3208	-35.8804	-25.2771	-25.0711
	9	-0.2338	-0.3776	-0.3997	-0.4569	-63.7718	-33.4334	-24.0221	-24.4623
	10	-0.2166	-0.3071	-0.3310	-0.4131	-59.3009	-30.7644	-23.4809	-25.7175
	11	-0.2055	-0.2618	-0.3012	-0.3787	-56.7428	-29.4092	-22.5533	-25.7433
	12	-0.2194	-0.2581	-0.3054	-0.3924	-55.5708	-29.0936	-21.8797	-25.4719
	13	-0.2571	-0.2749	-0.3208	-0.4421	-53.3593	-28.5947	-20.2278	-23.7463
	14	-0.2711	-0.2801	-0.3365	-0.4744	-53.8849	-29.1190	-20.3535	-23.9859
	15	-0.2742	-0.2893	-0.3444	-0.4878	-53.3280	-28.1511	-20.3672	-23.7248
	16	-0.2764	-0.2920	-0.3466	-0.4853	-52.5902	-27.9535	-20.1926	-23.9411
	17	-0.2753	-0.2931	-0.3523	-0.4847	-52.9691	-27.7276	-20.5091	-23.9782
	18	-0.2797	-0.2914	-0.3471	-0.5003	-52.9668	-27.7487	-20.6040	-24.4287

Note. α'_1, α'_2, α'_3, α'_4, α'_5, α'_6, α'_7, and α'_8, signified coefficients of transforming body height, body weight, chest circumference (CC), Sitting height (SH), Chest circumference-height ratio (CCHR), Chest circumference-sitting height ratio (CCSR), Chest circumference-low limb ratio (CCLR), and Sitting height-low limb ratio (SLR) into standardized variables, respectively.

Table 2. Factor Loads of the Explored Factor Analysis (Weight Coefficients of Calculating Latent Dimension Variables)

Variables	Male				Female			
	α''_1	α''_2	α''_3	α''_4	α''_1	α''_2	α''_3	α''_4
CHR (Z'_5)	0.9778	0.0145	0.0954	-0.0411	0.9802	0.0208	0.0701	-0.0231
CLR (Z'_7)	0.8046	0.1065	-0.0916	0.3676	0.8357	-0.0147	0.2019	-0.0374
CSR (Z'_6)	0.8029	-0.0533	0.2777	0.0043	0.7975	0.0866	-0.0686	0.3746
Height (Z'_1)	0.0321	0.9088	0.1707	0.0100	0.0409	0.8986	0.1606	0.0141
SH (Z'_4)	0.0388	0.8817	0.1169	0.0959	0.0275	0.8759	0.1374	0.0965
CC (Z'_3)	0.4029	0.1079	0.8436	-0.0113	-0.0958	0.4086	0.8386	0.0133
Weight (Z'_2)	-0.1333	0.5379	0.7357	0.0165	0.5192	0.0300	0.7792	-0.0242
SLR (Z'_8)	0.1056	0.0733	0.0084	0.9800	0.0810	0.0808	0.0023	0.9763

Note. Rotation Method was varimax with Kaiser Normalization for explored factor analysis; α''_1, α''_2, α''_3, and α''_4 signified weight coefficients of TLD (Z''_1), LD (Z''_2), TD (Z''_3), PD (Z''_4), respectively. CHR, CLR, CSR, SH, CC, SLR were abbreviations for chest circumference-height ratio, chest circumference-low limb ratio, chest circumference-sitting height ratio, sitting height, chest circumference, sitting height-low limb ratio, respectively.

Equations 1 to 3 were summarized to get Equation 4 for calculating actual body shape scores of four dimensions:

$C=\sum\alpha'''\times\{\alpha''\times(\alpha'\times[(x-\overline{x})^2]^{1/2}+b')\}+b'''=\sum\alpha'''\times\alpha''\times\alpha'[(x-\overline{x})^2]^{1/2}+\sum\alpha'''\times\alpha''\times b'+b'''=\sum\alpha[(x-\overline{x})^2]^{1/2}+b.$

In Equation 4, it was made $\alpha=\alpha'''\times\alpha''\times\alpha'$ and $b=\sum\alpha'''\times\alpha''\times b'+b'''$ for each age and sex. The Equation 5, $C_0=\sum C/4$ (C was each standardized latent dimension variable) was used to calculate the whole body shape score (WD). Table 4 shows coefficients of eights body parameters for four dimensions to evaluate actual body shapes in boys and girls aged 7 years, while those of children aged 7-18 years were shown in the supplementary Table 1 to 4.

Table 5 shows actual body shape scores of transverse-length dimension (TLD), length dimension (LD), transverse dimension (TD), proportion dimension (PD) and the whole body shape score (WD) in boys and girls. For WD, means and percentile 5, 25, 75, 95 in boys and girls were approximately 80, 69, 76, 84, 88 scores, respectively.

Table 3. Coefficients of Transforming Latent Dimension Variables (Z'') into Evaluation Variables (C)

Latent Variables	Male		Female	
	α'''	b'''	α'''	b'''
TLD (Z''_1)	3.1675	-4.4253	3.4442	-16.2987
LD (Z''_2)	3.9834	-10.0291	4.5969	-16.2971
TD (Z''_3)	5.0252	-15.0330	5.2228	-17.1157
PD (Z''_4)	6.5189	-1.7069	7.1224	-7.2592

Note. TLR, LD, TD, PD was abbreviation of transverse-length ratio dimension, length dimension, transverse dimension, proportion dimension, respectively. α''', b''' signified coefficients of TLD (Z''_1), LD (Z''_2), TD (Z''_3), PD (Z''_4) transformed into evaluation variables (C), respectively.

Table 4. Equation Coefficients of the Objective Measure for Child Aged 7 Years

Gender	Dimensions	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	b
Male	TLD (C_1)	-0.0273	0.2310	-0.6883	-0.0617	-223.3514	-98.3170	-63.1879	-7.8626	91.5943
	LD (C_2)	-0.9716	-1.1721	-0.2318	-1.7642	-4.1653	8.2080	-10.5183	-6.8635	92.6360
	TD (C_3)	-0.2302	-2.0223	-2.2865	-0.2951	-34.5723	-53.9490	11.4127	-0.9923	93.3515
	PD (C_4)	-0.0175	-0.0588	0.0397	-0.3140	19.3215	-1.0837	-59.4141	-150.1719	90.9860
Female	TLD (C_1)	-0.0382	-1.0152	0.1792	-0.0494	-243.6775	-105.2918	-72.2330	-6.5154	93.4395
	LD (C_2)	-1.1216	-0.0783	-1.0200	-2.1008	-6.9015	-15.2602	1.6958	-8.6745	93.4118
	TD (C_3)	-0.2277	-2.3104	-2.3785	-0.3744	-26.4264	13.7343	-26.4631	-0.2805	93.6860
	PD (C_4)	-0.0273	0.0979	-0.0514	-0.3586	11.8755	-102.2754	6.6849	-162.3972	91.7489

Note. α_1, α_2, α_3, α_4, α_5, α_6, α_7, and α_8 were coefficients of equation to assess body shape from four dimensions, which signified coefficients of variables height, weight, chest circumference, sitting height, CCHR, CCSR, CCLR, and SLR, respectively. TLD, LD, TD, PD was abbreviation of transverse-length ratio dimension, length dimension, transverse dimension, proportion dimension, respectively.

Discrimination Power of the Objective Measure

Based on BMI references, the students were divided into 4 groups: underweight, normal weight, overweight, and obesity. As shown in Table 6, actual body scores of four dimensions and the whole body shape scores among normal weight, underweight, overweight, and obese groups were significantly different in boys and girls (all *P-values* <0.001), and significant gender specific differences were also found between any two groups (all *P-values* <0.001). The descending order of actual body shape scores of four dimensions and the whole body shape among four groups were in accordance with the order of normal weight, underweight, overweight, and obese. Actual body shape scores of transverse-length ratio dimension (TLD) were less than 60 in obese children (40.68 in boys, 38.83 in girls), approximately 60 in overweight children (62.19 in boys, 60.19 in girls), and more than 70 in underweight children (74.48 in boys and 71.64 in girls). Actual body shape scores of transverse dimension (TD) were less than 60 in overweight children (57.52 in boys, 58.63 in girls), less than 40 in obese children (31.85 in boys, 35.70 in girls), and approximately 70 in underweight children. In length dimension, body shape scores were higher than 60 in obese children, and higher than 70 in underweight and overweight children. The whole body scores were less than 60, approximately 67, and 70 in obese, overweight and underweight children, respectively.

ROC curves were conducted to evaluate the discrimination powers of the objective measure among underweight, overweight, obese children compared with normal weight children. Table 7 shows areas under the curves which were significant in boys and girls (all *P*-values <0.001), and ROC were shown in Figure 2. The areas under the curves were from 0.58 to 0.81 of four dimensions and WD between underweight and normal weight in boys and girls. The areas were from 0.88 to 1.00 of TLD, TD and WD between overweight children and normal weight children, as well as between obese children and normal weight children, however, from 0.68 to 0.92 of LD and PD.

Table 5. The Whole Body Shape and Four Standardized Dimensions Scores among Children and Adolescents with Normal Weight

Body Dimensions	Gender	Mean	SD	$P_{2.5}$	P_5	P_{15}	P_{25}	P_{50}	P_{75}	P_{85}	P_{95}	$P_{97.5}$
TLD (C_1)	Male	80.01	7.75	61.24	65.60	72.75	76.30	81.79	85.52	86.97	88.78	89.45
	Female	80.00	7.75	61.47	65.38	72.26	75.89	81.56	85.68	87.34	89.51	90.39
LD (C_2)	Male	80.00	7.75	60.91	64.81	71.91	75.82	81.89	85.86	87.28	89.09	89.82
	Female	79.95	7.78	61.00	64.95	71.96	75.70	81.62	85.74	87.37	89.54	90.40
TD (C_3)	Male	80.01	7.76	61.20	65.24	72.21	75.83	81.49	85.76	87.51	89.68	90.53
	Female	79.99	7.76	61.37	65.30	72.04	75.65	81.51	85.80	87.55	89.69	90.52
PD (C_4)	Male	80.00	7.75	61.68	66.37	73.28	76.67	81.76	85.32	86.68	88.32	88.96
	Female	79.97	7.75	61.82	66.44	73.24	76.50	81.53	85.29	86.85	88.79	89.52
WD (C_0)	Male	80.00	5.63	67.31	69.92	74.52	76.89	80.75	84.02	85.51	87.62	88.50
	Female	79.98	5.93	66.64	69.41	74.12	76.58	80.73	84.23	85.83	88.19	89.15

Note. TLD, LD, TD, PD, WD were abbreviation of transverse-length ratio dimension, length dimension, transverse dimension, proportion dimension, and the whole body shape dimension, respectively.

DISCUSSION

Our purpose was to develop an objective measure to assess actual body shape among children and adolescents. Most previous studies on body dissatisfaction are subjective assessments of the level of satisfaction with their current body shape or size based on body figural scales and body image scales. Therefore participants might make inaccurate perceptions on the body parts or whole body shape (overestimation or underestimation) for the influence of media, culture, peers, stars, and so on[29-31]. The study has revealed a high frequency of body image distortion with 27.2% underestimating and 5.6% overestimating their own body mass index status[32]. There were 12.4% underestimating and 28.8% overestimating BMI status among non-overweight girls[33]. But individuals may not realize whether their actual body shape are normal, poor, or perfect. The objective measure can help participants know their actual body shapes. The present study selected eight body parameters including body

Table 6. Comparison of Four Dimensions and the Whole Shape Scores among Normal, Underweight, Overweight, and Obese Groups ($\bar{x} \pm s$)

Gender	Group	*N*	TLD (C_1)[c]	LD (C_2)[c]	TD (C_3)[c]	PD (C_4)[c]	WD (C_0)[c]
Male	Normal weight	4 142	79.90±7.99	80.09±7.77	80.11±7.81	80.01 ±7.66	80.03±5.66
	Underweight	4 142	74.48±8.92	75.74±8.58	71.64±8.57	77.90±8.44	74.96±5.82
	Overweight	4 142	62.19±13.60	72.14 ±9.36	57.52±12.85	75.98 ±8.08	66.96±7.68
	Obese	4 142	40.68 ±17.61	62.22±10.46	31.85±15.63	70.65±9.29	51.35±9.66
	F		7865.62	2902.33	13594.14	953.38	11924.24
	P		0.000	0.000	0.000	0.000	0.000
Female	Normal weight	2 559	79.96± 7.78	79.88±7.90	79.88±7.80	79.93 ±7.71	79.91±5.87
	Underweight	2 559	71.64± 8.62	76.48±9.03	70.07±8.38	78.14±7.84	74.09±6.19
	Overweight	2 559	60.09±11.78	73.78±9.16	58.63±11.90	75.56±7.65	67.02±7.71
	Obese	2 559	38.83±15.63	66.01±10.49	35.70±15.19	70.52±9.08	52.76±9.81
	F		6288.55	1056.22	7350.55	654.46	6111.48
	P		0.000	0.000	0.000	0.000	0.000

Note. [c]signified the significant differences any two groups of normal, underweight, overweight, and obese (all *P*-values <0.001). TLD, LD, TD, PD, and WD were abbreviation of transverse-length dimension ratio, length dimension, transverse dimension, proportion dimension, and the whole body shape dimension, respectively.

Table 7. Areas under the ROC Curve on Body Shape Scores of Four Dimensions and the Whole body shape

Items	TLD	LD	TD	PD	WD
Underweight *vs* Normal weight					
Male	0.69 (0.68-0.71)[c]	0.67 (0.66-0.68)[c]	0.78 (0.77-0.79)[c]	0.58 (0.57-0.60)[c]	0.75 (0.74-0.76)[c]
Female	0.78 (0.76-0.79)[c]	0.62 (0.6-0.63)[c]	0.81 (0.8-0.82)[c]	0.58 (0.57-0.60)[c]	0.76 (0.75-0.78)[c]
Overweight *vs* Normal weight					
Male	0.88 (0.87-0.88)[c]	0.77 (0.76-0.78)[c]	0.94 (0.93-0.94)[c]	0.68 (0.67-0.69)[c]	0.92 (0.91-0.92)[c]
Female	0.92 (0.91-0.93)[c]	0.71 (0.70-0.72)[c]	0.94 (0.93-0.94)[c]	0.69 (0.67-0.70)[c]	0.91 (0.90-0.92)[c]
Obese *vs* Normal weight					
Male	0.97 (0.96-0.97)[c]	0.92 (0.92-0.93)[c]	1.00 (0.99-1.00)[c]	0.82 (0.81-0.83)[c]	0.99 (0.99-0.99)[c]
Female	0.99 (0.99-0.99)[c]	0.86 (0.85-0.87)[c]	1.00 (0.99-1.00)[c]	0.82 (0.81-0.83)[c]	0.99 (0.99-0.99)[c]

Note. [c]*P*<0.001. Values outside ( ) were area under curve, values inside ( ) were 95% CI of area under curve.

height, body weight, chest circumference (CC), sitting height (SH), sitting-height ratio (SHR), chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR), chest circumference-low limb ratio (CCLR), sitting height-low limb ratio (SLR) to develop the objective measure, which were related with actual body shape and body dissatisfaction. For example, about 80% of American children wanted to be taller, boys and girls overestimated their heights by 1.2 cm and 1.0 cm, respectively[19]. Malete has found that students feel dissatisfied with their body proportions[20]. The significant effects for the object of distortion on chest, thighs, and calves have been revealed[22]. In current study, the selected body parameters not only showed the characteristics of actual body shape, but also combined with body image perceptions.

The representative sample data is the premise of developing the objective measure. In the present study, Chinese National Survey on Student's Constitution and Health (CNSSCH) in 2005 was used to develop the objective measure, a total of 210 927 students were surveyed, and there were more than 5 592 students in each sex and age groups. The survey was jointly launched by the Ministry of Education, the State Sports General Administration, the National Health and Family Planning Commission, the State Ethnic Affairs Commission, the Ministry of Science and Technology, and the Ministry of Finance of People's Republic of China. It is, so far, the largest national representative sampling survey of school-aged children and adolescents in China[22-24,26]. The large sample size ensured the equation coefficients' representativeness of the objective measure in this study.

The results of the study showed that each body parameter had a trajectory tendency along with age, and there were significant differences between boys and girls, which have been universally acknowledged[34-35]. In fact, the higher values of objective measure might indicate that children and

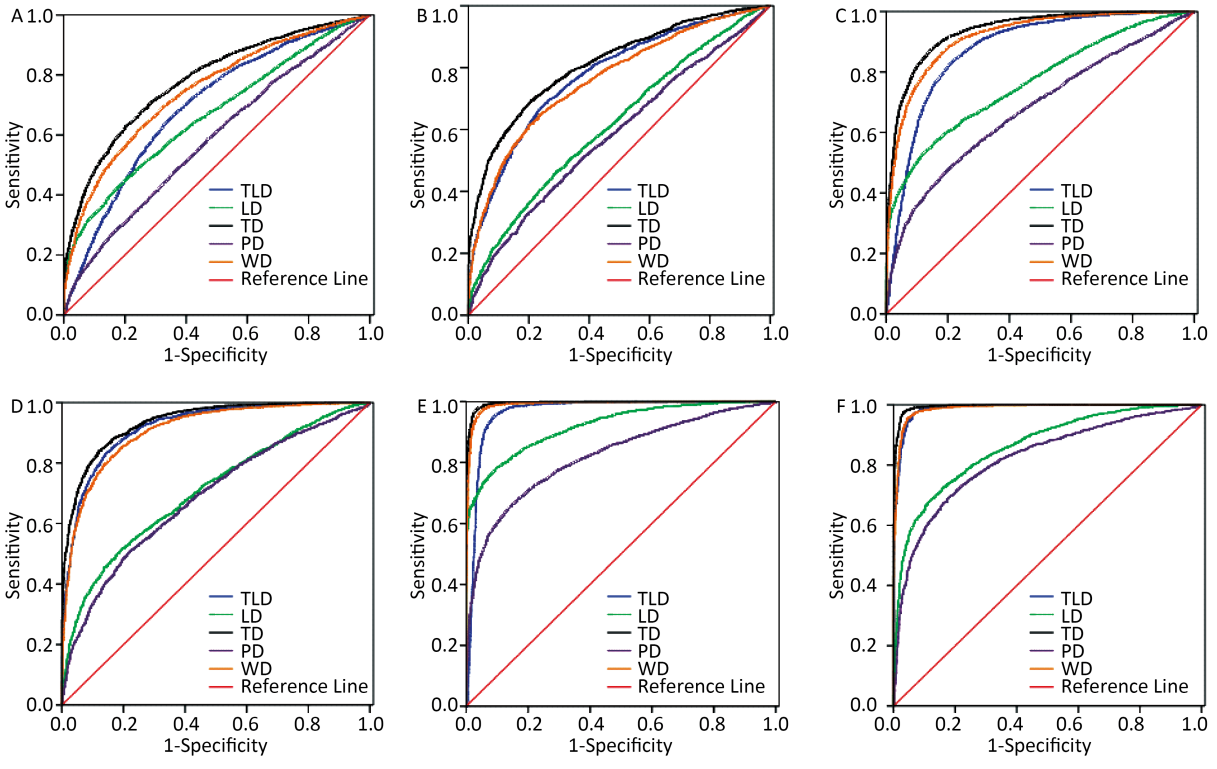

Figure 2. ROC on body shape scores of four dimensions and the whole body shape for comparing underweight, overweight and obese with normal weight in boys and girls. TLD, LD, TD, PD, WD were abbreviation of transverse-length ratio dimension, length dimension, transverse dimension, proportion dimension, the whole body shape dimension, respectively. ROC of underweight *vs* normal weight was A in boys, was B in girls; ROC of overweight *vs* normal weight was C in boys, was D in girls; ROC of obesity *vs* normal weight was E in boys, was F in girls.

adolescents have more standardized actual body shape, but the higher body parameter might not indicate better actual body shape, such as weight, chest circumference, which was defined as non-monotonicity of variables to assess actual body shape. Based on the influences of trajectory, the original or derivative variables must be transformed into monotonic standardized ones, which are critical to set up the objective measure. Because of the large sample size, the values of original or derivative body parameters are more closed to their averages, so the actual body shape should be regarded as more standardized. Based on this idea, body parameters were standardized using the absolute value of deviate from mean method (ADM; $z'=a'[(x-\overline{x})^2]^{1/2}+b'$). There are several methods to transform variables into standardized ones, for example, parabolic method ($z'=a'(x-\overline{x}^2)+b'$), linear standard deviation from mean method ($z'=a'(x-\overline{x})+b'$), centesimal system evaluation method ($z'=a'x+b'$), and percentile method ($z'=\frac{x-x_{min}}{x_{max}-x_{min}}\times 100$), and so on. But the parabolic method may increase deviations of new variables due to the square, and make the evaluation model complicated. The linear deviation from mean method can eliminate influences of units, however, when the original variable's value is greater or smaller than their averages, the sign of the new variables is the opposite. The centesimal system evaluation and percentile method are fitted for the monotonic variables to assess actual body shape, which means higher values of original variables should be transformed into a higher value of standardized ones. Thus centesimal system evaluation and the percentile method are not applicable for setting up the objective measure. In the present study, the absolute deviate from mean method (ADM; $z'=a'[(x-\overline{x})^2]^{1/2}+b'$) did not increase deviation of new variables, and generated new monotonic variables to assess actual body shape. The standardized variables transformed using ADM were stable and consistent, of which the average score for each sex and age (7-18 years) was approximately 8.77, and standard deviation (SD) was approximately 0.95.

The objective measure should be set up for each sex. Because actual body shapes for boys and girls were different in anthropometry. In addition, there are different body perceptions between boys and girls. In general, Girls are more dissatisfied with their bodies than boys[2-3,36-37], they show more dissatisfaction towards their weight or curvaceous upper body, whereas boys tend to show their negative evaluations of their bodies' muscle or bulk[38-40]. So the objective measure was developed by using the standardized body parameters for each sex.

The explored factor analysis (EFA) was used to calculate latent dimensions of standardized variables for each sex. This method has been frequently used in studies on evaluation and scales[41-42]. Factor loads of EFA were defined as weight of calculating every latent dimension, which was frequently used to set up the evaluation system method, such as comprehensive evaluation or the analytic hierarchy process method[43]. In the current study, eight body parameters were explained by four dimensions including transverse dimension (TD; including weight, CC), length dimension (LD; including height, sitting height), transverse-length ratio dimension (TLD; CHR, CLR, CSR) and proportion dimension (PD; including SLR). Cumulative variances of four dimensions were >85% in boys or girls, which indicated that four latent dimensions could be used to assess actual body shape from different dimensions. In addition, the four dimensions scores may be combined with body image scales for different body parts. The transverse dimension mainly indicates actual body shape on weight and chest circumference, which may be combined with body image scales on muscle of upper body, and curvaceous upper body. The length dimension mainly indicates height and sitting height, which may be combined with participants' satisfaction with height, sitting height, and low limb. The transverse-length ratio dimension mainly indicates actual body shape with chest circumference-height ratio, chest circumference-sitting height ratio, chest circumference-low limb ratio, which may be combined with individuals' satisfaction with their body status on the whole body, upper body, and under body. The proportion dimension mainly indicates sitting height - low limb ratio, which may be combined with participants' satisfaction with body proportion. As for the objective measure, the higher scores of four dimensions and WD showed more normal actual body shape, which were about 80 in boys and girls with normal weight.

The objective measure has shown significant discrimination power in transverse dimension (TD), transverse-length ratio dimension (TLD) and the whole dimension (WD) between overweight and normal weight children, as well as obese and normal

weight children. Average score of TD, TLD, and WD was approximately 80 in children with normal weight, while it was less than 60, 70 in obesity, overweight children, respectively. Compared with normal weight, areas under curves of TD, TLD, and WD were greater than 0.95 for obese children, and greater than 0.88 for overweight children. Overweight and obesity were defined based on BMI reference. TD and TLD mainly indicate body status on weight, chest circumference, chest circumference-height ratio, chest circumference-sitting height ratio and chest circumference-low limb ratio, which have close associations with BMI. The whole body shape dimension has significant discrimination power, because it includes TD and TLD. LD and PD has low discrimination powers, because LD and PD mainly show height, sitting height and body proportion, however, BMI is weakly correlated with body length and proportion. Thus the objective measure can be applied to judge actual body shape, and define potential bias of body concerns on weight, chest circumference, upper body, under body. The results of the current study showed that the discrimination powers of TD, TLD, and WD between underweight children and normal weight children were mild, which shows the differences in body parameters between underweight children and normal weight children were smaller than between obese children or overweight children and normal weight children. This result is consistent with the fact that the prevalence of body dissatisfaction among underweight children is lower than that of overweight or obese children[44-45].

LIMITATIONS

Though the objective measure includes four dimensions of eight body parameters, it has some limitations. More parts of the body can not be included in the objective measure, such as arms, muscle, face, waist, hip, and so on. Waist and hip circumference are very important body parameters to assess actual body shape because adults are often dissatisfied with the two body parts of body. However, chest circumference parameter may be more effective in children and adolescent survey. Furthermore, the objective measures of TD, TLD, and WD have very good discrimination power based on BMI references, however, LD and PD have low discrimination powers. The objective measure requires further practice to assess its effectiveness. Another limitation is that the objective measure only shows normal actual body shape scores, which cannot indicate the best body shape. For example, a child has perfect body shape, whose height and sitting height are high, and weight is normal, chest circumference and body proportion are ideal; however, these body parameters deviate from the normal population references, so his actual body shape scores may be very low. Of course, if appropriate and representative body parameters references can be selected, the objective measure is still applicable in special populations.

CONCLUSION

The developed objective measure included four dimensions: transverse dimension (TD), length dimension (LD), transverse-length ratio dimension (TLD), proportion dimension (PD). TD, TLD, and the whole shape (WD) had significant discrimination powers for overweight and obesity.

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CONTRIBUTIONS OF EACH AUTHOR

FU Lian Guo, Analysis of the data, as well as design, the writing of the paper. WANG Hai Jun, Collection of the data, director of the design and revision of the paper. LI Xiao Hui, Analysis of the data. WANG Zhi Qiang, director of the design and revision of the paper. Patrick WC Lau, director of the design and revision of the paper. YANG Yi De, Analysis of the data. MENG Xiang Kun, Analysis of the data. MA Jun, Collection of the data, director of the design and revision of the paper.

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Supplementary Table 1. Equation Coefficients of the Objective Measure for TLD (C_1)

Gender	Age	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	b
Male	7	-0.0273	0.2310	-0.6883	-0.0617	-223.3514	-98.3170	-63.1879	-7.8626	91.5943
	8	-0.0265	0.1956	-0.6245	-0.0623	-222.5731	-97.4905	-64.9541	-8.3224	91.5943
	9	-0.0258	0.1672	-0.5553	-0.0608	-215.6021	-92.3306	-65.4282	-8.5756	91.5943
	10	-0.0246	0.1452	-0.5023	-0.0603	-204.8927	-88.1778	-63.7580	-8.7878	91.5943
	11	-0.0218	0.1207	-0.4524	-0.0531	-195.7128	-81.5780	-63.5359	-8.8285	91.5943
	12	-0.0190	0.1021	-0.4105	-0.0440	-193.0475	-81.0270	-63.3855	-9.2079	91.5943
	13	-0.0184	0.0927	-0.3866	-0.0401	-188.0209	-77.8989	-61.2847	-8.5419	91.5943
	14	-0.0203	0.0919	-0.4007	-0.0424	-194.2436	-82.5394	-61.0217	-8.5166	91.5943
	15	-0.0232	0.0975	-0.4221	-0.0490	-194.9388	-82.0108	-60.9239	-8.4108	91.5943
	16	-0.0249	0.1021	-0.4366	-0.0533	-189.7124	-80.6546	-59.3384	-8.3776	91.5943
	17	-0.0249	0.1012	-0.4411	-0.0545	-192.4393	-81.7718	-59.1785	-8.1049	91.5943
	18	-0.0254	0.1037	-0.4538	-0.0557	-195.8836	-82.4606	-60.7650	-8.3625	91.5943
Female	7	-0.0382	-1.0152	0.1792	-0.0494	-243.6775	-105.2918	-72.2330	-6.5154	93.4395
	8	-0.0365	-0.8221	0.1516	-0.0481	-230.6496	-98.5535	-72.7550	-6.9943	93.4395
	9	-0.0329	-0.6752	0.1319	-0.0433	-215.2922	-91.8326	-69.1428	-6.8244	93.4395
	10	-0.0305	-0.5492	0.1092	-0.0391	-200.1985	-84.5013	-67.5850	-7.1746	93.4395
	11	-0.0290	-0.4682	0.0994	-0.0359	-191.5623	-80.7790	-64.9152	-7.1818	93.4395
	12	-0.0309	-0.4615	0.1008	-0.0372	-187.6057	-79.9122	-62.9762	-7.1061	93.4395
	13	-0.0362	-0.4916	0.1059	-0.0419	-180.1397	-78.5417	-58.2217	-6.6247	93.4395
	14	-0.0382	-0.5008	0.1110	-0.0449	-181.9143	-79.9819	-58.5835	-6.6915	93.4395
	15	-0.0386	-0.5173	0.1136	-0.0462	-180.0340	-77.3233	-58.6228	-6.6187	93.4395
	16	-0.0389	-0.5221	0.1144	-0.0460	-177.5432	-76.7805	-58.1202	-6.6791	93.4395
	17	-0.0388	-0.5242	0.1163	-0.0459	-178.8226	-76.1602	-59.0314	-6.6894	93.4395
	18	-0.0394	-0.5211	0.1145	-0.0474	-178.8149	-76.2181	-59.3043	-6.8151	93.4395

Note. α_1, α_2, α_3, α_4, α_5, α_6, α_7, *and* α_8 are coefficients of the objective measure for the transverse-length ratio dimension, which signifies coefficients of variables height, weight, chest circumference, sitting height, chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR), chest circumference-low limb (CCLR), and sitting height-low limb ratio (SLR), respectively; b is constant.

Supplementary Table 2. Equation Coefficients of the Objective Measure for LD (C_2)

Gender	Age	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	b
Male	7	-0.9716	-1.1721	-0.2318	-1.7642	-4.1653	8.2080	-10.5183	-6.8635	92.6360
	8	-0.9433	-0.9925	-0.2103	-1.7812	-4.1508	8.1390	-10.8123	-7.2649	92.6360
	9	-0.9177	-0.8484	-0.1870	-1.7382	-4.0208	7.7082	-10.8912	-7.4859	92.6360
	10	-0.8767	-0.7367	-0.1692	-1.7245	-3.8211	7.3615	-10.6132	-7.6712	92.6360
	11	-0.7751	-0.6125	-0.1524	-1.5181	-3.6499	6.8105	-10.5762	-7.7067	92.6360
	12	-0.6763	-0.5183	-0.1382	-1.2572	-3.6002	6.7645	-10.5512	-8.0378	92.6360
	13	-0.6548	-0.4704	-0.1302	-1.1455	-3.5064	6.5034	-10.2015	-7.4565	92.6360
	14	-0.7216	-0.4663	-0.1350	-1.2129	-3.6225	6.8908	-10.1577	-7.4344	92.6360
	15	-0.8270	-0.4950	-0.1422	-1.4013	-3.6354	6.8466	-10.1414	-7.3420	92.6360
	16	-0.8862	-0.5182	-0.1470	-1.5242	-3.5380	6.7334	-9.8775	-7.3131	92.6360
	17	-0.8863	-0.5138	-0.1486	-1.5574	-3.5888	6.8267	-9.8509	-7.0751	92.6360
	18	-0.9046	-0.5260	-0.1528	-1.5931	-3.6531	6.8842	-10.1150	-7.2999	92.6360
Female	7	-1.1216	-0.0783	-1.0200	-2.1008	-6.9015	-15.2602	1.6958	-8.6745	93.4118
	8	-1.0690	-0.0634	-0.8633	-2.0465	-6.5325	-14.2836	1.7081	-9.3121	93.4118
	9	-0.9656	-0.0521	-0.7508	-1.8396	-6.0975	-13.3095	1.6233	-9.0860	93.4118
	10	-0.8946	-0.0424	-0.6216	-1.6631	-5.6700	-12.2469	1.5867	-9.5522	93.4118
	11	-0.8490	-0.0361	-0.5657	-1.5247	-5.4255	-11.7075	1.5240	-9.5618	93.4118
	12	-0.9061	-0.0356	-0.5736	-1.5799	-5.3134	-11.5818	1.4785	-9.4610	93.4118
	13	-1.0622	-0.0379	-0.6026	-1.7800	-5.1019	-11.3832	1.3669	-8.8200	93.4118
	14	-1.1197	-0.0386	-0.6320	-1.9101	-5.1522	-11.5919	1.3754	-8.9090	93.4118
	15	-1.1327	-0.0399	-0.6468	-1.9639	-5.0989	-11.2066	1.3763	-8.8120	93.4118
	16	-1.1415	-0.0403	-0.6510	-1.9541	-5.0284	-11.1280	1.3645	-8.8924	93.4118
	17	-1.1371	-0.0404	-0.6618	-1.9516	-5.0646	-11.0381	1.3859	-8.9062	93.4118
	18	-1.1552	-0.0402	-0.6520	-2.0146	-5.0644	-11.0464	1.3923	-9.0735	93.4118

Note. α_1, α_2, α_3, α_4, α_5, α_6, α_7, *and* α_8 are coefficients of the objective measure for the length dimension, which signify coefficients of variables height, weight, chest circumference, sitting height, chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR), chest circumference-low limb (CCLR), and sitting height-low limb ratio (SLR), respectively; b is constant.

Supplementary Table 3. Equation Coefficients of the Objective Measure for TD (C_3)

Gender	Age	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	b
Male	7	-0.2302	-2.0223	-2.2865	-0.2951	-34.5723	-53.9490	11.4127	-0.9923	93.3515
	8	-0.2235	-1.7125	-2.0746	-0.2979	-34.4518	-53.4956	11.7318	-1.0503	93.3515
	9	-0.2174	-1.4639	-1.8447	-0.2907	-33.3728	-50.6642	11.8174	-1.0822	93.3515
	10	-0.2077	-1.2712	-1.6687	-0.2884	-31.7151	-48.3854	11.5157	-1.1090	93.3515
	11	-0.1837	-1.0568	-1.5028	-0.2539	-30.2941	-44.7639	11.4756	-1.1142	93.3515
	12	-0.1602	-0.8942	-1.3635	-0.2103	-29.8816	-44.4616	11.4484	-1.1620	93.3515
	13	-0.1551	-0.8116	-1.2843	-0.1916	-29.1035	-42.7451	11.0690	-1.0780	93.3515
	14	-0.1710	-0.8046	-1.3312	-0.2029	-30.0667	-45.2915	11.0215	-1.0748	93.3515
	15	-0.1960	-0.8541	-1.4021	-0.2344	-30.1743	-45.0015	11.0038	-1.0614	93.3515
	16	-0.2100	-0.8941	-1.4503	-0.2549	-29.3653	-44.2573	10.7175	-1.0572	93.3515
	17	-0.2100	-0.8865	-1.4653	-0.2605	-29.7874	-44.8703	10.6886	-1.0228	93.3515
	18	-0.2144	-0.9076	-1.5076	-0.2665	-30.3206	-45.2482	10.9751	-1.0553	93.3515
Female	7	-0.2277	-2.3104	-2.3785	-0.3744	-26.4264	13.7343	-26.4631	-0.2805	93.6860
	8	-0.2171	-1.8709	-2.0130	-0.3647	-25.0135	12.8554	-26.6543	-0.3012	93.6860
	9	-0.1961	-1.5365	-1.7508	-0.3279	-23.3480	11.9787	-25.3310	-0.2939	93.6860
	10	-0.1817	-1.2500	-1.4495	-0.2964	-21.7111	11.0224	-24.7602	-0.3089	93.6860
	11	-0.1724	-1.0654	-1.3190	-0.2717	-20.7746	10.5368	-23.7821	-0.3092	93.6860
	12	-0.1840	-1.0502	-1.3376	-0.2816	-20.3455	10.4238	-23.0718	-0.3060	93.6860
	13	-0.2157	-1.1187	-1.4051	-0.3172	-19.5358	10.2450	-21.3299	-0.2853	93.6860
	14	-0.2274	-1.1398	-1.4738	-0.3404	-19.7283	10.4329	-21.4625	-0.2881	93.6860
	15	-0.2300	-1.1772	-1.5083	-0.3500	-19.5244	10.0861	-21.4769	-0.2850	93.6860
	16	-0.2318	-1.1883	-1.5181	-0.3483	-19.2542	10.0153	-21.2927	-0.2876	93.6860
	17	-0.2309	-1.1929	-1.5432	-0.3478	-19.3930	9.9344	-21.6266	-0.2880	93.6860
	18	-0.2346	-1.1858	-1.5203	-0.3591	-19.3921	9.9419	-21.7265	-0.2934	93.6860

Note. α_1, α_2, α_3, α_4, α_5, α_6, α_7, *and* α_8 are coefficients of the objective measure for the transverse dimension, which signified coefficients of variables height, weight, chest circumference, sitting height, chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR), chest circumference-low limb (CCLR), and sitting height-low limb ratio (SLR), respectively; b is constant.

Supplementary Table 4. Equation Coefficients of the Objective Measure for PD(C_4)

Gender	Age	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	b
Male	7	-0.0175	-0.0588	0.0397	-0.3140	19.3215	-1.0837	-59.4141	-150.1719	90.9860
	8	-0.0170	-0.0498	0.0360	-0.3171	19.2542	-1.0746	-61.0749	-158.9537	90.9860
	9	-0.0165	-0.0426	0.0321	-0.3094	18.6511	-1.0177	-61.5207	-163.7901	90.9860
	10	-0.0158	-0.0370	0.0290	-0.3070	17.7247	-0.9719	-59.9503	-167.8429	90.9860
	11	-0.0140	-0.0307	0.0261	-0.2702	16.9306	-0.8992	-59.7414	-168.6212	90.9860
	12	-0.0122	-0.0260	0.0237	-0.2238	16.7000	-0.8931	-59.6000	-175.8659	90.9860
	13	-0.0118	-0.0236	0.0223	-0.2039	16.2652	-0.8586	-57.6246	-163.1454	90.9860
	14	-0.0130	-0.0234	0.0231	-0.2159	16.8035	-0.9098	-57.3773	-162.6635	90.9860
	15	-0.0149	-0.0248	0.0244	-0.2494	16.8636	-0.9039	-57.2853	-160.6415	90.9860
	16	-0.0160	-0.0260	0.0252	-0.2713	16.4115	-0.8890	-55.7946	-160.0076	90.9860
	17	-0.0160	-0.0258	0.0255	-0.2772	16.6474	-0.9013	-55.6443	-154.8006	90.9860
	18	-0.0163	-0.0264	0.0262	-0.2836	16.9453	-0.9089	-57.1360	-159.7199	90.9860
Female	7	-0.0273	0.0979	-0.0514	-0.3586	11.8755	-102.2754	6.6849	-162.3972	91.7489
	8	-0.0260	0.0792	-0.0435	-0.3493	11.2406	-95.7302	6.7332	-174.3340	91.7489
	9	-0.0235	0.0651	-0.0379	-0.3140	10.4922	-89.2018	6.3989	-170.1003	91.7489
	10	-0.0217	0.0529	-0.0314	-0.2839	9.7566	-82.0805	6.2548	-178.8285	91.7489
	11	-0.0206	0.0451	-0.0285	-0.2603	9.3357	-78.4649	6.0077	-179.0081	91.7489
	12	-0.0220	0.0445	-0.0289	-0.2697	9.1429	-77.6229	5.8282	-177.1207	91.7489
	13	-0.0258	0.0474	-0.0304	-0.3038	8.7790	-76.2917	5.3882	-165.1217	91.7489
	14	-0.0272	0.0483	-0.0319	-0.3261	8.8655	-77.6906	5.4217	-166.7874	91.7489
	15	-0.0275	0.0499	-0.0326	-0.3352	8.7739	-75.1081	5.4253	-164.9718	91.7489
	16	-0.0278	0.0503	-0.0328	-0.3336	8.6525	-74.5809	5.3788	-166.4764	91.7489
	17	-0.0276	0.0505	-0.0334	-0.3331	8.7148	-73.9784	5.4632	-166.7342	91.7489
	18	-0.0281	0.0502	-0.0329	-0.3439	8.7145	-74.0346	5.4884	-169.8663	91.7489

Note. *α_1, α_2, α_3, α_4, α_5, α_6, α_7, and α_8* are coefficients of the objective measure for the proportion dimension, which signified coefficients of variables height, weight, chest circumference, sitting height, chest circumference-height ratio (CCHR), chest circumference-sitting height ratio (CCSR), chest circumference-low limb (CCLR), and sitting height-low limb ratio (SLR), respectively; ***b*** is constant.