Iran J Public Health, Vol. 52, No.6, Jun 2023, pp.1190-1198

Original Article

The Establishment of the Cut-off Value of Weight-for-Height for Preschool Children in China and an Empirical Study on the Influence of Overweight and Obesity on Physical Performance

Chunjing Tu [1], ***Yuxuan Tu*** [2], ****Chongmin Jiang*** [3], ***Sanhua Zhang*** [4]

1. *School of Teacher Education, Taizhou University, Taizhou, China*
2. *Department of Polymer Science and Engineering, Zhejiang University, Hangzhou, China*
3. *China Institute of Sport Science, Beijing, China*
4. *College of Education, Hangzhou Normal University, Hangzhou, China*

***Corresponding Author:** Email: jiangchongming@ciss.cn

(Received 10 Jan 2023; accepted 14 Apr 2023)

Abstract

Background: We aimed to establish the cut-off value of weight-for-height for preschool children in China, and to explore the influence of overweight and obesity on the physical performance of preschool children.

Methods: Data from 31 provinces in China monitored in 2010 and 2014, the standard deviation unit curves of WFH were established by using GAMLSS (generalized additive model for location, scale, and shape) method preschool children in China, and then the cut-off values of normal weight, overweight and obesity were divided. The research group tested 5 physical performance indicators of 5154 preschool children from April 2018 to June 2019 in Beijing and Zhejiang in China. We then compared physical performance differences between the normal-weight group and the overweight-obesity group.

Results: A smooth and effective standard deviation unit curve of WFH was established. The overweight and obesity of Chinese preschool children were at a high level. Being overweight and obese reduced preschool children's relative strength, speed, sensitivity, coordination, and balance ability, but did not reduce preschool children's flexibility. In general, the physical performance of preschool children in the normal weight group was better than that in the overweight and obesity group.

Conclusion: It is suggested to use the WFH criteria in this study to evaluate overweight and obesity in Chinese preschool children, and strengthen physical activity and take in energy substances properly of preschool children, to control the spread of overweight and obesity, to improve physical performance level.

Keywords: Z-score curve; Weight-for-height (WFH); Obesity; Preschool children; China

Introduction

Weight-for-height (WFH) percentile curve (or Z-score curve) is an important tool for evaluating child growth and development; it is also the reference basis for classifying the threshold of normal weight and overweight obesity in children. Many countries and international organizations have developed their Z-score standard curves for height and weight, for example, the WHO used

the GAMLSS model to develop a standard curve of height by weight z-score for children aged 0 to 5 years (1), and according to the curve, the corresponding overweight and obesity thresholds were classified. Iranian scholars have instituted the primary schools of Shiraz (Southern Iran) of WFH percentile curve (2). Scholars in other countries, such as America (3) Sweden (4), and Japan (5), have used the GAMLSS or LMS method to set the Z-score standard curve for height and weight in the country and set the corresponding thresholds for overweight and obesity. In China, Chinese Capital Institute of Pediatrics (CCIP) (6) developed height and weight percentile curves for children and adolescents in nine major cities, the height and weight percentile curves of children aged 0~11.5 years in Shanghai were developed (7). However, there are no WFH z-score curves and overweight and obesity thresholds for preschool children covering all of mainland China. Therefore, it is crucial for us to research it.

Being overweight and obese is harmful to our body, especially to our motion system, cardiovascular system, respiratory system, and endocrine system (8), and then affects our physical health and psychological behavior (9), etc. Being overweight and obese has been shown to reduce the physical fitness of preschool children. Therefore, it is necessary to explore the effects of being overweight and obese on physical health. However, most of the relevant studies at home and abroad have focused on preschool children and fewer studies have been conducted on preschool children. Nowadays, the physical performance level of preschool children in China is not optimistic, the Chinese national physique monitoring data released in 2010, 2014 and 2020 shows that preschool children's strength, balance, and sensitivity have become weaker, and the skinfold thickness of the leather increased, especially the skinfold thickness of the belly, The trend of overweight and obesity at younger age children is obvious (10-12). In addition, there is no national WFH standard deviation unit curve, and cut-off values of normal weight, overweight, and obesity were divided in China.

Given this, this study established the Z-score curve of WFH of preschool children through used data from a large sample of 101,861 preschool children from 31 provinces monitored by the National Center for Physical Fitness Monitoring in 2010 and 2014 (10, 11), and divide the threshold of normal weight and overweight (including obesity). Then, we tested the physical fitness data of 5154 children in Beijing and Zhejiang from 2018 to 2019, comparing physical health differences between normal weight and overweight (including obesity) from Preschool children, which can provide a reference for the improvement of physical health.

Methods

Modeling data source

Standard deviation unit curves modeling data

The modeling data source is the physical fitness data (including height and weight) of children aged 3 to 6 years old from all 31 provinces (autonomous regions and municipalities directly under the Central Government) in China obtained from the two national physical fitness monitoring in 2010 and 2014. Valid sample of 51,159 in 2010, of which 25,583 were male and 25,576 were female; the valid sample of 50702 in 2014, there were 25,381 boys and 25,321 girls; the total modeling sample totaled 101,861 (10,11).

Empirical study data

The research group of this paper collected validation data from April 2018 to June 2019. Data were collected from 16 kindergartens in Zhejiang (Hangzhou and Jiaxing) and Beijing (Dongcheng District and Fengtai District), every place tested 4 Kindergartens, A total of 5839 children aged 3~6 years were tested, and after removing the unqualified data, a total of 5154 valid samples (2663 boys and 2491 girls) were finally obtained. Parents or guardians are given a sports medicine questionnaire before they are tested, on the promise that parents have learned and consented and signed a consent form, the tester checks the subjects who participate in this experiment ac-

tively, Exclude children with diseases the heart, lungs, liver, kidneys and other major organs (such as a history of heart disease, asthma, hyperthyroidism or other physical disabilities) or other children who are not suitable to participate in more strenuous sports.

The research work program protocol was approved by the ethical review committee of these participating institutes.

Research indicators and test methods

Research Indicators

There were 8 indicators in this study, including height, weight, and WFH; physical performance indicators were Sit and Reach, 15-meter running around obstacles, standing long jump, grip strength, walking balance beam, and other 5 indicators. The selection of these indicators mainly refers to the suggestions of the China National Physique Monitoring Center.

Main index test methods

Run 15 meters around obstacles: Run 15 meters around obstacles mainly to evaluate the quality of coordination and speed quality, the test program is as follows: Field Equipment: On a flat surface, draw the starting and finishing lines at the ends of the runway 15 meters apart, place the first marker barrel at 3 meters from the starting line, and then place 7 large cones every 1.5 meters in turn; several stopwatches. Test method: Subjects ran in groups of 2, starting from the starting point, crossing the finish line around the cone, and recording the time of crossing the finish line in seconds, accurate to 0.1 seconds. Each child was measured twice, and the best one was taken as the final result (Fig. 1).

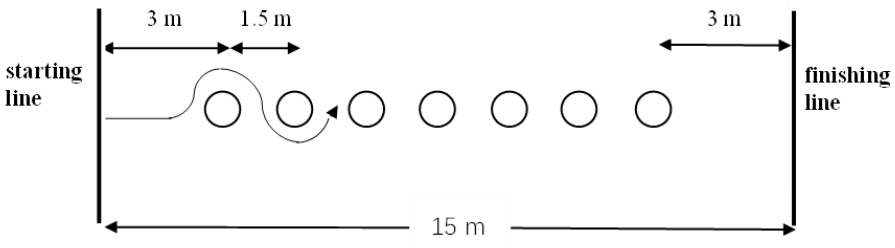

Fig. 1: Diagram of running 15 meters around an obstacle course

The remaining 7 physical health indicators: This research involves the remaining physical health indicators following test specifications and requirements of National Physical Fitness Test Program (Early Childhood Component) to test (11). Testing Instruments adopt the uniformed equipment used in national physical fitness surveillance Previous.

Research Methodology

GAMLSS Model Method

Apply GAMLSS Model Method (Generalized Additive Model for Location, Scale, and Shape, abbreviations: GAMLSS) to research WFH Standard deviation unit curve, then cut-off the normal weight and overweight (including obesity) thresholds. The GAMLSS model method is based on a generalized additive model of position, scale, and shape. The GAMLSS model is presented in the form of a specific distribution of D (median μ, standard deviation σ, skewness ν, kurtosis τ), and any percentile curve and standard deviation unit curve are directly expressed by four parameter curves μ, σ, ν, τ. The model is widely used in the development of time series percentile curves. GAMLSS The specific principles and methods of modeling can be found in the original literature (13), and the details of the principles, key steps, and the accuracy and validity verification of the model results of body mass index modeling can be found in the related literature of the authors of this paper (14). The GAMLSS model uses R software.

Empirical Research Method

In this study, the two-sample *t*-test was used to compare the physical differences between the normal weight group and the overweight-obesity group of the same gender and age group; Chi-square test was used to compare the two population rates. Significance test level test level α= 0.05, data analysis software was SPSS 24.0 (IBM Corp., Armonk, NY, USA).

Results

Standard z-score curve of WFH

The standard z-score curve of WFH Standard z-score curve and the value for WFH was constructed using the GAMLSS model, the results are shown in Table 1. The rating criterion of WFH was as follows: Weight corresponding to a height greater than or equal to "median+SD" is considered overweight-obesity, and "median-2SD~median+SD" is normal weight.

Table 1: The standard *Z* score curve of WFH for preschool children in China (kg)

Height	***Boys***					***Girls***				
(cm)	-2SD	-1SD	Median	+1SD	+2SD	-2SD	-1SD	Median	+1SD	+2SD
78 ~	9.1	9.9	10.5	11.5	13.0	8.8	9.4	10.3	11.4	12.5
80 ~	9.5	10.2	10.9	11.9	13.4	9.1	9.8	10.7	11.8	12.8
82 ~	9.8	10.6	11.3	12.4	13.8	9.5	10.2	11.2	12.2	13.2
84 ~	10.1	10.9	11.8	12.8	14.2	9.8	10.6	11.6	12.6	13.6
86 ~	10.5	11.2	12.2	13.2	14.6	10.2	11.0	12.0	13.0	14.0
88 ~	10.9	11.6	12.6	13.7	15.1	10.6	11.4	12.4	13.4	14.5
90 ~	11.2	12.0	13.1	14.1	15.6	11.0	11.9	12.9	13.9	15.1
92 ~	11.6	12.4	13.5	14.6	16.1	11.4	12.3	13.3	14.3	15.7
94 ~	12.1	12.8	14.0	15.1	16.7	11.8	12.7	13.7	14.8	16.3
96 ~	12.5	13.3	14.5	15.6	17.4	12.2	13.2	14.2	15.4	17.0
98 ~	12.9	13.7	14.9	16.2	18.0	12.6	13.6	14.7	15.9	17.7
100 ~	13.4	14.2	15.5	16.8	18.8	13.1	14.1	15.2	16.5	18.5
102 ~	13.9	14.8	16.0	17.4	19.6	13.6	14.6	15.7	17.2	19.3
104 ~	14.4	15.3	16.6	18.0	20.4	14.0	15.1	16.3	17.8	20.2
106 ~	14.9	15.9	17.2	18.8	21.4	14.5	15.7	16.9	18.6	21.1
108 ~	15.4	16.6	17.8	19.5	22.3	15.0	16.2	17.5	19.3	22.0
110 ~	15.9	17.2	18.5	20.3	23.4	15.6	16.8	18.2	20.1	23.0
112 ~	16.5	17.9	19.2	21.2	24.5	16.1	17.4	18.9	21.0	24.0
114 ~	17.0	18.6	20.0	22.2	25.7	16.7	18.0	19.6	21.9	25.1
116 ~	17.6	19.3	20.8	23.2	27.0	17.2	18.7	20.4	22.8	26.2
118 ~	18.2	20.0	21.7	24.3	28.4	17.8	19.4	21.3	23.8	27.4

120 ~	18.8	20.8	22.7	25.5	29.8	18.4	20.1	22.2	24.9	28.5
122 ~	19.4	21.6	23.7	26.8	31.3	19.1	20.8	23.1	26.0	29.8
124 ~	20.0	22.4	24.8	28.1	32.9	19.7	21.6	24.1	27.2	31.0
126 ~	20.7	23.3	25.9	29.6	34.6	20.4	22.4	25.2	28.4	32.3
128 ~	21.3	24.2	27.2	31.1	36.4	21.0	23.3	26.4	29.8	33.6
130 ~	22.0	25.1	28.5	32.8	38.3	21.7	24.2	27.6	31.1	35.0
132 ~	22.7	26.0	29.9	34.5	40.3	22.5	25.1	28.9	32.6	36.4
134 ~	23.4	27.0	31.4	36.4	42.4	23.2	26.1	30.2	34.1	37.8
136 ~	24.1	28.0	32.9	38.4	44.6	23.9	27.1	31.7	35.7	39.2
138 ~	24.9	29.0	34.6	40.5	46.9	24.7	28.1	33.2	37.4	40.7
140 ~	25.6	30.0	36.4	42.8	49.4	25.5	29.2	34.8	39.1	42.2

Body type distribution of subjects in empirical studies

A classification of the 5154 valid sample size tested in the empirical study could be obtained (Table 2): 2146 (80.6%) and 2002 (80.4%) boys and girls with normal body composition, respectively; There were 445 (16.7%) and 419 (16.8%) boys and girls in the overweight-obesity group, respectively. There were only 72 and 70 thin boys and girls respectively, which was a small proportion. Considering that the number of thin body samples was small compared with the continuous improvement of nutritional status, this study only dealt with the comparison of physical health between the normal weight group and the overweight-obesity group.

Table 2: Distribution of normal weight, overweight-obesity among preschool children in China

Gender	*Age (yr)*	*Normal weight group*		*Overweight-obesity group*	
		N	Rates（%）	N	Rates（%）
Boys	3	528	80.2	113	17.1
	4	549	81.5	108	16.0
	5	534	80.9	108	16.4
	6	535	79.7	116	17.3
	Total	2146	80.6	445	16.7
Girls	3	495	80.4	106	17.2
	4	505	80.2	106	16.8
	5	490	78.8	114	18.4
	6	512	82.3	93	15.0
	Total	2002	80.4	419	16.8

Note: The number of thin boys and girls was 72 and 70 respectively.

Comparison of the physical performance of normal weight group and overweight-obesity group preschool children

Findings were made using a two-sample *t*-test: that the differences between normal weight and overweight-obesity groups for most physical fitness indexes were statistically significant ($P<0.05$), and that the normal weight group's physical performance indicator was generally better than those of the overweight-obesity group, and the specific results were as follows (Table 3).

Sitting forward bend: mainly reflects flexibility quality. There was no statistically significant difference between the normal weight group and the overweight-obesity group of the same gender and age group. Run 15 meters around obstacles: this indicator mainly reflects the coordination and Sensitivity quality. the normal weight group was better than the overweight-obesity group in all age groups in coordination and Sensitivity, among which the difference was statistically significant in 4, 5, and 6 years old (P<0.05). Standing long jump: which mainly reflects the explosive power of the lower limbs. The weight scores of the normal weight group in the same sex and age group were better than those of the overweight-obesity group, and among which the difference was statistically significant in 3, 5, and 6 years old of boys and 5 and 6 years old of girls (P<0.05). Grip strength and Grip strength index: which mainly reflects upper limb strength. It was no statistically significant difference between the normal weight group and the overweight-obesity group of the same gender and age group in Grip strength (P<0.05). But, All normal weight groups had a greater grip strength index (grip strength/weight*100) than the overweight-obesity group (P<0.05). Walking the balance beam: this index mainly reflects the balance ability. All children of the same sex had better scores in the normal weight group than the overweight and obese group; among which the difference was statistically significant in 5 and 6 years old of boys and 4,5 and 6 years old of girls (P<0.05).

Table 3: Comparison of physical ability between normal weight group and overweight-obesity group ($\bar{X}$±SD)

Index	***Age (yr)***	***Boys***					***Girls***				
		Normal weight group	Overweight -obesity group	Difference	*t*	*P*	Normal weight group	Overweight -obesity group	Difference	*t*	*P*
Sit and Reach (cm)	3	10.93±3.94	11.57±3.84	-0.64	-1.60	0.11	12.43±3.32	12.95±3.51	-0.52	-1.40	0.16
	4	10.68±3.92	11.31±3.73	-0.63	-1.59	0.11	12.54±3.57	12.87±3.53	-0.33	-0.87	0.38
	5	9.92±4.18	10.15±4.43	-0.23	-0.50	0.62	12.46±4.02	12.64±4.44	-0.18	-0.40	0.69
	6	9.36±4.68	9.56±4.33	-0.20	-0.44	0.66	12.37±4.35	12.45±4.23	-0.08	-0.17	0.87
Run 15 meters around obstacles (s)	3	9.63±0.98	9.83±1.23	-0.20	-1.62	0.11	9.79±1.19	9.88±1.16	-0.09	-0.72	0.47
	4	8.46±1.15	8.77±1.26	-0.31*	-2.37	0.02	8.53±1.64	8.83±1.08	-0.30*	-2.35	0.02
	5	6.82±0.89	7.28±1.24	-0.46★	-3.67	0.00	7.01±1.13	7.42±1.22	-0.41★	-3.28	0.00
	6	6.31±0.86	6.68±1.18	-0.37★	-3.20	0.00	6.62±1.21	6.96±1.14	-0.34★	-2.62	0.01
Standing long jump (cm)	3	68.86±18.51	65.18±17.73	3.68*	1.99	0.05	64.17±18.33	61.97±16.59	2.20	1.22	0.22
	4	83.79±18.36	81.56±18.35	2.23	1.15	0.25	77.79±16.41	76.15±16.16	1.64	0.95	0.34
	5	103.48±17.25	99.45±16.62	4.03*	2.28	0.02	95.35±15.29	92.13±14.69	3.22*	2.09	0.04
	6	113.15±17.34	108.96±16.61	4.19*	2.44	0.01	103.63±16.21	99.67±14.43	3.96*	2.39	0.02
Grip strength (kg)	3	4.56±1.31	4.67±0.40	-0.11	-1.61	0.11	4.45±1.23	4.58±1.16	-0.13	-1.04	0.30
	4	5.42±1.83	5.67±1.82	-0.25	-1.30	0.19	4.88±2.00	4.96±1.44	-0.08	-0.48	0.63
	5	6.91±2.45	6.97±2.33	-0.06	-0.24	0.81	6.43±2.23	6.46±1.82	-0.03	-0.15	0.88
	6	8.95±2.33	9.16±1.96	-0.21	-1.01	0.31	7.85±2.13	8.12±2.15	-0.27	-1.12	0.26
Grip strength	3	5.79±4.01	4.92±3.29	0.87*	2.45	0.01	5.42±2.75	4.78±2.68	0.64*	2.22	0.03

index	4	7.78±3.52	6.19±2.90	1.59★	5.02	0.00	7.79±3.36	6.33± 2.53	1.46★	5.08	0.00
	5	10.33±5.36	8.47±3.53	1.86★	4.52	0.00	9.45±4.26	8.46± 3.19	0.99★	2.79	0.01
	6	12.66±7.29	9.12±3.59	3.54★	7.72	0.00	10.56±4.38	8.64± 3.23	1.92★	4.96	0.00
Walking balance beam (s)	3	12.85±7.12	14.15±7.23	-1.30	-1.74	0.08	14.25±8.41	14.59±8.45	-0.34	-0.38	0.71
	4	11.13±6.41	11.22±6.19	-0.09	-0.14	0.89	10.09±7.59	11.91±7.66	-1.82*	-2.23	0.03
	5	7.46±5.36	8.26±5.65	-1.23*	-2.08	0.04	6.71±5.46	8.24±5.46	-1.53★	-2.69	0.01
	6	5.29±4.19	6.23±4.35	-0.94*	-2.12	0.03	5.45±4.92	6.56±4.53	-1.11*	-2.14	0.03

Note:①Difference represents the normal weight group, overweight and obese group;②*P<0.05，★*P*<0.01

Discussion

Overweight and obesity in China is becoming increasingly serious at an early age

This study finds that overweight-obesity rates are 16.7% and 16.8% for male and female children, respectively, and the overweight and obesity are at a high level. Since the 1980s, the overweight and obesity of children in the world have increased rapidly, the trend (15, 16) of younger age is obvious, childhood obesity has become an increasingly serious public health problem, and the overweight and obesity rates of children in developing countries have a tendency to catch up with those in developed countries. The State of the World's Children 2019 released by the United Nations Children's Fund also shows the existence (17) of the above-mentioned status quo. Simple obesity in preschool children in China was at a very low level in the early 1980s, and in 1985 the detection rate of obesity in children aged 0-7 years in the main nine cities of China was 0.91% and 0,9% for men and women, respectively (18), and in 2015 the survey of physical development of children under seven years old in nine cities of China found that the weight of children aged 0-7 years continued to increase (19). A large number of regional survey studies in China in the past five years illustrated that the detection rate of overweight and obesity in preschool children aged 3~6 years is particularly severe (20), which is consistent with the findings of this study, and it can be expected that the overweight and obesity of preschool children in China will continue to grow in the future.

Overweight and obesity reduce the physical performance of preschool children

These results show that overweight and obesity decrease qualities of relative strength, speed, agility, coordination, and balance of preschool children, but the effect of overweight-obesity on the flexibility of preschool children could be ignored. This is similar to other studies, such as Xu Liangliang (21). According to the BMI overweight standard of the International Obesity Task Force (IOTF) found that being overweight reduced the physical fitness of Chinese children aged 5-6 years. Xie Jieyan (22) found that being overweight and obese would have many adverse effects on the strength, balance, coordination, and other qualities of children in preschool children of most ages. Krombholz et al (23) suggested that: overweight children (ages 43 to 84 months) showed lower performance in gross motor skills (coordination and fitness) if compared with healthy-weight children. Our study also found that the health effects of being overweight and obese increase with age, For example, in terms of balance ability, there was a significant difference between normal weight and overweight and obese children at 5 and 6 years old, but no significant difference at 3 years old. This trend should arouse our attention.

Preschool children are in a sensitive period of body growth and development, as well as a period of active adipose tissue development and regrouping (24), during this time, it is of great significance for the health level of children's constitution to control their weight. Physical activity of a certain duration and intensity is effective in reducing overweight, obesity, and improving the

physical health of preschool children (25). Physical activity should be done throughout the day for children aged 3 to 5 years, and preschoolers should be encouraged to engage actively in all types of physical activity (light, moderate, or vigorous intensity) for at least 3 hours per day (26).

Conclusion

The research was based on large sample data from 31 provinces (Autonomous regions and municipalities). It applies the GAMLSS model to construct a Standard deviation unit curve for WFH and divides the thresholds of normal weight and overweight obesity.

At present, overweight and obesity of children aged 3~6 years old are at a high level in China, and the negative effects of overweight and obesity on children's physical performance have already appeared in preschool.

Preschool children are in a period of rapid development of physical development, functions, and quality, government departments, universities, kindergartens, etc. should increase the exploration of physical health education to curb the spread of overweight and obesity among preschool children and improve the health level of preschool children.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Funding

This work was supported by Zhejiang Provincial Philosophy and Social Science Planning Project under Grant No.19NDJC059YB, and 19NDJC061YB, and Key Project of the Ministry of Education of the People's Republic of China in the 13th Five-Year Plan for Education under Grant No.DHA180359, and Zhejiang Province Education Science planning Project under Grant No.2021SB021.

Acknowledgements

We are grateful to the China National Physique Monitoring Center and Participants in the test for their assistance in collecting data for our study.

Conflict of interest

The authors declare that there is no conflict of interest.

References

1. WHO (2006).WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatrrica* Suppl, 95(S450):76-85.
2. Ayatollahi SMT, Bagheri Z (2011). New Trends in Weight-for-Height Charts of Shirazi School Children Relation to the CDC Reference Data. *Iran J Pediatr*, 20(4):407-412.
3. Hoover-Fong JE, Schulze, KJ, Alade AY, et al (2021). Growth in achondroplasia including stature, weight, weight-for-height and head circumference from CLARITY: achondroplasia natural history study-a multi-center retrospective cohort study of achondroplasia in the US. *Orphanet J Rare Dis*, 2021,16(1):1750-1172.
4. Albertsson-Wikland K, NiklassonA, Gelander L, et al (2020). Swedish references for weight, weight-for-height and body mass index: The GrowUp 1990 Gothenburg study. *Acta Paediatr*, 110(2):537-548.
5. Inokuchi M, Matsuo N, Takayama JI, et al (2019). National anthropometric reference values and growth curves for Japanese children: history and critical review. *Ann Hum Biol*, 46(4):287-292.
6. Chinese Capital Institute of Pediatrics (2009). Growth standardized values and curves based on weight for length／height body mass index for Chinese children under 7 years of age. *Zhonghua Er Ke Za Zhi,* 47(4):281-285. [In Chinese]
7. Jiang Y, Tim Cole, Pan Huiqi, et al (2007). Development of height and weight standards for

0-18 year olds in Shanghai. *Shanghai Journal of Preventive Medicine*, (11):544-547.
8. Ma Guan-sheng, Mi J, Ma Jun, et al (2017). *Report on childhood obesity in China.* People's Health Publishing House Inc, China.
9. Wang Weirong (2014). Study on factors influencing psychological behavior and countermeasures in 160 cases of obese children. *Clin Lab Med,* 11(23):3354-3355.
10. General Administration of Sports of China (2011). *2010 National Physical Fitness Monitoring Report.*Beijing: People's Sports Publishing House.
11. General Administration of Sports of China (2017). *2014 National Physical Fitness Monitoring Report.*Beijing: People's Sports Publishing House.
12. General Administration of Sports of China (2022). *The fifth Bulletin of China's National Physical Fitness Monitoring.* Available from: https://www.sport.gov.cn/n315/n329/c24335066/content.html.
13. Rigby RA, Stasinopoulos DM (2004). Smooth centile curves for skew and kurtotic data modelled using the Box–Cox power exponential distribution. *Stat Med*, 23(19):3053-3076.
14. Chunjing T, Yanfeng Z, Chongmin J, et al (2021). Construction BMI Percentile Standard Curve and Cut-offs Point for Overweight and Obesity of 3~6 Years Children Based on GAMLSS Model in China. *China Sports Science*, 41(3):63-73.
15. Marie N, Tom F, Robinson M, et al (2014). Global, Regional, and National Prevalence of Overweight and Obesity in Children and Adults during 1980–2013: A Systematic Analysis for the Global Burden of Disease Study 2013.*The Lancet*, 384(9945):766-781.
16. Han JC, Lawlor DA, Kimm SY (2010). Childhood obesity. *Lancet*, 375(9727):1737-1748.
17. United Nations Children's Fund (2019). The State of the World's Children 2019.Available from: https://www.unicef.cn/
18. Li F, Zhang X, Yan GF (2002). Ten-year trends in the prevalence of simple obesity in children under 7 years of age in eight cities. *Chinese Journal of Child Health*,10(05):316-318.
19. Capital Institute of Pediatrics (2018). Collaborative Group of Survey on Physical Development of Children in Nine Cities. 2015 Survey on physical development of children under seven years old in nine cities of China. *Chinese Journal of Pediatrics*, 56(3):192-199.
20. Han Yuchen (2016). Comparison of growth curves of height, weight and body mass index of children aged 3~6 years in Nanjing with LMS method and international standards [MD thesis].Yangzhou University, China.
21. Xu Liangliang, Liu Xin, Wang Mei (2015).Effect of underweight and overweight on children's physical fitness. *China Sport Science and Technolog*, 51(01):127-131.
22. Xie Jieyan, Yan Xueqin, Zeng Jie, et al (2020). Analysis on physical condition of preschool children in Zhongshan City. *School health in China*,41(04):604-607.
23. Kondric M, Trajkovski B, Strbad, M, Foretic (2013). Anthropometric influence on physical fitness among preschool children: gender-specific linear and curvilinear regression models. *Collegium Antropologicum*, 37(4),1245– 1252.
24. Liu G, He YQ (2010). *Preschool nutrition*. Fudan University Press, Shanghai.
25. Chang ZY, Wang SH, Zhang XH (2020). The relationship between physical activity, sedentary behavior and preschool children's physical health. *Preschool Education Research*, 303(3):42-56.
26. Piercy Katrina L, Troiano Richard P, Ballard Rachel M, et al (2018).The Physical Activity Guidelines for Americans. *JAMA*, 320(19):2020-28.