Influencing factors of thyroid volume and comparative analysis of different thyroid volume correction methods of children aged 8-10 Years in Gansu, China

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Running title: Thyroid volume correction methods of children

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ABSTRACT

Background and Objectives: This study aimed to analyze the relationship between thyroid volume (TVOL) and physical development of children, and explore the suitable TVOL correction methods. **Methods and Study Design:** 1500 children aged 8-10 years from Gansu Province northwest China were selected. The height (H), weight (W), urine iodine of children was measured and their thyroid was examined by ultrasound. Body mass index (BMI), body surface area (BSA) and TVOL were calculated (BSA was calculated by three formulas), and the relationship between TVOL and age, sex, physical development was analyzed. The applicability of TVOL correction methods including BMI corrected volume (BMIV), BSA corrected volume (BSAV), weight and height corrected volume indicator (WHVI) and height corrected volume indicator (HVI) were compared. **Results:** Median urinary iodine concentrations of children aged 8, 9, 10 years were 166.6 μg/L, 167.2 μg/L and 178.8 μg/L respectively. The rate of iodine deficiency was 20.3%, the rate of thyroid goiter was 3.2%. The physical development indexes (height, weight, BMI and BSA) and TVOL increased with age. The physical development indexes (height, weight, BMI and BSA) of boys were higher than girls (p <0.05). Only BSAV1 had no correlation with all physical development indexes (p >0.05). The TVOL P97 (97th percentile) of children aged 8, 9, 10 years were 4.4 ml, 4.9 ml, 6.5 ml, the values were 4.6 mL, 4.7 mL, 5.9 mL after BSAV1 corrected. The difference between TVOL and BSAV1 ranges from -0.37% to 0.36%. **Conclusions:** The thyroid volume is not only affected by age, but it is also affected by physical development. Thyroid goiter should be assessed based on age and physical development. The formula BSAV1=TVOL/ ($W^{0.425}\times H^{0.725}\times 71.84\times^{10-4}$) was a suitable TVOL correction method.

Key Words: children, iodine, thyroid, BSA, nutrition

INTRODUCTION

Thyroid volume (TVOL) is the basis for evaluation of iodine deficiency disorders (IDD). Long-term iodine deficiency can lead to enlarged TVOL and goiter.[1] The World Health Organization (WHO) recommended that when the thyroid goiter rate of school-age children (6-12 years) in an area is greater than or equal 5%, this area was considered to have IDD prevalence.[2,3] Accurate measurement of TVOL is important. Ultrasound could measure TVOL more accurately and objectively than palpation, which plays a vital role in the prevention and treatment of IDD.[4] TVOL was not only affected by age, sex and iodine nutrition,[5] but also related to physical development such as height, weight, BMI, BSA.[6, 7]

World Health Organization and International Council for the Control of Iodine Deficiency Disease (WHO/ ICCIDD) considered there were regional differences in TVOL,[8, 9] and recommended that age and BSA should be taken as influencing factors to establish the diagnostic criteria for goiter,[10] which has been widely recognized.

Compared with WHO/ICCIDD standard, the current diagnostic criteria for goiter of 2007 version in China only considered the influence of age on volume,[3] but did not consider the influence of physical development such as BSA. In order to eliminate the influence of physical development on TVOL, a variety of methods such as BMI corrected volume (BMIV), BSA corrected volume (BSAV), weight and height corrected volume indicator (WHVI) and height corrected volume indicator (HVI) had been explored and studied to correct TVOL of children.[11] Currently, whether the above TVOL correction methods could be applied to the current nutritional status of Chinese children remains unclear. There are three formulas to calculate BSA, but it is unclear which one suitable for correcting TVOL. In this study, related influencing factors of TVOL of children aged 8-10 years lived in appropriate iodine intake area were studied, and different correction methods were analyzed whether they could eliminate the differences in TVOL caused by physical development factors, and this study was explored for suitable TVOL correction methods of children aged 8-10 years in Gansu, China.

MATERIALS AND METHODS

Samples and anthropometry

30 counties were selected by population proportion probability sampling (PPS) method in Gansu Province northwest China, and one primary school was random selected from each county. Children with thyroid goiter by palpated examination were excluded. Fifty children aged 8-10 years were selected from each primary school. A total of 1500 children were selected with an equal age and sexes ratio (the ratio of children aged 8, 9, 10 years was close to 1:1:1, also the ratio of boys and girls was close to 1:1) .

The height and weight of selected children were measured by uniform standards to the nearest millimetre and 0.1 kilograms respectively, weight and height were measured three times for each child. TVOL was examined by ultrasound. Urine was collected for determination of urinary iodine. This study was conducted according to the guidelines established in the Declaration of Helsinki, and all procedures involving human volunteers were approved by the Ethics Committee of Gansu Provincial Center for Disease Control and

Prevention (the number was 2022034). Written informed consent was obtained from each parent.

Physical development assessment methods

Height (H), body weight (W), BMI and BSA were used as evaluation indexes for physical growth and development. BMI=Weight (kg) / Height $(m)^2$. BMI, expressed as 0.1 kg/m^2.

In this paper, three formulas suitable were used to calculate BSA of children and compare their difference. Height (H), body weight (W) and BSA expressed as 0.1 cm, 0.1 kg and 0.01 m^2 respectively.

(1) Du Bois formula[12] $BSA1=W^{0.425}\times H^{0.725}\times 71.84\times^{10-4}$

(2) Stevenson Formula[13] $BSA2=0.0061\times H+0.0128\times W-0.1529$

(3) Hu Yongmei Formula[14] $BSA3=0.0061\times H+0.0124\times W-0.0099$

Examination, calculation and correction of TVOL

The operator of thyroid ultrasound were trained by nationally accredited provincial professional. The length, width, thickness of bilateral thyroid of children was measured by ultrasound machine with probe frequency 7.5 MHZ. The length, width, thickness of thyroid were expressed as mm. TVOL was calculated by the WHO criteria using formula as $V=0.479\times(Ll\times Lw\times Lt+Rl\times Rw\times Rt)$, Where L, R represent left, right and l, w, t represent the maximum length, width and thickness of thyroid lateral lobe respectively. The TVOL was compared with reference value of TVOL established by China according to children's age, the TVOL P97 values of children aged 8, 9, 10 were 4.5 mL, 5.0 mL, 6.0 mL, respectively,3 TVOL > P97 values was considered to be enlarged.

The TVOL correction methods were as follows, $BMIV=V/BMI\times 10$, $WHVI=V/(W\times H)\times 1000$, $HVI=V/H2\times 10000$, $BSAV1=V/BSA1$, $BSAV2=V/BSA2$, $BSAV3=V/BSA3$, V represents TVOL. By comparing the effects of sex, age, height, weight, BMI and BSA on TVOL as well as the correlation among different TVOL correction result, the merits and disadvantages of different correction methods were determined.

Urine iodine concentration

Urine samples were stored in 4° refrigerator and urine iodine was measured within 24 hours. The modified acid digestion method, As^{3+}-Ce^{4+}catalytic spectrophotometric was used to determine urinary iodine concentrations of children,15 urine iodine was measured three times. The evaluation was carried out according to the criteria recommended by

WHO/UNICEF/ICCIDD, on basis of which, median urinary iodine less than 100 μg/L is an insufficient iodine intake, 100-199 μg/L urine iodine median is an adequate intake, 200-299 μg/L urine iodine median is an intake which is above requirements iodine intake, urine iodine median ≥300 μg/L is excess iodine intake.

Statistical analysis

Data were analyzed using IBM SPSS 20.0. Continuous variable with Gaussian distribution were presented as (mean ± standard deviation), while skewed distribution datas were presented as median (P50) and inter-quartile range (P25, P75). Difference of physical development (height, weight, BMI, BSA) and TVOL values among ages were analyzed by Kruskal-Wallis H(K) test, which were analyzed by Mann-Whitney U test between sexes. Correlation analysis between TVOL and development indexes (height, weight, BMI, BSA) were analyzed by Spearman correlation method. In all analyses $p < 0.05$ was considered statistically significant.

RESULTS

Basic information of sample population

A total of 1500 children were surveyed, among which 757 (50.47%) were male students and 743(49.53%) were female students. The mean age was (9.0±0.8) years, and among which 501 (33.40%), 503 (33.53%) and 496 (33.07%) were in the groups of aged 8, 9 and 10 years, respectively.

A total of 1499 urine sample were tested, median urinary iodine (MUI) of children aged 8, 9 and 10 was 166.6 (108.4, 229.6) μg/L, 167.2 (106.3, 239.2) μg/L and 178.8 (106.3, 239.2) μg/L, respectively. There was no difference in urinary iodine level distribution among different ages (Z=-2.306, p=0.021). That indicated the iodine intake of children aged 8-10 was appropriate. The urinary iodine of children less than 100 μg/L, 100-199 μg/L, 200-299 μg/L and ≥300 μg/L was 20.3%, 43.0%, 24.5%, 12.3%, respectively. The rate of thyroid goiter was 3.2%. (Table 1).

Distribution characteristics of TVOL value and physical development indexes

The height data, weight data, BMI data, BSA1 data, BSA2 data, BSA3 data, TVOL data, BMIV data, HVI data, WHIV data, BSAV1 data, BSAV2 data and BSAV3 data were positively skewed distribution (K-S-Z value were 1.856-5.632, p <0.01, Kurtosis and Skewness values were all >0.200).

Characteristics of physical development indicators of children

The median (P50) of height, weight, BMI, BSA1, BSA2 and BSA3 of children aged 8-10 years were 131.0 cm, 26.9 kg, 15.5 kg/m^2, 0.99 m^2, 0.99 m^2 and 1.12 m^2, respectively. All indexes value of physical development increased with age (p <0.05). All the physical development indexes values of boys were higher than that of girls (p <0.05) (Table 2).

Age, sex characteristics of TVOL, corrected TVOL values

The values of TVOL increased with age (H=127.107, p <0.05). The values of TVOL, was no significant difference between sexes (Z=1.741, p > 0.05) (Table 3).

The values of BMIV, BSAV1, BSAV2 BSAV3 and HVI increased with age (p <0.05). The values of BMIV, BSAV1, BSAV2, BSAV3 and HVI were no difference between sexes (Z values were 0.070, 0.157, 0.090, 0.364, 0.453, p >0.05). WHIV differed between sexes (Z=2.702, p <0.05) (Table 3).

Relationship between TVOL values and physical development indexes

The values (P50, P97) of TVOL, BMIV, WHIV, HVI and BSAV were shown in table 4 as grouped according to the median (P50) values of height, weight, BMI, BSA. Less than or equal to P50 value was considered as lower physical development while greater than P50 value was considered as higher physical development.

The values of TVOL, BMIV, WHIV, BSAV3 had significant differences between lower and higher physical development indexes (p <0.05). HVI had no difference between lower and higher height (p >0.05), but had significant different between lower and higher weight, BMI, BSA (p <0.05). BSAV2 had no difference between lower and higher BMI (p >0.05), but had significant differences between lower and higher height, weight, BSA (p <0.05). Only BSAV1 values had no difference between lower and higher physical development indexes (p >0.05) (Table 4).

Correlation analysis between TVOL and physical development indexes

There were positive correlation between TVOL and all corrected TVOL (p <0.05). TVOL, BMIV, HVI, BSAV1, BSAV2, BSAV3 values were positively correlated with ages (p <0.05). WHIV was negatively correlated with age and all physical development indexes (p <0.05). TVOL, BMIV, BSAV2, BSAV3 were positively correlated with all physical development indexes (p <0.05). HVI were positively correlated with weight, BMI, BSA (p <0.05) but no

correlated with height (p >0.05). Only BSAV1 was no correlation with all physical development indexes (p >0.05) (Table 5).

TVOL and BSAV1

The TVOL P97 of children aged 8, 9, 10 years were 4.4 mL, 4.9 mL, 6.5 mL, the values were 4.6 mL, 4.7 mL, 5.9 mL after BSAV1 corrected. The difference between TVOL and BSAV1 ranges from -0.37% to 0.36%. TVOL P97 of children aged 10 years was closer to the Chinese standard (Table 6).

DISCUSSION

Due to geographical difference, iodine content in water and food in different regions is different, resulting in different in the intake of iodine among people, so the TVOL of children in difference regions is difference. China is a huge geographical country. Appropriate TVOL evaluation indexes should be established for different regions. All regions of Gansu Province are iodine deficient, and residents supplement iodine nutrition mainly through salt iodization. According to the research of Xu Lihua, the coverage rate of iodized salt in Gansu Province was 99.6%.[16]

In this study, the median urinary iodine (MUI) of children was 166.6 μg/L in the group aged 8 years, 167.2 μg/L in the group aged 9 years, 178.8 μg/L in the group aged 10 years, the results indicating that the intake of iodine of this population belonged to the appropriate iodine state.[15] The rate of thyroid goiter <5% (3.2%) according to the standard (WS 276-2007). Height, weight, BMI, BSA of children aged 8-10 years increased with age, and the values of boys were higher than that of girls (p <0.05) . Height of boys aged 8, 9, 10 years old from Gansu Province was 2.9 cm, 3.8 cm, 3.8 cm lower than the reference height of Chinese same aged boys in 2018 (height of boys aged 8, 9, 10 years old in Gansu province was 127.8 cm, 132.0 cm, 137.0 cm, while the height of China was 130.7 cm, 135.8 cm, 140.8 cm). And height of girls aged 8, 9, 10 years old from Gansu Province was 3.3 cm, 4.9 cm, 6.7 cm lower than the reference height of Chinese same aged girls in 2018 (height of girls aged 8, 9, 10 years old in Gan province was 126.0 cm, 130.0 cm, 134.5 cm, while the height of China was 129.3 cm, 134.9 cm, 141.2 cm).[17] The analysis of children's physical development showed that there was a gap between Gansu and Chinese children.

The P97 of TVOL of children aged 8-10 years increased with age, which was consistent with research reports at present.18 The reference TVOL values (P97) of children aged 8, 9, 10 years in Gansu province were 4.4 mL, 4.9 mL and 6.5 mL, respectively. Compared with the

current Chinese standard, the TVOL of children aged 8 and 9 years was 0.1 mL lower than the current Chinese standard (WS 276-2007), while the TVOL of children aged 10 was 0.5 mL higher.[3] Compared with the WHO/UNICEF/ICCIDD standard, the TVOL of children aged 8, 9, 10 years was lower.[2] TVOL was affected by weight and height, this study found that there was positive correlation between TVOL and weight, height, BMI and BSA (p <0.05), this was consistent with the study of Qiaoyong Liu.[19]

The values of TVOL, BMIV, WHIV, BSAV1, BSAV2, BSAV3, HVI increased with age, which had difference among age but had no difference between genders beside WHIV. There was a highly positive correlation between TVOL and BSAV3, BSAV2, BSAV1, HVI, BMIV, WHIV (p <0.01). There was a positive correlation between HVI and weight, BMI, BSA1, BSA2, BSA3 (p <0.05). There was a negative correlation between WHIV and age, weight, BMI, BSA1, BSA2, BSA3 (p <0.05). Only BSAV1 had no correlation with height, weight, BMI, BSA (p >0.05), and there was a highly positive correlation between TVOL and BSAV1 (r=0.897), this was consistent with the study of Liu L et al.[20] Chen Fang et al and Wang Na et al calculated BSA (BSA2) by Stevenson Formula and found that BSA2 corrected thyroid volume could eliminate the influence of physical development on thyroid volume of children in Wuhan and Shanghai.[21, 22]

The P97 value of TVOL of children aged 8, 9, 10 years corrected by BSA1 was 4.6 mL, 4.7 mL, 5.9 mL, respectively. The difference was -9.23%-4.54% between BSAV1 and TVOL. The P97 of BSA1 of children aged 9 years in Gansu province was consistent with the Chinese standard (WS/T 10027-2024).23 The standard (WS/T 10027-2024) was published on October 11, 2024 and will be implemented on March 1, 2025. BSAV was a suitable method to correct TVOL of children aged 8-10 years. The formula ($BSA1=W^{0.425}\times H^{0.725}\times 71.84\times^{10-4}$) was the best method to correct TVOL which could eliminate the influence of physical development on thyroid volume.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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Table 1. Urinary iodine frequency and thyroid goiter distribution in children aged 8-10 years n (%)

Age (years)/ Sex	Urinary iodine						Thyroid	
	n	urinary iodine (μg/L) M (P25, P97)	100 μg/L	100-199 μg/L	200-299 μg/L	≥300 μg/L	n	Thyroid goitre n (%)
Age								
8	500	116.6 (108.4, 229.6)	102 (20.4)	224 (44.8)	120 (24.0)	54 (10.8)	501	13 (2.6)
9	503	167.1 (106.3, 239.2)	110 (21.9)	209 (41.6)	121 (24.1)	63 (12.5)	503	14 (2.8)
10	496	178.8 (119.6, 244.0)	92 (18.6)	211 (42.5)	126 (25.4)	67 (13.5)	496	21 (4.2)
		H value/ *p* value	3.304 / 0.192					2.586 / 0.274
Sex								
boy	756	175.2 (117.7, 237.5)	130 (17.2)	335 (44.3)	196 (25.9)	95 (12.6)	757	24 (3.2)
girl	743	164.4 (104.5, 239.2)	174 (23.4)	309 (41.6)	171 (23.0)	89 (12.0)	743	24 (3.2)
all	1499	169.8 (110.8, 237.7)	304 (20.3)	644 (43.0)	367 (24.45)	184 (12.3)	1500	48 (3.2)
		H value/ *p* value	-0.273 /-0.038					2.586 / 0.274

√, The project was taken on that day.

Table 2. Physical development index values of children aged 8-10 (median)

Age (years) /Sex	n	Weight (kg)	Height (cm)	BMI (m^2)	BSA1(m^2)	BSA2 (m^2)	BSA3 (m^2)
8							
boy	262	25.0	127.8	15.5	0.95	0.95	1.08
girl	239	24.0	126.0	15.2	0.93	0.93	1.06
all	501	25.0	127.0	15.4	0.94	0.94	1.07
9							
boy	250	27.0	132.0	15.7	1.00	1.00	1.13
girl	253	26.0	130.0	15.3	0.97	0.97	1.10
all	503	26.5	130.5	15.5	0.99	0.99	1.12
10							
boy	245	30.0	137.0	15.8	1.07	1.06	1.19
girl	251	28.0	134.5	15.5	1.04	1.03	1.16
all	496	29.0	136.0	15.7	1.06	1.05	1.18
All							
boy	757	27.0	132.0	15.7	1.01	1.00	1.13
girl	743	26.0	130.0	15.4	0.98	0.98	1.11
all	1500	26.9	131.0	15.5	0.99	0.99	1.12
Age							
H value		253.313	387.336	16.463	332.244	342.241	342.398
p value		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Sex							
Z value		-5.506	-4.239	-4.573	-5.381	-5.266	-5.262
p value		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 3. Comparison of TVOL with different ages and sexes (mL, median)

Age (years) /Sex	n	TVOL	BMIV	WHIV	HVI	BSAV1	BSAV2	BSAV3
8								
boy	262	2.5 (4.5)	1.6 (2.9)	0.8 (1.4)	1.5(2.7)	2.6 (4.5)	2.6 (4.6)	2.3 (4.0)
girl	239	2.5 (4.4)	1.6 (2.8)	0.8 (1.4)	1.5(2.8)	2.7 (4.6)	2. 7(4.7)	2.3 (4.1)
all	501	2.5 (4.4)	1.6 (2.9)	0.8 (1.4)	1.5(2.7)	2.6 (4.6)	2.7 (4.6)	2.3 (4.0)
9								
boy	250	2.8 (5.0)	1.8 (3.1)	0.8 (1.4)	1.6(2.8)	2.8 (4.7)	2.8 (4.8)	2.5 (4.2)
girl	253	2.6 (5.0)	1.7 (3.1)	0.8 (1.4)	1.6(2.8)	2.7 (4.9)	2.7 (4.9)	2.4 (4.4)
all	503	2.7 (4.9)	1.7 (3.1)	0.8 (3.1)	1.6(2.7)	2.7 (4.7)	2.7 (4.8)	2.4 (4.3)
10								
boy	245	3.0 (6.5)	1.8 (3.8)	0.7 (1.5)	1.6(3.4)	2.8 (5.8)	2.8 (5.9)	2.5 (5.2)
girl	251	2.9 (6.7)	1.8 (4.0)	0.8 (1.6)	1.6(3.5)	2.8 (5.9)	2.8 (5.9)	2.5 (5.3)
all	496	3.0 (6.5)	1.8 (3.9)	0.7 (1.5)	1.6(3.4)	2.8 (5.9)	2.8 (5.9)	2.5 (5.3)
All								
boy	757	2.7 (5.6)	1.7 (3.3)	0.8 (1.4)	1.6(3.1)	2.7 (5.3)	2.7 (5.4)	2.4 (4.8)
girl	743	2.7 (5.3)	1.7 (3.2)	0.8 (1.4)	1.6(3.0)	2.7 (5.1)	2.7 (5.1)	2.4 (4.5)
all	1500	2.7 (5.5)	1.7 (3.3)	0.8 (1.4)	1.6(3.0)	2.7 (5.2)	2.7 (5.3)	2.4 (4.7)
Age								
H value		127.107	16.770	310.044	386.235	331.570	341.495	341.652
p value		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Sex								
Z value		-1.741	-0.070	-2.702	-0.453	-0.157	-0.090	-0.364
p value		0.082	0.945	< 0.05	0.651	0.875	0.928	0.716

The values in brackets were P97 value.

Table 4. Comparison of TVOL of children with different physical development indexes (mL, Median)

Indicator/Group	n	TVOL	BMIV	WHIV	HVI	BSAV1	BSAV2	BSAV3
Height								
≤ 131.0 cm	761	2.5 (4.8)	1.6 (3.0)	0.8 (1.4)	1.6 (2.9)	2.7 (4.9)	2.7 (5.0)	2.4 (4.4)
> 131.0cm	739	2.9 (6.1)	1.8 (3.6)	0.7 (1.4)	1.6 (3.2)	2.7 (5.3)	2.7 (5.4)	2.5 (4.8)
Z value		12.931	10.171	9.671	0.090	1.634	2.349	3.925
p value		< 0.05	< 0.05	< 0.05	> 0.05	> 0.05	< 0.05	< 0.05
Weight								
≤26.9 kg	751	2.5 (4.4)	1.7 (3.0)	0.8 (1.4)	1.5 (2.7)	2.7 (4.7)	2.7 (4.6)	2.4 (4.0)
>26.9 kg	749	2.9 (6.1)	1.8 (3.4)	0.7 (1.4)	1.6 (3.3)	2.7 (5.4)	2.7 (5.4)	2.4 (4.9)
Z value		13.214	3.386	12.271	3.176	1.000	2.189	3.859
p value		< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05
BMI								
≤15.5kg/m^2	758	2.6 (4.8)	1.8 (3.2)	0.8 (1.5)	1.5 (2.8)	2.7 (5.0)	2.7 (5.0)	2.4 (4.4)
>15.5kg/m^2	742	2.8 (6.0)	1.7 (3.2)	0.7 (1.4)	1.6 (3.3)	2.7 (5.3)	2.7 (5.4)	2.4 (4.8)
Z value		7.350	5.683	8.509	6.109	0.459	1.575	2.527
p value		< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	> 0.05	< 0.05
BSA1								
≤ 0.99 m^2	726	2.5 (4.3)	1.7 (3.0)	0.8 (1.4)	1.6 (2.7)	2.7 (4.6)	2.7 (4.6)	2.3 (4.0)
> 0.99 m^2	774	3.0 (6.1)	1.8 (3.5)	0.7 (1.4)	1.6 (3.3)	2.7 (5.4)	2.8 (5.4)	2.5 (4.8)
Z value		14.070	6.537	11.583	2.336	1.592	2.658	4.376
p value		< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05
BSA2								
≤ 0.99 m^2	763	2.5 (4.4)	1.7 (3.0)	0.8 (1.4)	1.6 (2.7)	2.7 (4.8)	2.7 (4.7)	2.4 (4.1)
> 0.99 m^2	737	3.0 (6.1)	1.8 (3.5)	0.7 (1.4)	1.6 (3.2)	2.7 (5.3)	2.8 (5.4)	2.6 (4.8)
Z value		14.137	7.190	11.417	2.031	1.650	2.673	4.388
p value		< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05
BSA3								
≤ 1.12m^2	757	2.5 (4.4)	1.6 (3.0)	0.8 (1.5)	1.6 (2.7)	2.7 (4.8)	2.7 (4.7)	2.4 (4.1)
> 1.12m^2	743	3.0 (6.1)	1.8 (3.5)	0.7 (1.4)	1.6 (3.2)	2.7 (5.3)	2.8 (5.4)	2.5 (4.8)
Z value		14.331	7.411	11.199	2.222	1.865	2.886	4.601
p value		< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05

The values in brackets were P97 value.

Table 5. Correlation analysis of influencing factors of thyroid volume

V	TVOL	Ages	Sexes	Physical development indexes					
				Height	Weight	BMI	BSA1	BSA2	BSA3
TVOL									
r	—	0.290	0.045	0.395	0.425	0.251	0.438	0.437	0.437
p	—	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
BMIV									
r	0.881	0.247	-0.002	0.315	0.102	-0.169	0.187	0.201	0.201
p	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
WHIV									
r	0.606	-0.074	-0.086	-0.305	-0.377	-0.266	-0.373	-0.369	-0.369
p	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
HVI									
r	0.891	0.084	0.012	-0.014	0.121	0.208	0.077	0.068	0.068
p	< 0.05	< 0.05	> 0.05	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
BSA1									
r	0.897	0.113	-0.004	0.043	0.044	0.026	0.046	0.046	0.046
p	< 0.05	< 0.05	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05
BSA2									
r	0.912	0.125	0.002	0.065	0.082	0.062	0.079	0.078	0.078
p	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
BSA3									
r	0.936	0.150	0.009	0.114	0.135	0.093	0.134	0.133	0.133
p	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 6. Thyroid volume in children aged 8-10 years

Age (years)	TVOL (mL) P97			Chinese standard (mL) P97	
	TVOL (mL)	BSAV1	Difference value	WS 276-2007	WS/T 10027-2024
8	4.4	4.6	-0.37%~0.29%	4.5	4.6
9	4.9	4.7	-0.25%~0.33%	5.0	5.1
10	6.5	5.9	-0.16%~0.36%	6.0	6.0

TVOL, Thyroid volume; BSAV, Body Surface Area corrected Volume.