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Ultrasonic Parameters of Palatine Tonsils in Healthy Children: Correlations with Individual Factors

Qi Zhang
the Second Affiliated Hospital of Xi'an Jiaotong University
Xiaopeng Li
the Second Affiliated Hospital of Xi'an Jiaotong University
Yue Gao
the Second Affiliated Hospital of Xi'an Jiaotong University
Xiangru Wang
the Second Affiliated Hospital of Xi'an Jiaotong University
Lei Sun
the Second Affiliated Hospital of Xi'an Jiaotong University
Hua Wang
wanghua37@xjtu.edu.cn
the Second Affiliated Hospital of Xi'an Jiaotong University

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Abstract

Background High-frequency ultrasound is gradually being applied to the diagnosis of tonsil diseases. However,there remains a lack of relevant quantitative reference indicators and unified assessment standards. which limits the development and application of ultrasound examinations.

Objective High-frequency ultrasound was applied to observe and measure the palatine tonsils of healthy children, and the reference value range of relevant parameters was initially established.

Methods and methods A total of 375 healthy children aged 2-14 y were enrolled between June 2023 and September 2023.Basic data such as gender, age, height, weight, BMI, and BSA were recorded and the relevant parameters of bilateral palatine tonsils were measured by high-frequency ultrasound. The data were stratified by age group and gender. To explore the correlations between the relevant parameters of the palatine tonsils and individual factors.

Results The normal reference value ranges for the superior-inferior diameters, anteroposterior diameters, left-right diameters, volumes and internal of bilateral palatine tonsils in 375 healthy children are as follows: (18.83-33.80)mm, (9.60-18.74)mm, (8.98-17.22)mm, (0.92-5.16)cm3, (9.32-25.50)mm. The parameters of bilateral palatine tonsils in healthy children were significantly positively correlated with height, weight, BSA and BMI.

Conclusion This study initially established the reference values of quantitative parameters of the palatine tonsils in healthy children, which can provide reference value for clinical practice.

Introduction

Tonsil diseases, particularly acute tonsillitis, are common and frequently occurring illnesses in children, significantly impacting their physical health.Currently, clinicians primarily rely on qualitative visual assessment through oral examination to judge the severity of tonsil lesions, lacking relevant quantitative reference indicators[1].With the iterative advancement of ultrasound equipment, high-frequency ultrasound has significantly improved the resolution of soft tissue imaging. As a non-invasive, real-time, and repeatable examination method, it is gradually being applied in the diagnosis of tonsil diseases[2].However, there is currently no unified standardized protocol for ultrasound examination, and quantitative reference data for healthy children are lacking, which restricts the development and application of this diagnostic method.

This study aims to (1) apply high-frequency ultrasound to measure the dimensions and internal distance of bilateral palatine tonsils in healthy children aged 2 to 14 years, calculate their volume, and establish the normal reference ranges for each relevant parameter. (2) Investigate the correlations between palatine tonsil parameters and factors such as age, height, weight, BMI, and BSA. This aims to provide reference data from healthy children for the diagnosis of tonsil-related diseases.

Materials and Methods

Ethical approval

The study complied with the Declaration of Helsinki,and the research protocol was approved by the Ethics committee of the Second Affiliated Hospital of Xi'an Jiaotong University(ethical approval number:2023503).A signed informed consent form was acquired from the parent or legal guardian of each child.

Study Population

This study was conducted at the Second Affiliated Hospital of Xi'an Jiaotong University from June 2023 to September 2023.A total of 375 children aged 2-14 years who underwent health examinations were enrolled as the study subjects,and their basic data such as gender, age, height, weight recorded,and calculated the Body Mass Index (BMI) (BMI (kg/m²)=weight (kg) / height (m)²) and Body Surface Area (BSA) (BSA (m²)=0.0061×height (cm) + 0.0128×weight (kg)-0.1529).Then, the children were divided into five age groups: 2-4y, 5-8y, 9-11y, 12-14y.

The inclusion criteria were:children aged 2 to 14 years without any respiratory diseases or tonsil-related symptoms. The exclusion criteria were as follows:(i)children with acute upper respiratory tract infections; (ii) those presenting with tonsil-related symptoms such as snoring, nasal congestion, or breathing difficulties; (iii)individuals with a history of tonsil surgery; (iv)patients complicated with severe cardiac, cerebral, pulmonary, hepatic, renal, hematological, or endocrine system diseases; (v)those with psychiatric conditions unable to cooperate with the examination.

Image acquisition

A Mindray Resona R7 color Doppler ultrasound system was used, equipped with a C11-3U micro-convex array probe.

The examined children were placed in a supine position with a small pillow under their shoulders and neck to achieve appropriate neck extension. The examination was conducted during quiet breathing. After applying an appropriate amount of coupling gel, the ultrasound probe was placed directly on the skin surface. Using the bilateral mandibular angles and the anterior midline of the neck as anatomical landmarks, real-time transverse and longitudinal scans were performed to visualize the palatine tonsils and their adjacent areas. During the scanning process, bilateral comparison was emphasized.

Image assessment and measurement

Using the bilateral mandibular angles as anatomical landmarks, transverse scanning was performed with the probe parallel to the mandibular angle and its orientation marker pointing toward the child's right side. After fully displaying the maximum cross-sectional view of the palatine tonsil, the image was frozen, and the widest left-right distance of the tonsil was measured as the left-right diameter.

Longitudinal scanning was then conducted with the probe perpendicular to the mandibular angle and its orientation marker pointing toward the child's head. After fully displaying the maximum longitudinal view of the palatine tonsil, the image was frozen. The longest superior-inferior distance was measured as the superior-inferior diameter, and the widest anterior-posterior distance was measured as the anteroposterior diameter.

During the longitudinal scans of the bilateral neck, the probe was positioned perpendicular to the mandible, with its indicator pointing toward the child's head. In this plane, the superior-inferior and anteroposterior diameters of the palatine tonsils were measured. For the transverse scans of the bilateral neck, the transducer was aligned parallel to the mandible, with its indicator directed toward the child's right side. The left-right diameter of the palatine tonsils was measured in this plane[3].For the midline neck scan, the transducer was placed midline on the neck and oriented toward the skull base, with the indicator pointing to the child's right side. The probe was moved superiorly and inferiorly to clearly display the maximum dimensions of both palatine tonsils. The internal distance between the bilateral palatine tonsils was measured in this plane.(Figure 1)

Calculation of Palatine Tonsil Volume: The volume of the palatine tonsil was calculated in cubic centimeters (cm^3) using the formula derived from the studies by Hosokawa T, et al.[4, 5], defined as: (Superior-Inferior diameter×left-right diameter×Anteroposterior diameter)×0.52.

Quality control

All measurements were performed by two ultrasound physicians at or above the senior resident level and reviewed by one physician at or above the associate chief physician level.All data were jointly entered and cross-verified by two researchers to ensure accuracy.

Statistical analysis

All the statistical analysis was performed using SPSS software (version 25.0). Measurement data conforming to a normal distribution are presented as the mean±standard deviation($\bar{x}\pm s$), while data with a non-normal distribution are expressed as the median with the interquartile range (M (Q1, Q3)). Comparisons among multiple groups were conducted using the Kruskal-Wallis rank-sum test (H test). Spearman's correlation analysis was employed to assess the relationships between the various diameters, volume, and internal distance of the bilateral palatine tonsils and the individual factors. The Spearman correlation coefficient ($|r|$) < 0.3 indicates a very weak or negligible correlation, 0.3–0.5 indicates a low correlation, 0.5–0.8 indicates a moderate correlation, and > 0.8 indicates a strong correlation.A two-tailed P-value of less than 0.05 was considered statistically significant.

Results

Participant characteristics

This study enrolled a total of 375 healthy children aged 2 to 14 years, with a median age of 9 (7, 11) years. The cohort consisted of 171 boys (45.6%) and 204 girls (54.4%). The baseline characteristics, including height, weight,BMI, and BSA, are summarized in Table 1.

Table 1 Summary of demographic information between males and females[IQR]

		Tatal(N=375)
age		9(7,11)y
Gender		
	male	167(44.5%)
	female	208(55.5%)
Height		135(120,146.6)cm
Weight		29(21,38)kg
BMI		16(14.4,18.1)kg/cm²
BSA		1.08(0.88,1.29)m²

N:number;BMI:body mass index;BSA:body surface area.

Ultrasound imaging features of the palatine tonsils

The palatine tonsils are located deep to the submandibular gland. On transverse scans, they appear roughly circular, while on longitudinal scans, they present as oval shape with a wider superiorly and narrower inferiorly. A complete capsular echo can be visualized. And the overall echogenicity of the tonsils is lower than that of the submandibular gland.The internal structure shows a striated pattern with alternating bands of medium and low echogenicity. In some children, hyperechoic gas may be observed within the palatine tonsil.(figure 2)

Comparison of bilateral palatine tonsil volume and internal distance across age groups by sex

The results showed that in the 9–11 age group, the internal distance between bilateral palatine tonsils was greater in boys than in girls, with a statistically significant difference(P<0.05). In the remaining age groups, there were no statistically significant differences in the volume of bilateral palatine tonsils or the internal distance between them between boys and girls(all P>0.05).(Table 2)

Table 2 Comparison of bilateral palatine tonsil volume and internal distance across age groups by sex

Age/y	Gender	Number	right palatine tonsil			left palatine tonsil			internal distance between the bilateral tonsils		
			volume/cm3	Z	P	volume/cm3	Z	P	distance/mm	Z	P
2-5	boy	27	1.79 (1.43,2.24)	-1.077	0.281	1.66 (1.42,2.11)	-1.805	0.071	13.50 (11.50,15.70)	-0.706	0.48
	girl	33	1.67 (1.25,2.04)			1.38 (1.26,1.82)			13.90 (11.00,15.50)		
2-6	boy	52	2.32 (1.64,2.88)	-1.383	0.167	2.20 (1.71,2.86)	-0.739	0.46	17.10 (14.40,19.40)	-0.73	0.465
	girl	59	2.02 (1.47,2.90)			1.98 (1.73,2.84)			16.60 (13.70,18.30)		
2-7	boy	52	2.43 (1.86,3.11)	-1.106	0.269	2.48 (1.95,3.09)	-0.735	0.462	19.35 (16.80,21.30)	-2.15	0.032
	girl	88	2.60 (2.04,3.35)			2.60 (2.05,3.17)			17.90 (15.15,20.05)		
2-8	boy	36	3.12 (2.29,3.82)	-1.191	0.234	2.93 (2.12,3.50)	-1.123	0.261	20.30 (18.05,24.00)	-1.76	0.078
	girl	28	2.53 (1.90,3.45)			2.47 (2.00,3.47)			19.00 (16.40,21.20)		

Comparison of palatine tonsil volume by side across age groups

The results showed no statistically significant differences in the volume between the left and right palatine tonsils across all age groups (all P > 0.05). Additionally, across different age groups, the volume of the palatine tonsils tended to increase with age.(Table 3)

Table 3 Comparison of palatine tonsil volume by side across age groups

Age/y	Number	side	volume/cm^3	Z	P
2-5	60	right	1.70 (1.27,2.09)	-0.777	0.437
		left	1.61 (1.31,2.00)		
6-8	111	right	2.15 (1.54,2.90)	-0.451	0.652
		left	2.16 (1.73,2.85)		
9-11	140	right	2.56 (2.01,3.18)	-0.123	0.902
		left	2.55 (2.03,3.14)		
12-14	64	right	2.64 (2.20,3.74)	-0.253	0.801
		left	2.77 (2.08,3.50)		

Reference ranges for palatine tonsil ultrasound parameters in healthy children

The normal reference ranges for the superior-inferior diameter, anteroposterior diameter, left-right diameter, volume, and internal distance of bilateral palatine tonsils in healthy children aged 2-14 years are as follows: (18.83-33.80)mm, (9.60-18.74)mm, (8.98-17.22)mm, (0.92-5.16)cm^3, (9.32-25.50)mm. (Table 4)

Table 4 95% Reference range for ultrasound measurement parameters of palatine tonsils in healthy children[P2.5-P97.5]

Age/y	superior-inferior diameter/mm	anteroposterior diameter/mm	left-right diameter/mm	volume/cm3	internal distance/mm
2-5	16.30-28.39	9.40-17.29	8.61-16.19	0.69-4.11	6.43-20.48
6-8	18.90-32.74	9.67-18.53	8.60-17.28	0.91-5.06	7.88-16.14
9-11	20.10-33.70	10.10-18.39	9.10-17.20	1.06-4.89	8.55-27.15
12-14	20.62-36.71	9.89-20.76	9.30-17.81	1.07-6.17	11.98-26.80

Analysis of the correlations between ultrasonic parameters of the palatine tonsils and individual factors in healthy children

The superior-inferior diameter, anteroposterior diameter, left-right diameter, volume, and internal distance of bilateral palatine tonsils all showed positive correlations with age, height, weight, body surface area (BSA), and body mass index (BMI) (all $P<0.01$). Specifically, the superior-inferior diameter demonstrated a strong positive correlation with height, weight, and BSA ($r > 0.5$).(Figure 3)

Discussion

In this single-center study, the superior-inferior diameter, anteroposterior diameter, left-right diameter, volume, and internal distance of bilateral palatine tonsils were measured and calculated in 375 healthy children aged 2–14 years. Based on these measurements, preliminary reference ranges for palatine tonsil-related parameters in healthy children of this age group were established. Additionally, the correlations between these parameters and age, height, weight, BMI, and BSA were analyzed. The findings provide objective and reliable quantitative data to support the diagnosis of palatine tonsil-related diseases.

The main findings are as follows:

(1)High-frequency ultrasound can clearly and completely visualize the bilateral palatine tonsils in children.

High-frequency ultrasound can objectively measure the size of the palatine tonsils and clearly display the internal structure, blood flow distribution, and surrounding tissues of the tonsils in most children[6].It provides an objective reference basis for clinical research and disease diagnosis.Previous studies have shown a strong agreement between the tonsillar volume measured by high-frequency ultrasound and the actual volume[7]. Compared to other imaging modalities such as X-ray, CT, and MRI, high-frequency ultrasound offers advantages including safety, non-invasiveness, and the ability to perform repeat examinations within a short period[8].

The palatine tonsils are located deep to the submandibular gland. On transverse scans, they appear roughly circular, while on longitudinal scans, they present as oval shape with a wider superiorly and narrower inferiorly. A complete capsular echo can be visualized. And the overall echogenicity of the tonsils is lower than that of the submandibular gland.The internal structure shows a striated pattern with alternating bands of medium and low echogenicity. In some children, hyperechoic gas may be observed within the palatine tonsil.

(2)Reference ranges for palatine tonsil ultrasound parameters in healthy children aged 2–14 years have been established, providing a data reference for clinical research.

The palatine tonsils are prone to recurrent infections during childhood[9-11]. The accumulation of numerous inflammatory factors and lymphocytes in this area leads to tonsillar hyperplasia and hypertrophy[12].Enlarged tonsils may obstruct the airway, leading to serious consequences and significantly impacting children's health. Currently, clinical diagnosis relies primarily on subjective qualitative indicators to assess the severity of tonsil-related diseases, which is not conducive to early diagnosis and prognosis improvement. This study has preliminarily established reference ranges for palatine tonsil-related parameters in healthy children aged 2–14 years, providing objective quantitative reference indicators for early disease diagnosis and clinical research.

Jiang et al.[3]performed ultrasonic measurements of bilateral palatine tonsils in 224 healthy children aged 1-16 years, reporting volumes of 1.58 (1.23, 1.88) cm^3 for boys and 1.46 (1.20, 1.69) cm^3 for girls. The study did not further stratify the data by gender and age, limiting its clinical reference value. In contrast, the data stratification conducted in this research better aligns with the growth and development characteristics of children.

Furthermore, palatine tonsillar hypertrophy is a significant contributing factor to pediatric obstructive sleep apnea-hypopnea syndrome (OSAHS)[13]. This study introduced the measurement of the internal distance between bilateral palatine tonsils, aiming to provide a simple and efficient method for reflecting the impact of tonsillar enlargement on the airway. The feasibility of this indicator for assessing the risk of pediatric OSAHS requires further confirmation through clinical research.

Similarly, comparison of left and right palatine tonsil volumes within the same age groups showed no significant lateral differences. This suggests that significant asymmetry is not a typical feature of normal tonsillar development in individuals. Therefore, the identification of substantial size disparity between bilateral tonsils during clinical evaluation may serve as an indicator of potential pathology[14, 15].

(3)Correlation between ultrasonic parameters of the palatine tonsils and individual factors in healthy children

The superior-inferior diameter, anteroposterior diameter, left-right diameter, volume, and internal distance of bilateral palatine tonsils all showed positive correlations with age, height, weight, BSA, and BMI (all $P < 0.01$). Additionally, the volume of bilateral palatine tonsils and the internal distance between them exhibited an increasing trend with age.which is generally consistent with previous studies[4, 16-20]. Hosokawa et al.[4],Muleta et al.[21] and Jiang et al.[3]suggested a strong correlation between palatine tonsil size and height, a finding that aligns with our results. Furthermore, our study also identified a high correlation between tonsil size and body surface area, in addition to height. This finding suggests that height and body surface area could serve as standards for establishing reference ranges for normal palatine tonsil size in children. Given that body surface area is closely associated with growth changes in children, using body surface area-standardized palatine tonsil volume may be a more reasonable approach[22].

Limitations of the Study

This research is a single-center study that only included Chinese children aged 2–14 years, and therefore may not reflect the actual conditions in regions such as Europe, the United States, or Indonesia. Future studies should involve multiple centers, broader geographical representation, and more researchers to further validate and expand upon these findings.

Conclusion

In summary, based on high-frequency ultrasound examinations of 375 healthy children aged 2–14 years, this study preliminarily established reference ranges for ultrasonic measurement parameters of pediatric palatine tonsils. This work highlights the role and value of high-frequency ultrasound scanning technology in disease screening and diagnosis.

Declarations

Author's Contribution Statement

Qi Zhang: Literature retrieval, data collection and analysis, thesis conception and writing.

Xiao-peng Li: Research guidance, Experimental Design.

Yue Gao: Data Collection and Analysis,

Xiang-ru Wang: Image data and data organization.

Lei Sun: Research guidance, proofreading and quality control, paper review

Hua Wang: Research guidance, financial support, proofreading and quality control.

Data availability statement

The research data are confidential due to ethical restrictions.

Conflict of interest

The authors declare no conflicts of interest to declare.

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Figures

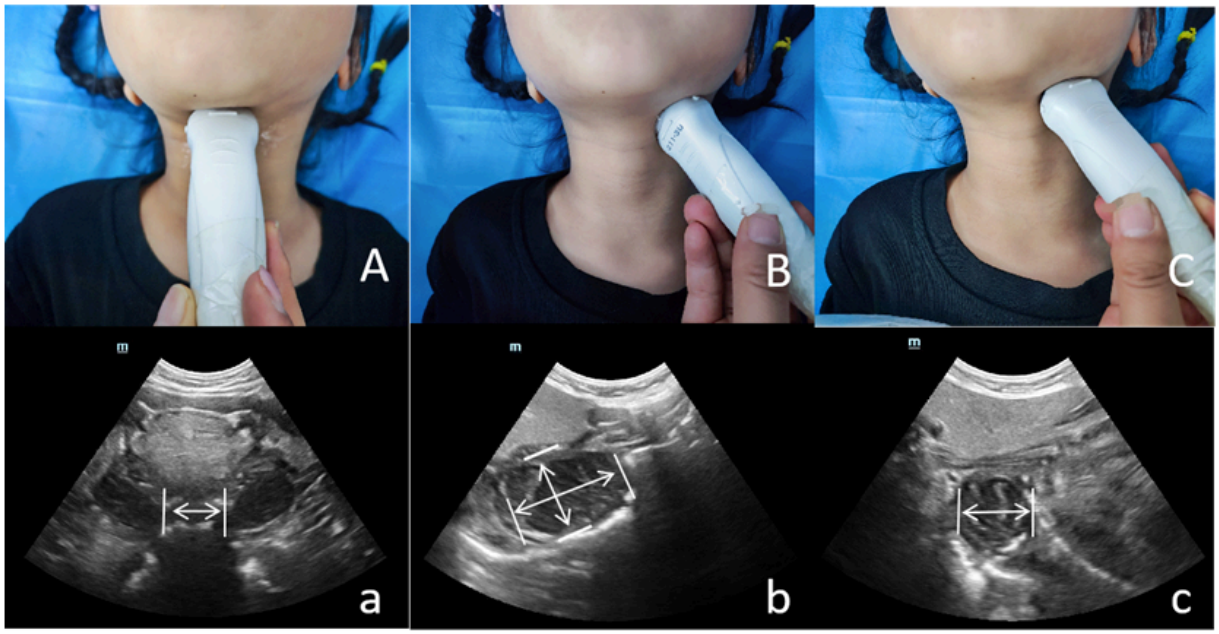


Figure 1

Ultrasonic examination method for palatine tonsil and corresponding image measurement methods. (A):Schematic diagram of the scanning method of median neck transverse of plane;(a):Ultrasonic measurement of the interal distance of the bilateral palatine tonsils;(B)Schematic diagram of the scanning method of longitudinal section of the left palatine tonsil;(b)Ultrasonic measurement of the longitudinal Section of the left palatine tonsil;(C)Schematic diagram of the scanning method of transverse section of the left palatine tonsil;(c)Ultrasonic measurement of the transverse section of the left palatine tonsil.the right side scan method and ultrasonic measurement are the same as the left.

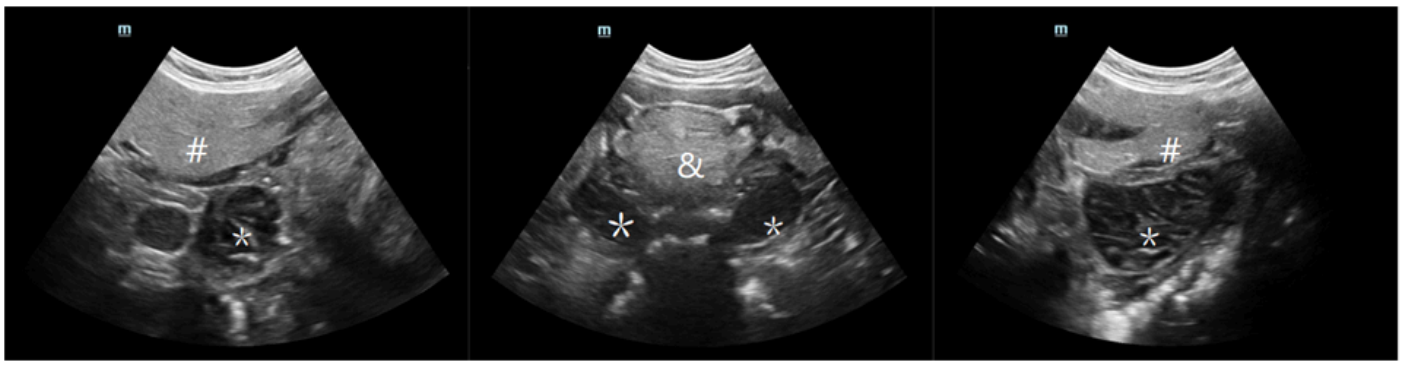


Figure 2

Ultrasound imaging of the palatine tonsil.□:palatine tonsil; #:submandibular gland; &:lingual Muscles.

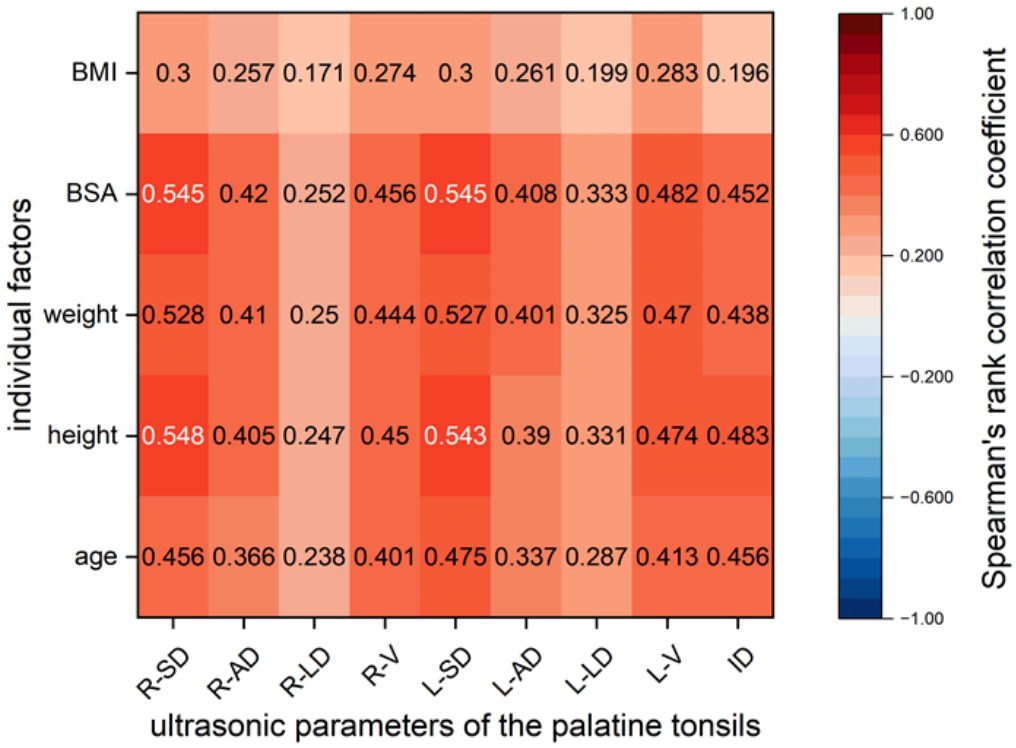


Figure 3

Correlation between ultrasonic parameters of the palatine tonsils and individual factors in healthy children.R-SD:superior-inferior diameter of the right palatine tonsil,R-AD:anteroposterior diameter of the right palatine tonsil,R-LD:left-right diameter of the right palatine tonsil,R-V:volume of the right palatine tonsil,L-SD:superior-inferior diameter of the left palatine tonsil,L-AD:anteroposterior diameter of the left palatine tonsil,L-LD:left-right diameter of the left palatine tonsil,L-V:volume of the left palatine tonsil,ID:internal distance of bilateral palatine tonsils.