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Original Article

Determining the normal range of the dimensions and volume of the pituitary gland of children using a 3D magnetic resonance imaging (MRI) protocol in Imam Hossein Hospital of Isfahan in 2021 to 2024

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Abstract: Background: Understanding the morphological changes and dimensions of the pituitary gland is crucial for accurate diagnosis and personalized treatment in pediatric patients. Advanced imaging techniques, such as 3D magnetic resonance imaging (MRI), enhance our ability to address knowledge gaps and improve clinical practices in pediatric endocrinology. This study aims to determine normative pituitary gland dimensions and volumes in pediatric patients at Imam Hossein Hospital in Isfahan using advanced 3D MRI protocols. Methods: Conducted as a prospective cross-sectional study, this research focused on children under 15 years without specific conditions. A total of 412 participants were selected through simple random sampling, and data were analyzed using SPSS version 20 to rigorously assess measurements and extract insights beneficial for pediatric endocrinology. Results: The study included participants aged 0 to 15 years, with a higher representation of boys (63.83%) compared to girls (36.17%). Significant differences were observed in height and volume based on gender and age group. Scatterplots illustrated variations in the pituitary gland's volume, width, height, and anterior-posterior diameter according to age and gender. Conclusion: This research provides valuable insights into pediatric endocrinology, facilitating accurate diagnosis and treatment of pituitary disorders in children.

Keywords: Dimensions, volume, pituitary gland, pediatrics, magnetic resonance imaging

Introduction

The pituitary gland is a vital endocrine organ that regulates several physiological processes. Located at the base of the skull within the sella turcica, it comprises two distinct lobes: the anterior (adenohypophysis) and posterior (neurohypophysis) lobes [1, 2]. The anterior lobe secretes key hormones such as growth hormone, prolactin, and thyroid-stimulating hormone, constituting approximately 75% of the gland volume. The posterior lobe contains oxytocin and vasopressin and, is linked to the hypothalamus via the pituitary stalk, facilitating hormonal communication [3, 4].

Throughout life, the pituitary gland undergoes morphological changes characterized by variations in size and shape influenced by age and gender. Abnormalities in pituitary gland size can lead to significant endocrine disorders [5-7]. For example, a smaller-than-normal gland may result in insufficient hormone production, leading to conditions such as growth hormone deficiency, which can cause stunted growth in children. Conversely, an enlarged pituitary gland may indicate conditions like acromegaly, characterized by excessive growth hormone, resulting in various health issues, including cardiovascular complications and an increased incidence of diabetes [8, 9].

Magnetic resonance imaging (MRI), particularly T1-weighted and T2-weighted sequences, is an effective modality for assessing abnormalities within the gland [10-12]. However, accurate measurement of pituitary dimensions is essential for diagnosing endocrine disorders, espe-

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cially in children, where advanced imaging techniques such as 3D MRI are necessary for precise evaluations [13-15].

The evolution of MRI technology has significantly improved the diagnosis of pituitary lesions, offering a non-invasive and detailed approach to evaluating endocrine anomalies [13, 16]. By focusing on pediatric populations, this study broadens our understanding of normative pituitary gland dimensions, thereby enhancing the diagnostic accuracy and treatment strategies for young patients with pituitary disorders. The adoption of 3D MRI protocols represents a substantial advancement in providing detailed measurements and assessments of pituitary morphology [13, 15, 17, 18].

Recognizing the importance of establishing normative ranges for pituitary gland dimensions in children, this study at the Imam Hossein Hospital in Isfahan seeks to fill this knowledge gap. By employing 3D MRI protocols, researchers aim to analyze anatomical variations in children from 2021 to 2024 (1400-1403 in the Iranian calendar). The objectives include assessing size and volume distribution based on age, gender, and other relevant parameters, thus providing valuable insights for clinical practice and patient care.

Ultimately, this research is poised to contribute significantly to the understanding of normal pituitary gland dimensions in children, enhancing clinical practices for diagnosing and managing pituitary disorders effectively. Understanding the implications of 1400 variations on endocrine function will enable healthcare providers to better predict and address potential adverse effects on patient health.

Materials and methods

Study design

This study is a prospective cross-sectional research project conducted at Imam Hossein Isfahan Hospital from 2021 to 2024, specifically focusing on pediatric patients to evaluate the normal range of pituitary gland dimensions and volume using a 3D MRI protocol.

While MRI is a valuable tool for assessing pituitary gland size, conventional MRI techniques have several drawbacks. One significant limitation is resolution; conventional MRI may not provide the level of detail necessary for accurate visualization of the gland's intricate anatomy. Sensitivity is also a concern; conventional methods might miss subtle size variations or abnormalities, especially in pediatric patients whose glands may be smaller and more difficult to assess. Additionally, variability in imaging protocols across different facilities can lead to inconsistent measurements, which can affect diagnostic accuracy. Technical challenges, such as motion artifacts and patient cooperation issues, may further compromise image quality and the reliability of size assessments.

Inclusion and exclusion criteria

Participants included children below 15 years who required a routine 3D MRI but did not have congenital brain diseases, genetic syndromes, or endocrine disorders. The exclusion criteria were a history of preterm birth (< 35 weeks), birth asphyxia, craniospinal radiation, or abnormal MRI findings in the brain. The study aims to enhance understanding of pediatric pituitary anatomy and explore normative variations before puberty.

Clinical indicators for 3D MRI usage

To determine the necessity for routine 3D MRI in pediatric patients, the following clinical indicators were evaluated systematically.

1. Growth abnormalities: a. Definition: 1) Short stature: Height-for-age ≤ 3rd percentile (WHO growth charts). 2) Growth velocity deviations: Annual growth rate < 4 cm/year (prepubertal) or < 6 cm/year (pubertal). b. Relevance: Directly linked to growth hormone (GH) axis dysfunction. c. Measurement: Serial height monitoring over 6-12 months using stadiometry, excluding familial/genetic short stature via parental height assessment.

2. Hormonal imbalances: a. Precocious Puberty: 1) Girls: Secondary sexual characteristics before age 8 (thelarche, pubarche). 2) Boys: Testicular enlargement (volume ≥ 4 mL) before age 9. b. Delayed Puberty: Absent thelarche by 13 (girls) or testicular volume < 4 mL by 14 (boys). c. Other Imbalances: TSH, ACTH, or gonadotropin irregularities confirmed via serum hormone panels (e.g., IGF-1, cortisol, FSH/LH).

Table 1. Demographic and clinical characteristics of children

Variables	Mean ± SD	Min-Max	Median
Age	6.35±3.94	Under one year old-15	6
Height	4.50±1.16	2.05-8.63	4.26
Width	12.61±2.37	5.99-19.55	12.35
Anteroposterior diameter	8.59±1.32	2.85-13.36	8.52
Volume	258.95±110.58	51.36-714.19	235.62
Sex		N (%)	
Girl		149 (36.17)	
Boy		263 (63.83)	

Table 2. Participant characteristics for each of the Sex groups (Mean ± SD)

Sex	N=412	Height	Width	Anteroposterior diameter	Volume
Girl	149	4.69±1.26	12.59±2.33	8.73±1.18	274.07±116.16
Boy	263	4.39±1.08	12.62±2.39	8.52±1.38	250.59±106.68
P-value*		0.117	0.469	0.536	0.462
P-value**		**0.015**	0.919	0.131	**0.043**

*P values are based on the chi-square test. **P value based on Independent Samples Test. Boldface indicates statistical significance ($P < 0.05$).

Table 3. Participant characteristics for each of the age groups (Mean ± SD)

Age	N=412	Height	Width	Anteroposterior diameter	Volume
Under one year old	16	3.57±0.64	10.93±1.49	7.37±1.89	151.72±56.59
1	46	3.84±1.02	11.22±2.02	8.05±1.00	177.23±48.87
2	40	3.98±0.71	12.68±2.72	8.09±0.89	212.61±60.13
3	38	4.13±0.79	12.36±2.33	7.99±0.98	211.32±59.13
4	28	4.42±1.01	12.86±2.71	8.32±1.51	242.75±76.43
5	40	4.14±0.91	12.70±2.81	8.38±1.25	229.59±81.27
6	20	3.92±1.13	12.85±1.95	8.49±0.99	224.55±84.23
7	25	4.63±0.80	13.29±1.85	8.66±1.08	278.82±81.48
8	32	4.62±0.89	12.33±1.50	8.80±1.15	259.02±61.61
9	23	4.33±0.87	12.52±2.12	9.16±0.87	258.48±73.29
10	34	5.07±1.63	12.32±2.02	8.93±1.47	299.16±133.19
11	27	5.03±1.01	12.54±2.34	8.62±1.62	293.85±121.80
12	17	5.35±0.99	12.76±1.75	9.68±1.45	351.19±119.42
13	13	6.15±1.04	14.70±1.96	9.98±1.45	466.56±116.31
14	7	5.91±0.57	14.78±2.79	9.35±1.31	422.44±90.68
15	6	6.66±0.54	15.56±3.40	11.02±1.26	586.29±121.27
P-value*		**0.000**	**0.000**	**0.000**	**0.000**

*P-value based on Independent Samples Test. Boldface indicates statistical significance ($P < 0.05$).

3. Neurological concerns: a. Persistent Headaches: ≥ 3 months' duration refractory to analgesics, with red flags (nocturnal awakening, positional changes). b. Visual Disturbances: Formal ophthalmologic documentation of bitemporal hemianopsia or reduced visual acuity. c. Developmental Delay: Assessed via Denver II screening tool with > 2 domain delays (motor, language, social).

4. Referral process: Referrals for 3D MRI typically originate from pediatric endocrino-

Table 4. Participant characteristics of girls for each of the age groups (Mean ± SD)

Age	N=149	Height	Width	Anteroposterior diameter	Volume
Under one year old	8	3.56±0.77	10.94±1.42	7.60±1.08	153.66±41.68
1	13	4.01±0.74	11.69±1.43	8.22±0.72	200.47±48.51
2	14	3.80±0.69	12.54±2.99	8.21±0.88	203.02±59.57
3	14	4.40±1.05	11.51±1.72	8.03±1.17	211.34±65.04
4	9	4.19±0.48	13.82±2.46	8.13±0.94	244.92±60.07
5	10	4.25±0.94	11.65±3.34	9.19±1.42	237.70±93.42
6	10	4.27±1.33	13.81±2.12	8.87±0.64	271.15±85.60
7	10	4.87±0.79	12.90±2.45	8.68±0.57	288.19±95.08
8	13	4.93±0.83	12.62±1.83	8.25±0.95	266.82±67.98
9	11	4.63±1.07	12.49±1.67	9.01±0.92	273.45±85.41
10	16	5.45±2.05	12.32±2.06	9.13±0.60	322.00±139.07
11	10	5.32±0.97	13.40±2.51	8.87±1.45	343.06±145.15
12	5	5.88±1.24	12.27±1.60	10.32±2.27	396.50±152.72
13	2	6.86±0.29	15.74±2.01	10.34±1.87	572.81±6.47
14	2	5.58±0.60	12.82±2.71	9.92±0.13	371.98±112.83
15	2	6.82±0.47	14.16±5.58	11.34±0.53	565.12±210.82
P-value*		**0.000**	0.125	**0.000**	**0.000**

**P*-value based on Independent Samples Test. Boldface indicates statistical significance ($P < 0.05$).

Table 5. Participant characteristics of boys for each of the age groups (Mean ± SD)

Age	N=263	Height	Width	Anteroposterior diameter	Volume
Under one year old	8	3.57±0.54	10.93±1.65	7.14±2.52	149.78±71.54
1	33	3.77±1.12	11.04±2.20	7.99±1.09	168.08±46.59
2	26	4.08±0.72	12.75±2.63	8.03±0.91	217.78±60.96
3	24	3.97±0.57	12.85±2.52	7.96±0.88	211.32±56.87
4	19	4.53±1.18	12.41±2.77	8.40±1.73	241.72±84.59
5	30	4.10±0.91	13.04±2.58	8.11±1.08	226.89±78.38
6	10	3.56±0.81	11.89±1.22	8.11±1.18	177.96±53.14
7	15	4.46±0.80	13.55±1.35	8.65±1.34	272.57±73.93
8	19	4.41±0.89	12.12±1.24	9.18±1.14	253.69±58.15
9	12	4.0608	12.55±2.55	9.29±0.84	244.76±60.68
10	18	4.74±1.09	12.33±2.05	8.75±1.95	278.86±128.23
11	17	4.86±1.03	12.04±2.15	8.47±1.73	264.90±99.26
12	12	5.12±0.83	12.97±1.84	9.42±0.95	332.32±104.59
13	11	6.02±1.09	14.51±1.99	9.91±1.47	447.24±116.46
14	4	6.08±0.56	15.77±2.59	9.07±1.59	447.66±83.16
15	5	6.55±0.66	16.50±2.06	10.81±1.69	600.39±80.29
P-value*		**0.000**	**0.000**	**0.000**	**0.000**

**P*-value based on Independent Samples Test. Boldface indicates statistical significance ($P < 0.05$).

logists or neurologists, who evaluate clinical indications and patient history in alignment with established pediatric MRI protocols.

Sample size

A target sample size of 396 participants was determined using simple random sampling,

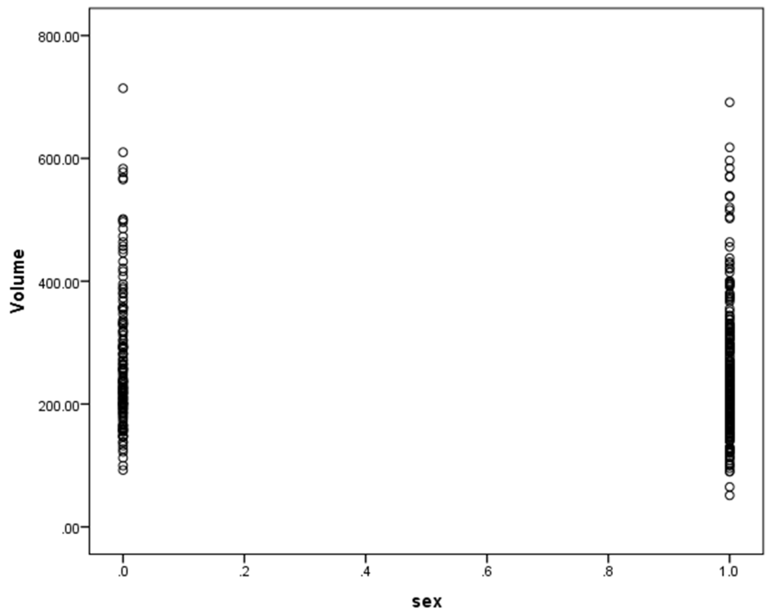

Figure 1. The scatter of volume and sex.

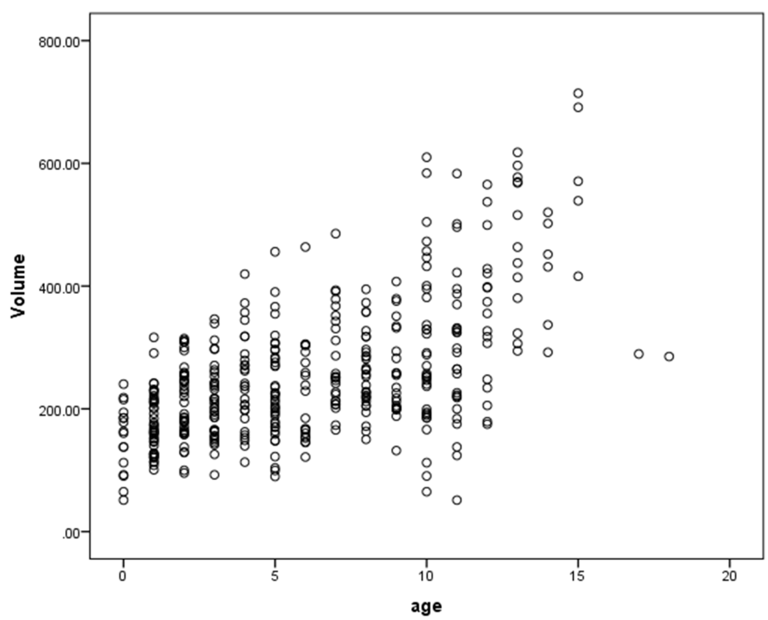

Figure 2. The scatter of volume and age.

accounting for a 10% dropout rate. Patient demographics, including age, sex, height, and weight, were meticulously recorded.

Imaging protocol

MRI scans were performed using a GE Signa Excite 1.5 Tesla machine, following detailed protocols specifying slice thickness, echo time, repetition time, and other essential parameters. Measurements of pituitary dimensions - including height, width, and anteroposterior diameter - were obtained using advanced imaging techniques to ensure accuracy and reliability.

Statistical analysis

Data analysis was conducted using SPSS version 20, employing independent sample tests and chi-square tests. A significance level of $P < 0.05$ was established to ascertain statistical validity. Experienced radiologists rigorously evaluated measurements from imaging sessions to ensure consistency and precision in assessing pituitary dimensions and volumes. This meticulous approach aims to clarify the normal morphology of the pituitary gland in children and inform clinical practice in pediatric endocrinology.

Results

The study included participants with a median age of 6 years (range: 0 to 15 years) and an average age of 6.35 years (SD: 3.94). The mean height of the hypophysis was 4.50 mm (SD: 1.16, range: 2.05 to 8.63 mm), the mean width was 12.61 mm (SD: 2.37, range: 5.99 to 19.55 mm), and the mean anteroposterior diameter was 8.59 mm (SD: 1.32, range: 2.85 to 13.36 mm). The mean volume of the pituitary gland was 258.95 mm^3 (SD: 110.58). Among the participants, 149 were girls (36.17%) and 263 were boys (63.83%).

Gender differences

Analysis revealed no significant age difference between genders (P=0.579). However, statisti-

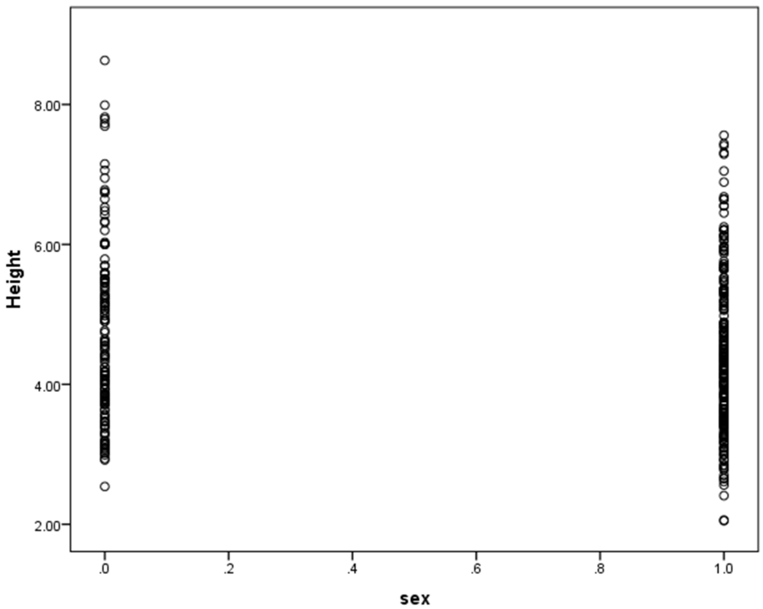

Figure 3. The scatter of height and sex.

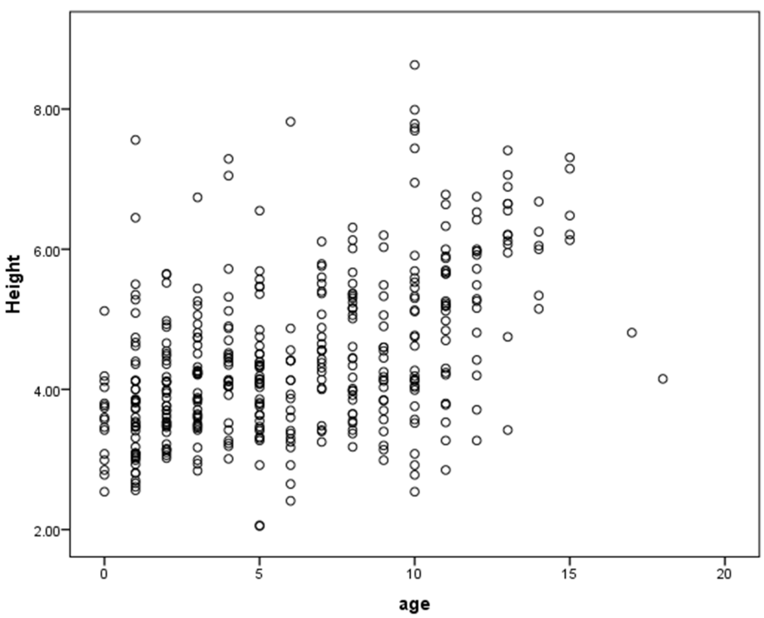

Figure 4. The scatter of height and age.

cally significant differences were observed in height (P < 0.05) and volume (P < 0.05) between boys and girls.

Age group differences

Statistically significant differences were noted across age groups in height (P < 0.001), width (P < 0.001), anteroposterior diameter (P < 0.001), and volume (P < 0.001).

Gender-specific age differences

Statistically significant differences in height (P < 0.001), anteroposterior diameter (P < 0.001), and volume (P < 0.001) were found for girls across age groups. For boys, significant differences were also noted in height (P < 0.001), width (P < 0.001), anteroposterior diameter (P < 0.001), and volume (P < 0.001) across age groups (**Tables 1-5**). **Figures 1-8** depict these differences in volume, width, depth, and anteroposterior diameter among various age and sex groups.

Discussion

This study, conducted at Imam Hossein Hospital in Isfahan from 2021 to 2024 (1400 to 1403 in the Iranian calendar), aimed to establish normative values for the dimensions and volume of the pituitary gland in children using a three-dimensional (3D) MRI protocol. The pituitary gland plays a critical role in regulating various physiological processes through hormone secretion, and understanding its normative dimensions in pediatric patients is essential for accurate diagnosis and effective treatment of endocrine disorders [19-21].

In our view, the morphological changes observed in the pituitary gland emphasize the urgent need to integrate demographic data into clinical assessments. These variations can significantly impact patient outcomes and should not be overlooked. Advanced imaging techniques, particularly 3D MRI, facilitate detailed evaluation of the structure of the gland, supporting the hypothesis that improved imaging

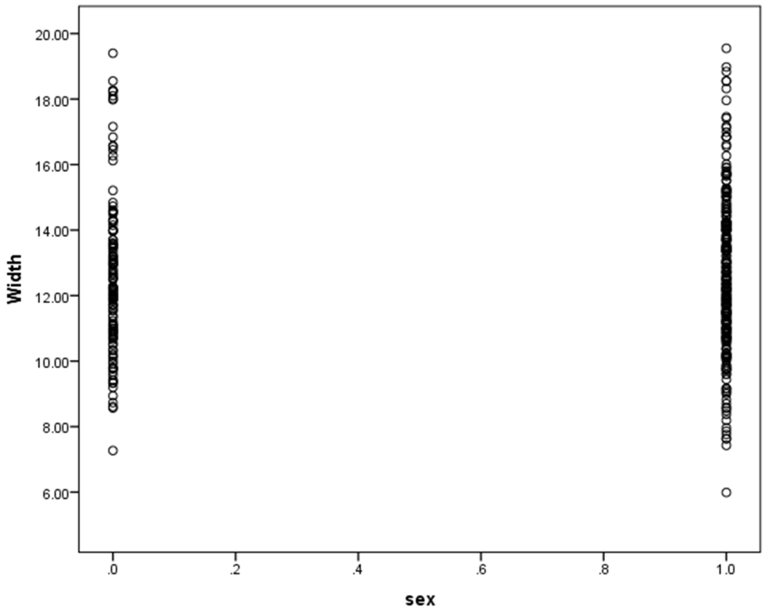

Figure 5. The scatter of width and sex.

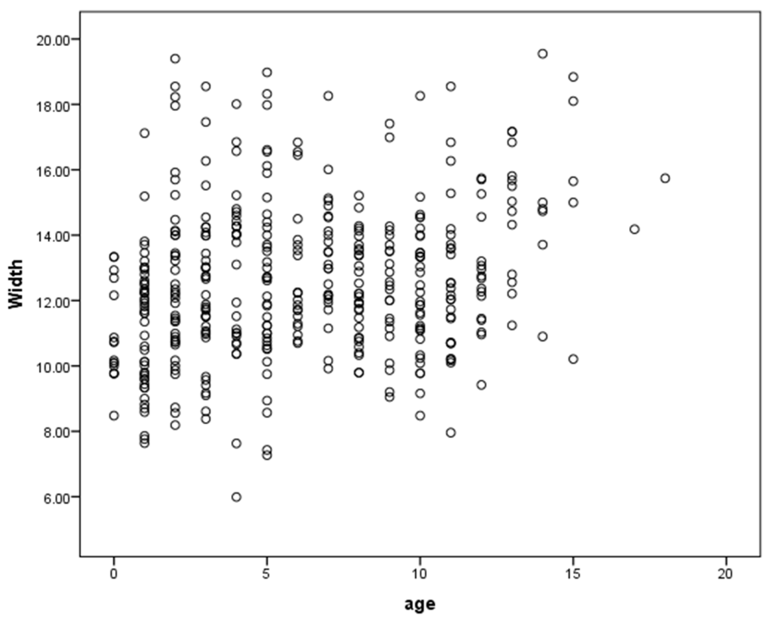

Figure 6. The scatter of width and age.

can lead to better clinical insights. The focus on pediatric populations has allowed for comprehensive assessments of normative dimensions, which enhance diagnostic accuracy and inform tailored treatment strategies for children with pituitary disorders. Statistical analyses revealed significant differences in pituitary dimensions based on age and sex, highlighting the critical need for developing age- and sex-specific normative values in pediatric endocrinology.

We believe that the use of advanced imaging techniques marks a significant advancement in evaluating pituitary gland morphology in children. The rigorous methodologies employed in this study, including precise data collection and expert evaluations by radiologists, are crucial for ensuring the reliability of findings. The data indicated distinctive patterns of pituitary dimensions and volumes across various age groups and sexes. Acknowledging this variability is essential in clinical practice for optimizing diagnostic and therapeutic interventions [13, 18].

Despite its contributions, several limitations of this study should be acknowledged. One significant shortcoming is the relatively small sample size, which may restrict the generalizability of findings across diverse pediatric populations. I feel that potential confounding factors, such as comorbid conditions or variations in imaging techniques, were not explored, which could influence pituitary morphology. Furthermore, the cross-sectional design limits the ability to draw causal inferences about the relationships between pituitary dimensions and clinical outcomes.

Looking ahead, future research should address these shortcomings by expanding the sample size with more diverse cohorts and exploring the clinical implications of variations in pituitary size and volume. It is my belief that longitudinal studies examining changes in pituitary morphology could also provide invaluable insights into the developmental dynamics of this critical gland in children. Such research will likely

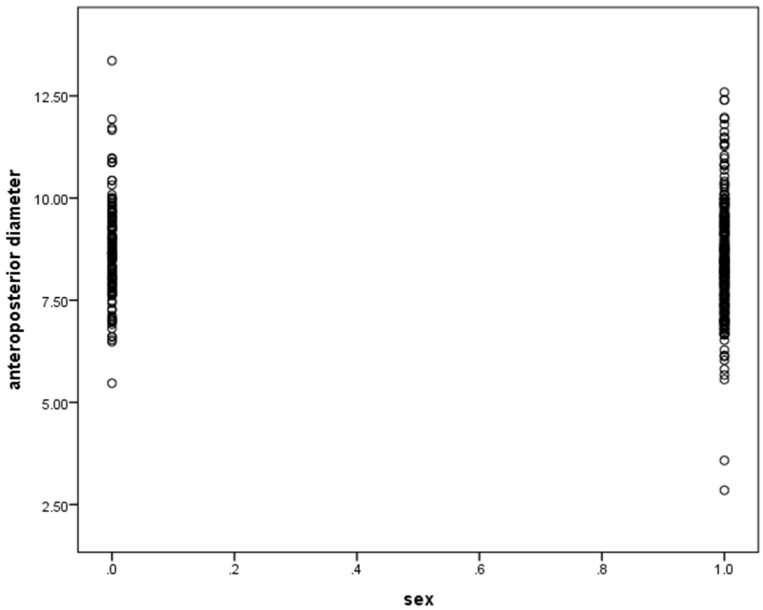

Figure 7. The scatter of anteroposterior diameter-sex.

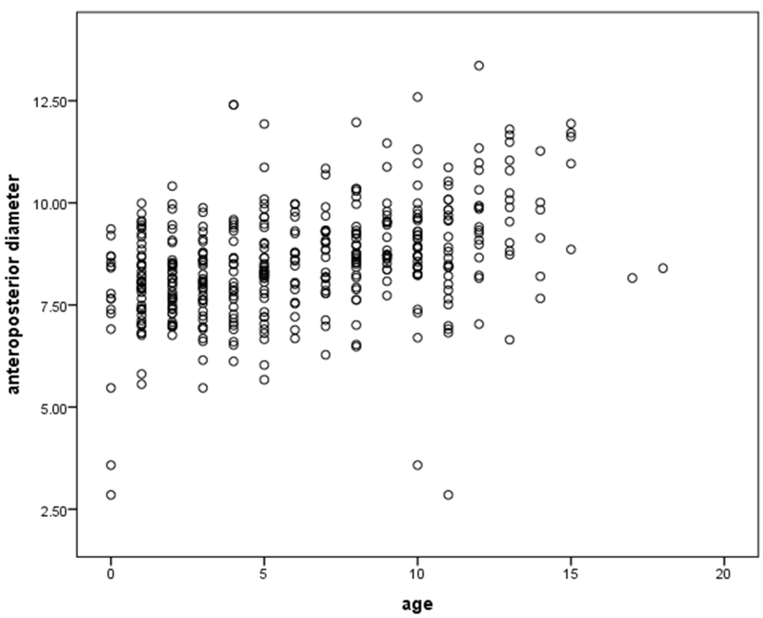

Figure 8. The scatter of anteroposterior diameter age.

inform better clinical practices and enhance our understanding of pediatric endocrinology.

Conclusion

In conclusion, this research at Imam Hossein Hospital in Isfahan utilized a 3D MRI protocol to ascertain the normal range of pituitary gland dimensions in children, providing invaluable insights into pediatric endocrinology. By analyzing the dimensions and volume of the pituitary gland, this study contributes to a deeper understanding of normative variations in pediatric pituitary anatomy. These findings provide essential reference data for clinicians diagnosing and managing pituitary disorders in children. This study represents a significant advancement in pediatric endocrinology, supporting more precise evaluation and personalized treatment plans for young patients. Establishing normative ranges for pituitary gland dimensions based on age and gender will enhance clinical practices and improve healthcare outcomes in pediatric endocrine care.

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Informed consent was obtained from the parents or guardians of all participants before enrollment.

Disclosure of conflict of interest

None.

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