ASSESSMENT OF NORMAL DEVELOPMENT OF THE PITUITARY GLAND IN NORMAL INDIAN ADOLESCENT POPULATION WITH THREE-DIMENSIONAL MR VOLUMETRY
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ABSTRACT

BACKGROUND
The aim of the study is to determine the normal development of pituitary volume in Indian adolescent population by means of direct measurements made on thin-section 3D MR acquisitions.

MATERIALS AND METHODS
200 children and adolescents in the age group of 10 to 19 years with no abnormal findings on routine MR studies were subjected to the study. The volume of pituitary gland was measured in these subjects using 3D MR sequences with a section thickness of 1 mm. The simplified ellipsoid formula length x height x width/2 was used for calculation of the volume of the pituitary.

RESULTS
The mean pituitary volume was 0.42±0.16 cc in females and 0.40±0.16 cc in males. There was a gradual increase in pituitary height with age. Females had a slightly larger pituitary gland, but the difference was not statistically significant.

CONCLUSION
In this study, we used 3D MR volumetry for the calculation of pituitary volume in normal Indian children and adolescents. Using this technique, we found that females had a slightly larger pituitary volume compared to males.

KEYWORDS
Pituitary, MRI, Volumetry, Indian, Adolescent.

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BACKGROUND
The use of Magnetic Resonance Imaging (MRI) for the evaluation of neurological and endocrine disorders in children has increased dramatically over the last 10 years. Rapid evolution of MRI technology with fast sequences and increasing image resolution allow accurate visualisation of even small structures. Direct evaluation of pituitary volume is possible now by three-dimensional (3D) data acquisition. Despite this, there is no useful reference data for the normal range of pituitary volumes in Indian adolescent population.¹,²

MRI has proven to be useful in the assessment of pituitary morphology due to its excellent contrast resolution and high spatial resolution. T1 weighted sequences can be used to differentiate the neurohypophysis from the adenohypophysis due to the high signal intensity of the neurohypophysis.³ Several authors have reported pituitary volumes using indirect methods and by direct methods using thin section 2D and 3D MR images.⁴-⁷ Volume measurements using three-dimensional MR volumetry have been shown to be more accurate.⁸ Most of these studies have dealt with adults. In the adolescent age group, the size of the pituitary gland maybe altered by both physiological and pathological processes (affected by various conditions such as growth hormone deficiency, idiopathic short stature in which the size is small and tumours, physiological hyperplasia in which the size is increased). It is important to differentiate benign causes of pituitary hyperplasia from pathological conditions.⁹ The purpose of this study is to measure the normal volumetric growth of the pituitary gland in the adolescent age group (10 to 19 years) and to compare our findings with those of previous studies.

MATERIALS AND METHODS
This study is conducted in the Department of Radiodiagnosis, Bangalore Medical College and Research Institute, Bangalore, which is a referral as well as a teaching institute. Ethical clearance is obtained from the ethical committee BMC and RI.

All MR imaging examinations were performed on a Siemens Magnetom 1.5-T MR system. 1 mm sections of the pituitary gland were obtained in both sagittal and coronal planes using T1 weighted images. Maximal pituitary height was determined from midline sagittal images by measuring the greatest distance between the superior and inferior plane.

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borders of the gland. Width and length were similarly determined by measuring the greatest dimensions on coronal and sagittal images, respectively. The volume of interest was determined by manual tracing with a mouse-guided pointer using the simplified ellipsoid formula length x height x width/2 (Figure 1 and 2).

Inclusion Criteria
Patients in the age group of 10 to 19 years who have undergone magnetic resonance imaging of skull base.

Exclusion Criteria
1. Patients with history of surgery in sellar and parasellar region.
2. Patients with traumatic involvement of pituitary gland.
3. Any patient with a history or clinical evidence of endocrine abnormality, genetic syndrome, birth asphyxia, hospitalisation for head injury, craniospinal irradiation or abnormal MRI of the brain was excluded from the study.

RESULTS
Out of the 200 subjects (96 males, 104 females), the mean pituitary volume was 0.42±0.16 cc in females and 0.40±0.16 cc in males. The mean pituitary length, height and width for males and females were 0.99±0.14 cm, 0.58±0.15 cm, 1.2±0.15 cm, 1.0±0.14 cm, 0.60±0.16 cm and 1.4±0.19 cm, respectively (Table 2 and 3). Of all the measurements, height showed the best correlation with pituitary volume. There was a gradual increase in pituitary height with age (Graph 1). No significant growth spurt was observed. Females had a slightly larger pituitary gland, but the difference was not statistically significant. There was no relationship between the volume of the neurohypophysis and either age or sex.

<table>
<thead>
<tr>
<th>Number of Males</th>
<th>Number of Females</th>
<th>Total Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>96</td>
<td>104</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 1. Gender Distribution

![Gender Distribution Chart](chart.png)

<table>
<thead>
<tr>
<th>Males (N=96)</th>
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<tbody>
<tr>
<td>Length</td>
<td>Mean: 0.994 cm, SD: 0.1420 cm</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>Mean: 0.582 cm, SD: 0.1536 cm</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>Mean: 1.246 cm, SD: 0.1516 cm</td>
<td></td>
</tr>
<tr>
<td>Pituitary Volume</td>
<td>Mean: 0.402 cc, SD: 0.1620 cc</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Mean and Standard Deviation of Pituitary Gland Dimensions and Volume in Males

<table>
<thead>
<tr>
<th>Females (N=104)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Mean: 1.020 cm, SD: 0.1426 cm</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>Mean: 0.603 cm, SD: 0.1633 cm</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>Mean: 1.411 cm, SD: 0.1922 cm</td>
<td></td>
</tr>
<tr>
<td>Pituitary Volume</td>
<td>Mean: 0.423 cc, SD: 0.1649 cc</td>
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</tr>
</tbody>
</table>

Table 3. Mean and Standard Deviation of Pituitary Gland Dimensions and Volume in Females
DISCUSSION
CT and MR findings of physical hyperplasia of the pituitary gland during puberty have been reported previously.\textsuperscript{10-13} The pituitary gland is much larger in teenage girls than in teenage boys since growth is much more prominent in girls. This pubertal hyperplasia is because of the physical hypersecretion of pituitary hormones at puberty.\textsuperscript{12,14,15} However, these earlier findings were based on linear parameters (e.g., height and width of the pituitary gland) or planimetry on 2D images. Since, the pituitary gland develops dynamically during puberty, a more accurate method of measurement maybe needed to distinguish between a normal- and abnormal-sized pituitary. For this reason, we used thin section 3-dimensional MR sequences on which the pituitary volume can be measured directly. Although, the data are limited to a south Indian population and may not be extrapolated to all groups. The results can probably serve as a standard of reference for pituitary measurements in paediatric patients.

Takano et al published data on whole pituitary gland volume in a similar age group as in our study.\textsuperscript{16} In their study on 199 Japanese children aged 0 to 19 years, a growth spurt was observed, which was more prominent in girls, unlike that seen in our study. They also reported gradual growth of the posterior pituitary without a spurt. However, in our study, there was no growth of the posterior pituitary observed. This study reported average pituitary volumes in males and females in the age group of 10 to 19 years of 0.51 cc and 0.61 cc, respectively, which correspond to the results of our study. It has been well documented that the size of the pituitary varies with age. Some authors have also reported sex differences in pituitary volumes with females having slightly larger glands.\textsuperscript{13,17} Our study did not show a statistically significant difference in pituitary volume between the two sexes.

Another similar study was conducted by Deepthi et al\textsuperscript{18} where they used two different methods to calculate the pituitary volume, voxel counting method and the ellipsoid formula. The average pituitary volume by voxel counting method was found to be 0.54±0.16 cc in both sexes, 0.51±0.13 cc in males and 0.56±0.19 cc in females. The average pituitary volume by ROI was found to be 0.42±0.16 cc in both sexes, 0.40±0.15 cc in males and 0.43±0.17 cc in females. The average pituitary height was 0.58±0.15 cm in both sexes, 0.55±0.16 cm in males and 0.60±0.15 cm in females.

In summary, we have presented normative, directly measured, 3D volumetric data for pituitary size in South Indian adolescent population. Pituitary gland shape in this age group is highly variable; hence, it is best to use direct measures of pituitary volume rather than one-dimensional estimates (height) or 2D, indirectly calculated volumes. Our approach to direct measurement of pituitary volume appears to be robust with assessment using either sagittal or coronal data reconstructions giving practically identical results. We recommend that with the advent of improved MRI technology and 3D data acquisition, indirect estimates of pituitary size and volume should be replaced by direct volumetric analysis.

CONCLUSION
In this study, the pituitary volume in normal Indian adolescent population was assessed using 3D MR volumetry. We found a strong positive correlation in both linear and volumetric measurement of pituitary volume. A gradual increase in pituitary volume was observed with age. Females were found to have slightly larger pituitary volumes compared to males. 3D MR volumetry is a more accurate method for calculating the normal pituitary volume compared to other indirect methods, which is helpful in devising standard reference values for normal pituitary dimensions and volume in a population.

REFERENCES


