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MRI Assessment of Pituitary Gland Size Variability in Relation to Age and Sex: A Cross-Sectional Morphometric Study

Richa Chaudhary[1], Mah Paiker[2], Dr. Mokkarram Jah[3], Abeer Zubair Khan[4], Shazia Perwez[5], Aman Sonkar[6], Nahid Siraj[6]

[1]MSc. Medical Anatomy, Department of Anatomy, Integral Institute of Medical science, Lucknow.
[2]Associate Professor, Department of Anatomy, Integral Institute of Medical of science, Lucknow
[3]Assistant Professor, Department of Surgery, Career Institute of Medical Science, Lucknow.
[4]Professor and Head, Department of Anatomy, Integral Institute of Medical Science, Lucknow
[5]MSc. Medical Anatomy, Department of Anatomy, Integral Institute of Medical Science, Lucknow
[6]MD Pediatrics, Department of Pediatrics, Baba Raghav Dash Medical College, Gorakhpur
[7]MSc. Medical Anatomy, Department of Anatomy, Integral Institute of Medical Science Medical College, Lucknow.

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Corresponding Author:

Dr. Mokkarram Jah
Assistant Professor,
Department of Surgery, Career Institute of Medical Science, Lucknow.
(dr.mjah@hotmail.gmail.com)

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ABSTRACT

Background: Pituitary gland dimensions vary with age, sex and endocrine milieu. Magnetic resonance imaging (MRI) allows precise non-invasive assessment of pituitary morphometry and is useful for distinguishing physiological variation from sellar pathology.

Objective: To evaluate pituitary gland height, anteroposterior diameter, transverse diameter and calculated volume in adults and to examine their variation according to age and sex.

Methods: A hospital-based cross-sectional morphometric study was conducted at IIMSR, Integral University, Lucknow using MRI records of adults aged 18-70 years who underwent brain MRI for indications unrelated to hypothalamic-pituitary disease. Participants with sellar pathology, endocrine disorders, hormone therapy, prior cranial surgery or poor image quality were excluded. Pituitary height and anteroposterior diameter were measured on mid-sagittal T1-weighted images, transverse diameter on coronal images and volume was calculated using the ellipsoid formula. Descriptive statistics, independent samples t-test, one-way ANOVA with Tukey post hoc testing and Pearson correlation analysis were applied.

Results: 76 participants were included; 31 were male and 45 were female. Mean pituitary height was 7.27 +/- 1.98 mm, mean anteroposterior diameter was 9.57 +/- 1.93 mm, mean transverse diameter was 12.65 +/- 2.31 mm and mean volume was 465.84 +/- 191.46 mm3. Females had a significantly greater anteroposterior diameter than males (9.94 +/- 1.75 mm vs. 9.03 +/- 2.09 mm; $p = .043$), while height, transverse diameter and volume did not differ significantly by sex. Across age groups, transverse diameter differed significantly ($F = 3.992$, $p = .023$), with the largest mean value in the 18-32-year group. Volume correlated strongly with height ($r = .685$, $p < .001$) and anteroposterior diameter ($r = .688$, $p < .001$), and moderately with transverse diameter ($r = .426$, $p < .001$).

Conclusion: Pituitary morphometry showed measurable physiological variability in adults. In this cohort, sex-related difference was most evident in anteroposterior diameter, while age-related variation was significant for transverse diameter. MRI-based local morphometric reference data can support radiological interpretation of borderline pituitary enlargement or atrophy.

Keywords: pituitary gland; magnetic resonance imaging; morphometry; age; sex; pituitary volume; sella turcica.

INTRODUCTION

The pituitary gland is a small but highly important endocrine organ situated in the hypophyseal fossa of the sella turcica at the base of the skull. It is connected superiorly to the hypothalamus through the infundibulum or pituitary stalk and forms an essential part of the hypothalamo-pituitary axis. Despite its small size, the gland plays a central role in the regulation of growth, metabolism, reproduction, lactation, stress response and water balance through the secretion of anterior and posterior pituitary hormones. Because of its close anatomical relationship with the optic chiasm, cavernous sinuses and internal carotid arteries, even minor alterations in sellar and parasellar anatomy may produce clinically significant neurological or endocrine manifestations.[1,2]

Magnetic resonance imaging is considered the imaging modality of choice for evaluating the pituitary gland because it provides excellent soft-tissue contrast, multiplanar capability and detailed visualization of the pituitary gland, stalk, sellar floor and adjacent neurovascular structures. MRI is especially useful in distinguishing normal anatomical variation from pituitary hyperplasia, microadenoma, macroadenoma, empty sella and other sellar or parasellar lesions. Routine T1-weighted sagittal and coronal images are commonly used for assessment of pituitary height, anteroposterior diameter and transverse diameter, while volumetric assessment gives a more comprehensive estimate of gland size. However, linear measurements remain valuable in routine radiological practice because they are simple, reproducible and clinically feasible.[3,4]

Normal pituitary size is not constant throughout life. It varies with age, sex and hormonal status. Physiological enlargement of the pituitary gland has been described during adolescence, particularly among females, where convexity of the superior gland margin may be observed as a normal finding. Elster et al. reported that teenage girls frequently showed physiological pituitary hypertrophy and convex upper gland margins on MRI, indicating that such appearances should not always be interpreted as pathological enlargement.[5] Similarly, Tsunoda et al., in a large MRI-based study of 1,020 subjects, observed that pituitary height differed according to age and sex, with greater mean height in females and higher values in younger age groups before gradual decline with increasing age.[6]

Sex-related differences in pituitary dimensions have also been reported in several MRI-based studies. Females generally show greater pituitary height and volume than males, which may be related to hormonal influences during puberty, reproductive age and climacteric periods. Doraiswamy et al. demonstrated age- and gender-related variations in pituitary size and morphology, while Berntsen et al. provided normative MRI data showing larger pituitary size and volume in women than men in a general population cohort.[7,8] Recent studies also support the presence of age-specific and sex-specific variations in pituitary height, shape and volume, further emphasizing the need for reliable normative morphometric data.[9,10]

These physiological variations are clinically important because they may overlap with early pathological conditions. Mild pituitary enlargement may be misinterpreted as pituitary hyperplasia or microadenoma, while age-related reduction in gland size may be confused with partial empty sella or hypopituitarism if the patient's age, sex and normal reference range are not considered. Therefore, accurate knowledge of normal pituitary dimensions is necessary for radiologists, anatomists and clinicians involved in the evaluation of sellar region abnormalities.[3,6,9]

Most available reference values for pituitary gland size have been derived from Western populations. However, anatomical and morphometric parameters may vary across populations due to genetic, ethnic, nutritional and environmental factors. Hence, population-specific MRI-based normative data are important, especially in Indian settings where clinical interpretation often depends on reference standards developed from non-Indian cohorts. Indian and South Asian MRI studies have highlighted the usefulness of local morphometric assessment of the pituitary gland in relation to age and sex.[10,11]

The present study, therefore, has been designed to assess MRI-based morphometric dimensions of the pituitary gland in adults and to evaluate their variation according to age and sex. The findings may help in establishing reference data for pituitary gland size in the study population and may assist in differentiating normal physiological variation from pathological sellar enlargement or reduction

MATERIALS AND METHODS

Study Design and Setting

A hospital-based observational cross-sectional study design was used. The study was conducted in the Department of Radiodiagnosis in collaboration with the Department of Anatomy and Department of Radiology at Integral Institute of Medical Sciences and Research, Integral University, Lucknow, India.

Study Population and Eligibility Criteria

The study included adult individuals aged 18-70 years who underwent brain MRI for clinical reasons unrelated to hypothalamic-pituitary disorders and had normal pituitary morphology on MRI. Participants were excluded if they had known or suspected pituitary or sellar pathology, endocrine disorder, hormone therapy, previous cranial irradiation or surgery, or poor image quality due to motion artefact or technical limitations.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee of Integral Institute of Medical Sciences and Research (IEC No. IEC/IIMSR/2025/44). No additional imaging procedure was performed solely for this research. Written informed consent was obtained for use of anonymized MRI data for academic and research purposes.

MRI Protocol and Morphometric Assessment

MRI examinations were performed on 1.5 Tesla or 3.0 Tesla systems using a dedicated head coil. High-resolution sellar imaging included T1-weighted sagittal and coronal sequences, T2-weighted coronal images and post-contrast images when clinically indicated. Pituitary height was measured on the mid-sagittal T1-weighted image from the superior to inferior gland margin. Anteroposterior diameter was measured on sagittal images and transverse diameter on coronal images. Pituitary volume was calculated using the ellipsoid formula: volume = 0.52 x height x anteroposterior diameter x transverse diameter. Measurements were performed digitally on the radiology PACS workstation.

RESULTS

Participant Characteristics

After applying the eligible age range and exclusion criteria, 76 participants were included in the final analysis. The largest age group was 46-70 years (36.8%), followed by 18-32 years (34.2%) and 33-45 years (28.9%). Females constituted 59.2% of the sample and males constituted 40.8%.

Table 1: Distribution of Participants by Age Group and Sex

Variable	Category	n	%
Age group	18-32 years	26	34.2
Age group	33-45 years	22	28.9
Age group	46-70 years	28	36.8
Sex	Male	31	40.8
Sex	Female	45	59.2

Note. n = 76.

Descriptive Morphometry

The pituitary gland showed broad but clinically expected variation in all measured dimensions. Mean height was 7.27 +/- 1.98 mm, mean anteroposterior diameter was 9.57 +/- 1.93 mm and mean transverse diameter was 12.65 +/- 2.31 mm. The calculated mean volume was 465.84 +/- 191.46 mm3, with values ranging from 113.26 to 924.88 mm3.

Table 2: Descriptive Statistics of Pituitary Gland Morphometric Parameters

Parameter	Minimum	Maximum	Mean	SD
Height (mm)	3.3	10.8	7.27	1.98
Anteroposterior diameter (mm)	4.6	14.8	9.57	1.93
Transverse diameter (mm)	3.2	18.4	12.65	2.31
Volume (mm3)	113.26	924.88	465.84	191.46

Note. SD = standard deviation; mm3 = cubic millimetres.

Sex-Based Comparison

Anteroposterior diameter differed significantly between male and female participants. Females showed a higher mean anteroposterior diameter than males (9.94 +/- 1.75 mm vs. 9.03 +/- 2.09 mm; t = -2.064, p = .043). No significant sex-based differences were observed for height, transverse diameter or volume.

Table 3: Comparison of Pituitary Morphometric Parameters Between Male and Female Participants

Parameter	Male Mean +/- SD (n=31)	Female Mean +/- SD (n=45)	Mean difference	t	p
Height (mm)	7.25 +/- 2.07	7.28 +/- 1.95	-0.03	-0.068	.946
Anteroposterior diameter (mm)	9.03 +/- 2.09	9.94 +/- 1.75	-0.91	-2.064	.043
Transverse diameter (mm)	12.34 +/- 2.11	12.86 +/- 2.43	-0.52	-0.958	.341
Volume (mm3)	431.80 +/- 187.38	489.28 +/- 192.79	-57.48	-1.292	.200

Note. Independent samples t-test. Significant p value is shown in bold conceptually at p < .05.

Age-Based Comparison

One-way ANOVA showed a statistically significant difference in transverse diameter across age groups (F = 3.992, p = .023). The mean transverse diameter was highest in the 18-32-year group. Height, anteroposterior diameter and volume did not differ significantly across age groups, although anteroposterior diameter and volume showed a non-significant trend toward higher values in the 46-70-year group.

Table 4: Comparison of Pituitary Morphometric Parameters Across Age Groups

Parameter	Age group	n	Mean	SD	F	p
Height (mm)	18-32	26	7.43	2.01	0.880	.419
Height (mm)	33-45	22	6.80	1.99	0.880	.419
Height (mm)	46-70	28	7.49	1.96	0.880	.419
Anteroposterior diameter (mm)	18-32	26	9.26	1.49	2.881	.062
Anteroposterior diameter (mm)	33-45	22	9.08	1.70	2.881	.062
Anteroposterior diameter (mm)	46-70	28	10.25	2.31	2.881	.062
Transverse diameter (mm)	18-32	26	13.63	1.54	3.992	.023
Transverse diameter (mm)	33-45	22	11.97	2.93	3.992	.023
Transverse diameter (mm)	46-70	28	12.27	2.11	3.992	.023
Volume (mm3)	18-32	26	489.47	166.27	2.822	.066
Volume (mm3)	33-45	22	386.76	169.75	2.822	.066
Volume (mm3)	46-70	28	506.03	215.66	2.822	.066

Note. One-way ANOVA. Significant difference was observed for transverse diameter only.

Correlation Among Morphometric Parameters

Pituitary volume had strong positive correlations with height and anteroposterior diameter, and a moderate positive correlation with transverse diameter. Height also showed a weak but statistically significant positive correlation with anteroposterior diameter. No significant correlation was observed between height and transverse diameter or between anteroposterior and transverse diameters.

Table 5: Pearson Correlation Matrix of Pituitary Morphometric Parameters

Variable	Height	Anteroposterior diameter	Transverse diameter	Volume
Height	1	.234*	-.132	.685**
Anteroposterior diameter	.234*	1	.122	.688**
Transverse diameter	-.132	.122	1	.426**
Volume	.685**	.688**	.426**	1

*Note. * p < .05. ** p < .01.*

DISCUSSION

The present MRI-based morphometric study evaluated pituitary gland dimensions among adults and observed measurable variation in gland size according to sex and age groups. The mean pituitary height was 7.27 mm and the mean pituitary volume was 465.84 mm³, which fall within the broad normative range reported in MRI-based studies of normal pituitary morphology. However, the mean height in the present study appears relatively higher than some older population-based MRI reports. This variation may be attributed to differences in age distribution, MRI slice thickness, measurement plane, inclusion and exclusion criteria, calculation method for volume, and ethnic or regional morphometric differences. Previous studies have also emphasized that pituitary size is influenced by demographic and technical factors; therefore, interpretation of pituitary measurements should not depend on a single universal value.[6,8,10,12]

In the present study, a significant sex-based difference was observed in anteroposterior diameter, with higher values among females. This finding is broadly consistent with the established concept that pituitary dimensions are often greater in females than males due to hormonal influences. Tsunoda et al. reported significantly greater pituitary height in females than males in a large MRI cohort of 1,020 subjects, especially in adolescent, young adult and climacteric age groups.[6] Berntsen et al. also reported significantly greater pituitary height and volume among women aged 50 to 66 years in a population-based MRI study.[8] In the present study, females showed slightly higher pituitary height, transverse diameter and volume than males, but these differences did not reach statistical significance except for anteroposterior diameter. This

partial agreement may be due to the adult-only sample and the limited representation of pubertal and young reproductive age groups, where sex-related endocrine influence on pituitary morphology is usually more prominent.[5,6,8]

Age-related analysis in the present study showed a statistically significant difference only in transverse diameter. The highest mean transverse diameter was observed in the 18-32 years age group, while pituitary height did not show a statistically significant decline across age groups. This differs from classical MRI studies that reported an increase in pituitary height during adolescence and young adulthood followed by gradual reduction in later decades.[5,6] Elster et al. described physiological pituitary hypertrophy during adolescence, particularly among females, while Tsunoda et al. observed peak pituitary height in younger age groups with progressive reduction in older age groups.[5,6] The difference in the present study may be explained by the exclusion of children and adolescents, since pubertal hypertrophy is one of the strongest contributors to age-related pituitary height variation. In addition, the broad grouping of older adults into a 46-70 years category may have masked subtle decade-wise changes in pituitary morphology.

The mean pituitary volume observed in the present study was close to values reported in Indian MRI literature. Yadav et al. evaluated normal pituitary size and shape in an Indian population and emphasized that pituitary measurements vary with age and sex and should be interpreted in relation to patient demographics.[10] Their study also used linear measurements and ellipsoid-based volume calculation, similar to the present methodology. Shajil et al. reported age- and gender-related dimensional changes in an Indian MRI cohort and found that pituitary height and volume were highest in younger age groups, particularly during the second decade of life.[9] Although the present study did not include adolescents, the findings support the importance of local normative data, because adult pituitary size may vary according to population characteristics and methodological approach.[9,10,11]

The correlation analysis in the present study has practical radiological significance. Pituitary volume showed strong positive correlation with height and anteroposterior diameter, indicating that sagittal measurements contribute substantially to calculated gland volume. This supports the view that pituitary height is a useful and practical parameter in routine MRI reporting, although volume provides a more complete estimate of overall gland size. Lurie et al. demonstrated the usefulness of MRI-based pituitary volumetry in assessing age-related variation, while later MRI studies also highlighted the relevance of volumetric assessment in addition to linear measurements.[12,13] The moderate correlation between transverse diameter and volume in the present study indicates that coronal assessment remains important, particularly when the gland is asymmetric or when the superior surface is concave, flat or convex. Therefore, reliance on sagittal height alone may underestimate or overestimate true gland size in borderline cases.[3,4,12]

From a clinical perspective, the findings of the present study support the need to interpret pituitary MRI measurements with reference to age and sex rather than applying a single cut-off value for all patients. A relatively prominent pituitary gland in a young female may represent physiological variation, whereas similar enlargement in an older male may require careful correlation with clinical symptoms, endocrine profile and contrast-enhanced MRI findings. Conversely, mild reduction in pituitary size among older adults may reflect physiological involution rather than pathology. Dynamic contrast-enhanced MRI, hormonal evaluation and follow-up imaging remain important when morphometric findings are borderline or inconsistent with the clinical presentation.[3,4,6]

The strengths of the present study include MRI-based assessment, exclusion of known sellar or endocrine pathology, and evaluation of multiple morphometric parameters rather than pituitary height alone. However, certain limitations should be acknowledged. The sample size was modest and was derived from a hospital-based MRI population rather than community-based healthy volunteers. The study was cross-sectional, so it cannot determine longitudinal changes within the same individuals. Hormonal status, menstrual phase, parity, menopausal status and body mass index were not analyzed, although these factors may influence pituitary morphology. Manual measurements may also introduce interobserver or intraobserver variability. Future research should include larger multicentric Indian cohorts, decade-wise age stratification, endocrine correlation and three-dimensional volumetric segmentation to develop robust normative reference ranges for the Indian population.

CONCLUSION

MRI-based pituitary morphometry in this adult cohort demonstrated anatomical variability according to sex and age. Females showed significantly greater anteroposterior diameter, while age-group comparison showed significant variation in transverse diameter. Pituitary volume was strongly associated with height and anteroposterior diameter, confirming the importance of sagittal measurements in routine volumetric estimation. These findings support the use of age- and sex-aware interpretation of pituitary MRI and highlight the need for larger population-specific normative datasets in Indian adults.

Clinical Relevance

The findings may assist radiologists and clinicians in interpreting borderline pituitary measurements in adults. Considering age, sex and gland dimension pattern may reduce overdiagnosis of physiological enlargement and improve detection of clinically meaningful sellar abnormalities.

REFERENCES

1. Standring S. *Gray's Anatomy: The Anatomical Basis of Clinical Practice*. 42nd ed. London: Elsevier; 2021.
2. Melmed S. *The Pituitary*. 4th ed. Amsterdam: Elsevier; 2017.
3. Bonneville JF, Bonneville F, Cattin F. Magnetic resonance imaging of pituitary adenomas. Eur Radiol. 2005;15(3):543-548.
4. Sakamoto Y, Takahashi M, Korogi Y, Bussaka H, Ushio Y. Normal and abnormal pituitary glands: gadopentetate dimeglumine-enhanced MR imaging. Radiology. 1991;178(2):441-445.
5. Elster AD, Chen MYM, Williams DW, Key LL. Pituitary gland: MR imaging of physiologic hypertrophy in adolescence. Radiology. 1990;174(3 Pt 1):681-685.
6. Tsunoda A, Okuda O, Sato K. MR height of the pituitary gland as a function of age and sex. AJNR Am J Neuroradiol. 1997;18(3):551-554.
7. Doraiswamy PM, Potts JM, Axelson DA, Husain MM, Lurie SN, Na C, et al. MR assessment of pituitary gland morphology in healthy volunteers: age- and gender-related differences. AJNR Am J Neuroradiol. 1992;13(5):1295-1299.
8. Berntsen EM, Haukdal O, Håberg AK. Normative data for pituitary size and volume in the general population between 50 and 66 years. Pituitary. 2021;24(5):737-745.
9. Shajil S, et al. Role of magnetic resonance imaging in the evaluation of age and gender-related changes in the dimensions of pituitary gland. 2024.
10. Yadav P, Singhal S, Chauhan S, Harit S. MRI evaluation of size and shape of normal pituitary gland: age and sex related changes. J Clin Diagn Res. 2017;11(12):TC01-TC04.
11. Krishna GK, et al. Morphometric analysis of pituitary gland using magnetic resonance imaging. Asian J Med Sci. 2024.
12. Lurie SN, Doraiswamy PM, Husain MM, Boyko OB, Ellinwood EH Jr, Figiel GS, et al. In vivo assessment of pituitary gland volume with magnetic resonance imaging: the effect of age. J Clin Endocrinol Metab. 1990;71(2):505-508.
13. MacMaster FP, Keshavan M, Mirza Y, Carrey N, Upadhyaya AR, El-Sheikh R, et al. Development and sexual dimorphism of the pituitary gland. Life Sci. 2007;80(10):940-944.