ORIGINAL ARTICLE

MRI Based Analysis of Pituitary Gland Dimensions: Age and Sex Related Variation. A Hospital Based Study

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ABSTRACT

Introduction: The hypophysis cerebri (pituitary gland) is a small but pivotal endocrine organ that regulates the secretion of multiple peripheral endocrine glands. Accurate knowledge of its normal dimensions is essential for distinguishing physiological from pathological changes on neuroimaging. **Aims:** To establish normative reference data on pituitary gland dimensions and to evaluate the influence of age and sex on these measurements. **Methods:** A hospital based cross sectional study was conducted on 200 subjects (76 males, 124 females) aged 11 years and above, referred for brain Magnetic Resonance Imaging at the Department of Radiology, Nepalgunj Medical College. Anteroposterior diameter, transverse diameter, height, and volume of pituitary gland were measured from standardized magnetic resonance imaging sequences. **Results:** The overall mean anterioposterior diameter, transverse diameter, height, and volume were 10.01±1.60 mm, 13.33±2.34 mm, 6.47±1.53 mm, and 461.11±203.35 mm^3, respectively. Females demonstrated greater mean values across all parameters compared to males (AP: 10.16±1.42 vs 9.76±1.84 mm; height: 6.56±1.38 vs 6.33±1.74 mm; volume: 471.75±145.56 vs 443.76±272.91 mm^3). Pituitary height and volume were greatest in the 11–20 years age group, while maximum anterioposterior and transverse dimensions were observed in the 41–50 and 21–30 years groups, respectively. One way ANOVA revealed statistically significant variation with age for anterioposterior diameter (p=0.009) and height (p=0.024). **Conclusion:** Pituitary gland dimensions exhibit significant age and sex related variation. Normative reference values were established: overall mean anterioposterior diameter 10.01±1.60 mm, transverse diameter 13.33±2.34 mm, height 6.47±1.53 mm, and volume 461.11±203.35 mm^3. Females consistently demonstrate larger dimensions, with peak gland size observed during the pubertal decade. These normative data may serve as a useful radiological reference for differentiating physiological from pathological pituitary changes.

Keywords: Age; Dimensions; Magnetic Resonance Imaging; Pituitary Gland; Sex

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INTRODUCTION

The hypophysis cerebri is a small ovoid endocrine gland often referred to as the "master gland" of the endocrine system that orchestrates the secretory activity of multiple peripheral endocrine organs through its diverse hormonal output.[1] It occupies the hypophysial fossa of the sphenoid bone and is invested superiorly by the diaphragma sellae, a circular fold of dura mater, which is pierced centrally by an aperture accommodating the pituitary stalk (infundibulum). The diaphragma sellae sepa-

rates the anterosuperior surface of the gland from the optic chiasma, while inferiorly the gland is separated from the floor of the fossa by a venous sinus in communication with the circular sinus.[2,3] In the adult, the gland measures approximately 13 mm in the transverse, 10 mm in the anteroposterior, and 8 mm in the vertical dimension, with a mean weight of approximately 500 mg.[2] Magnetic resonance imaging (MRI) has become the modality of choice for evaluating the sellar, parasellar, and suprasellar regions, providing superior soft tissue contrast and multiplanar capability compared to computed tomography (CT) and plain radiography. It allows detailed delineation of the anterior and posterior lobes, pituitary stalk, infundibulum, optic chiasma, and adjacent parasellar structures.[4] Several factors, including age, sex, hormonal milieu, pregnancy, and body mass index, are known to influence the morphometry of the pituitary gland. Establishing population specific normative reference data is therefore of considerable clinical importance, as it enables radiologists to distinguish physiological variants from early pathological conditions such as microadenomas, hypophysitis, or secondary gland changes due to systemic endocrinopathies. This study aims to establish normative reference data on pituitary gland dimensions while examining the influence of age and sex on these measurements.

METHODS

This hospital based cross sectional study was conducted at Nepalgunj Medical College, Nepal, from May 2024 to April 2026. The study population comprised consecutive patients referred to the Department of Radiology for brain MRI for a variety of clinical indications (including headache, seizure, and other neurological complaints) in whom the pituitary gland was incidentally found to be morphologically normal on imaging. Measurement and analysis were performed in the Department of Anatomy using data collected by a single observer from the Department of Radiology.

The sample size was calculated using the formula:

$n = (Z \bullet \sigma / d^2)$

Where: Z = 1.96 (95% confidence level); σ = 107.74 mm^3 (standard deviation from pilot data)

d = 15 mm^3 (margin of error)

$n = [(107.74 \times 1.96) / 15]^2 = 198.19 \approx 200$

MRI examinations were performed using a 1.5 Tesla GE Signa Creator unit. Standard sequences included T1 weighted sagittal and coronal images (slice thickness 3 mm, field of view 20 cm) without contrast enhancement. Three pituitary dimensions were measured directly from MRI images: anteroposterior (AP) diameter, transverse diameter, and height. The reference values used to define a morphologically normal pituitary gland in this study were: AP diameter ≤ 15 mm, transverse diameter ≤ 15 mm, and height ≤ 8 mm in adults (and ≤ 10 mm in adolescent females and pregnant women), consistent with established radiological criteria.[2,3] Subjects whose pituitary measurements fell outside these limits, or who had imaging features suggesting a structural lesion, were excluded. To assess intra-observer reliability, a random subsample of 20 subjects (10%) was re measured by the same observer after a minimum interval of two weeks; the intraclass correlation coefficient was ≥0.90 for all parameters, indicating excellent reproducibility. Pituitary volume was subsequently estimated using the ellipsoid formula:

$V = 0.52 \times AP \times T \times H$ where V = Volume (mm^3), AP = anteroposterior diameter (mm), T = transverse diameter (mm), and H = height (mm). The coefficient 0.52 is derived from the sphere volume equation: $(4/3\pi)(r^3)/(2r)^3 = \pi/6 \approx 0.52$.[5,6]

Informed consent was obtained from each participant prior to enrollment, in accordance with the non-interventional, observational nature of the study. Ethical clearance was granted by the Institutional Review Committee on 28 April 2024 (Ref. No. 51/080–081).

Subjects with a prior history of pituitary surgery, cranial radiotherapy, endocrine abnormalities, or any known conditions affecting pituitary morphology were excluded. All remaining subjects were patients who met the inclusion criteria: aged 11 years or above, referred for brain MRI for any clinical indication, and found on imaging to have a morphologically normal pituitary gland with no evidence of structural pathology. These subjects were included in the analysis as a representative sample of the general patient population presenting to the radiology department.

Data were tabulated and analyzed using SPSS (IBM Corp., Version 25.0). Descriptive statistics including minimum, maximum, mean, and standard deviation were computed for all measured parameters. The association of pituitary dimensions with age was examined using one way analysis of variance (ANOVA); where a statistically significant result was obtained, post hoc analysis was performed to identify specific inter group differences. Sex based differences were examined using independent samples t test.

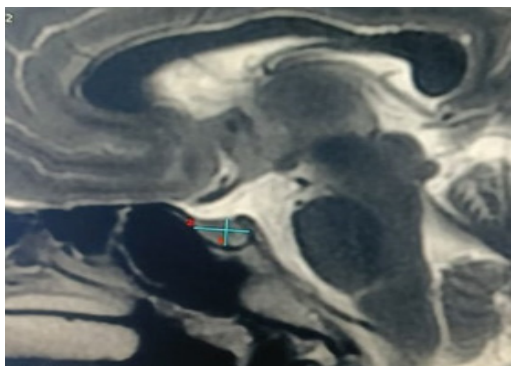

Figure 1: Mid sagittal T1 weighted MRI view at the level of the pituitary stalk showing the measurement lines used in this study: the vertical line represents height (H) and the horizontal line represents the anteroposterior (AP) diameter of the pituitary gland, as defined in the Methods section. Patient identifying information has been removed.

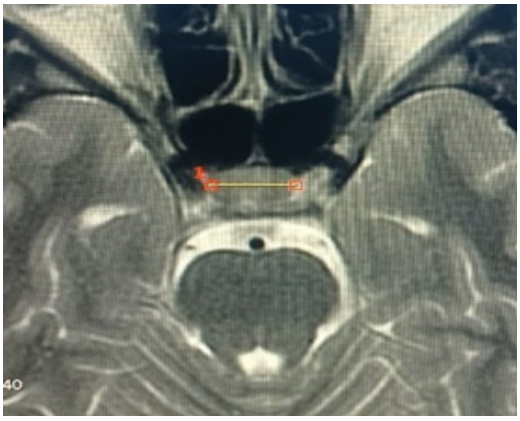

Figure 2: Coronal T1 weighted MRI view showing the central line representing the transverse dimension of the pituitary gland, as defined in the Methods section. Patient identifying information has been removed.

RESULTS

The cohort comprised 76 males and 124 females, distributed across six age groups (11–20, 21–30, 31–40, 41–50, 51–60, and 60+ years) as detailed in Tables I and II.

Age Group	11–20	21–30	31–40	41–50	51–60	60+
N	11	10	12	10	14	19
AP Diameter (mm) Min	5.20	7.90	7.80	6.30	5.50	7.00
AP Diameter (mm) Max	13.40	14.50	11.30	13.50	11.60	13.20
AP Diameter (mm) Mean	9.41	11.00	9.47	9.83	9.41	9.72
AP Diameter (mm) SD	2.30	2.15	1.17	2.50	1.59	1.39
Transverse Diameter (mm) Min	8.10	11.70	9.70	7.60	7.10	6.20
Transverse Diameter (mm) Max	17.80	17.10	16.00	16.20	15.10	18.60
Transverse Diameter (mm) Mean	13.61	14.65	13.05	11.91	12.44	12.93
Transverse Diameter (mm) SD	2.54	1.79	2.17	3.09	2.21	3.28
Height (mm) Min	4.80	4.50	4.00	3.90	3.10	4.00
Height (mm) Max	9.90	8.70	8.20	9.70	7.10	16.60
Height (mm) Mean	6.68	6.40	6.30	6.25	5.54	6.73
Height (mm) SD	1.50	1.24	1.38	1.53	0.97	2.61
Volume (mm^3) Min	105.13	351.66	236.55	158.87	126.78	177.34
Volume (mm^3) Max	1000.26	997.09	623.41	1082.69	590.78	2119.33
Volume (mm^3) Mean	475.74	541.40	411.17	416.45	341.66	484.03
Volume (mm^3) SD	239.52	199.18	144.27	282.58	112.83	424.18

Table I: Anteroposterior diameter, transverse diameter, height, and volume of the pituitary gland across age groups in males. M = mean; SD = standard deviation; N = number of subjects

Age Group	11–20	21–30	31–40	41–50	51–60	60+
N	13	21	24	24	16	26
AP Diameter (mm) Min	7.40	7.30	8.40	9.60	8.70	6.20
AP Diameter (mm) Max	11.00	11.40	13.00	14.40	13.90	12.40
AP Diameter (mm) Mean	9.27	10.14	10.35	10.99	10.52	9.46
AP Diameter (mm) SD	1.07	0.89	1.18	1.20	1.58	1.73
Transverse Diameter (mm) Min	12.20	8.80	8.00	9.30	10.40	8.70
Transverse Diameter (mm) Max	16.00	17.30	17.80	17.80	16.20	17.80
Transverse Diameter (mm) Mean	13.77	13.82	13.48	13.53	13.91	12.85
Transverse Diameter (mm) SD	1.24	2.34	2.59	2.06	1.68	2.10
Height (mm) Min	6.20	4.40	4.80	4.10	4.30	3.30
Height (mm) Max	10.70	10.20	9.20	9.60	8.10	10.50
Height (mm) Mean	7.84	6.64	6.34	6.63	6.11	6.25
Height (mm) SD	1.41	1.38	0.93	1.32	1.04	1.66
Volume (mm^3) Min	398.71	203.77	236.12	260.96	276.61	124.84
Volume (mm^3) Max	793.43	617.20	775.47	954.72	716.46	872.35
Volume (mm^3) Mean	523.38	480.51	464.89	512.69	467.06	410.28
Volume (mm^3) SD	135.20	107.05	142.50	144.14	123.68	179.68

Table II: Anteroposterior diameter, transverse diameter, height, and volume of the pituitary gland across age groups in females. M = mean; SD = standard deviation; N = number of subjects

Group	AP Diameter (mm)	Transverse Diameter (mm)	Height (mm)	Volume (mm^3)
Total (n=200)	10.01±1.60	13.33±2.34	6.47±1.53	461.11±203.35
Males (n=76)	9.76±1.84	13.05±2.67	6.33±1.74	443.76±272.91
Females (n=124)	10.16±1.42	13.50±2.11	6.56±1.38	471.75±145.56

Table III: Overall mean (±SD) pituitary gland dimensions by sex

Group	AP Diameter (mm)	Transverse Diameter (mm)	Height (mm)	Volume (mm^3)
11–20	9.34±1.70	13.70±1.90	7.31±1.53	501.55±187.26
21–30	10.42±1.44	14.09±2.18	6.56±1.32	500.15±142.75
31–40	10.06±1.23	13.34±2.43	6.33±1.08	446.99±143.34
41–50	10.65±1.73	13.05±2.48	6.52±1.37	484.38±195.55
51–60	10.00±1.65	13.22±2.05	5.84±1.03	408.54±132.92
60+	9.57±1.58	12.88±2.63	6.45±2.10	441.42±305.46

Table IV: Overall mean (±SD) pituitary gland dimensions across age groups

Age Group (yrs)	11–20	21–30	31–40	41–50	51–60	60+
AP Diameter (mm)	9.34±1.70	10.42±1.44	10.06±1.23	10.65±1.73	10.00±1.65	9.57±1.58
p value	0.009*					
Transverse Diameter (mm)	13.70±1.90	14.09±2.18	13.34±2.43	13.05±2.48	13.22±2.05	12.88±2.63
p value	0.308					
Height (mm)	7.31±1.53	6.56±1.32	6.33±1.08	6.52±1.37	5.84±1.03	6.45±2.10
p value	0.024*					
Volume (mm^3)	501.55±187.26	500.15±142.75	446.99±143.34	484.38±195.55	408.54±132.92	441.42±305.46
p value	0.402					

Table V: One way ANOVA of pituitary gland dimensions across age groups. *Statistically significant (p<0.05)

Overall pituitary dimensions. The overall mean AP diameter, transverse diameter, height, and volume for the entire cohort were 10.01±1.60 mm, 13.33±2.34 mm, 6.47±1.53 mm, and 461.11±203.35 mm^3, respectively (Table III). Across all parameters, females recorded greater mean values than males: AP diameter (10.16±1.42 vs 9.76±1.84 mm), transverse diameter (13.50±2.11 vs 13.05±2.67 mm), height (6.56±1.38 vs 6.33±1.74 mm), and volume (471.75±145.56 vs 443.76±272.91 mm^3), although these sex based differences did not reach statistical significance on independent samples t - test (p>0.05 for all parameters).

Age related variation. As shown in Table IV, the mean AP diameter peaked in the 41–50 years age group (10.65±1.73 mm) and was lowest in the 11–20 years group (9.34±1.70 mm). The maximum mean transverse diameter was observed in the 21–30 years group (14.09±2.18 mm), with a gradual decline thereafter. Pituitary height was greatest in the 11–20 years group (7.31±1.53 mm) and lowest in the 51–60 years group (5.84±1.03 mm), suggesting age related atrophy beyond the fifth decade. Total pituitary volume followed a similar trend to height, peaking in the 11–20 years group (501.55±187.26 mm^3) and reaching its nadir in the 51–60 years group (408.54±132.92 mm^3), with a modest secondary rise in the 60+ group (441.42±305.46 mm^3).

Sex stratified findings - anteroposterior diameter. In males, the mean AP diameter was greatest in the 21–30 years group (11.00±2.15 mm) and lowest in the 51–60 years group (9.41±1.59 mm). In females, the peak AP diameter occurred in the 41–50 years group (10.99±1.20 mm) and the minimum in the 11–20 years group (9.27±1.07 mm). Female values exceeded male values in all age groups except 11–20, 21–30, and 60+ years.

Sex stratified findings - transverse diameter. Among males, the maximum transverse diameter was recorded in the 21–30 years group (14.65±1.79 mm) and the minimum in the 41–50 years group (11.91±3.09 mm). In females, the peak transverse diameter occurred in the 51–60 years group (13.91±1.68 mm) and the minimum in the 60+ group (12.85±2.10 mm). Female transverse diameters exceeded male values in all age groups except 21–30 and 60+ years.

Sex stratified findings - height. In males, the greatest mean height was observed in the 60+ group (6.73±2.61 mm) and the lowest in the 51–60 group (5.54±0.97 mm). In females, maximum height was recorded in the 11–20 group (7.84±1.41 mm) and the minimum in the 51–60 group (6.11±1.04 mm). Female height values surpassed male values in all age groups except the 60+ group.

Sex stratified findings - volume. In males, pituitary volume peaked in the 21–30 years group (541.40±199.18 mm^3) and was lowest in the 51–60 years group (341.66±112.83 mm^3). In females, the maximum volume was observed in the 11–20 years group (523.38±135.20 mm^3) and the minimum in the 60+ group (410.28±179.68 mm^3). These findings highlight a notable association between pituitary volume and the pubertal decade, consistent with the known effects of gonadal hormones on gland morphology.

Statistical Analysis

One way ANOVA demonstrated statistically significant variation across age groups for AP diameter (p=0.009) and height (p=0.024), while transverse diameter (p=0.308) and volume (p=0.402) did not reach significance (Table V). Post hoc analysis for AP diameter identified significant differences between the 11–20 and 41–50 years groups and between the 41–50 and 60+ years groups. For height, a significant difference was found between the 11–20 and 51–60 years groups. No significant age-related variation was observed for transverse diameter or volume.

DISCUSSION

Females exhibited greater mean values across all four parameters compared to males, a finding that aligns with those of sev-

eral prior MRI based morphometric studies conducted in similar demographic settings.[7,8] The observed sex difference may be attributable to the stimulatory effect of estrogen on lactotrophic cells within the anterior pituitary, which are known to undergo hypertrophy under estrogenic influence.

In contrast to the study by Maskey et al[9] in which the maximum mean AP dimension was reported in the third decade (20–29 years) the present study found the peak AP diameter in the 41–50 years age group overall, although in males the peak occurred in the 21–30 years group, consistent with their observation. In females, the peak was delayed to the 41–50 years group, which may reflect the peri menopausal increase in gonadotrophic activity. Transverse dimension patterns were concordant between the two studies, with the highest values in the 21–30 years age group in both. These findings underscore that age related dimensional changes are not uniform across parameters or sexes.

Pituitary height was greatest in the 11–20 years age group, particularly among females, a finding similarly reported by Ibinaiye et al[10] in a Nigerian cohort. This is attributable to the physiological hypertrophy of the gland during puberty, driven by the surge in gonadotrophins and growth hormone. The decline in height observed in the 51–60 years group is consistent with the age-related pituitary atrophy documented by Tsunoda et al[11] and may reflect involutional changes following the cessation of gonadal hormonal stimulation. As in most morphometric studies, pituitary volume followed a trajectory similar to height, peaking in the 11–20 years group overall. In males, however, peak volume was observed in the 21–30 years group, while in females it occurred in the 11–20 years group. This sex specific timing is consistent with the earlier onset and peak of pubertal hormonal activity in females. The present findings corroborate the widely accepted concept that the pituitary gland enlarges during puberty and undergoes gradual volumetric decline with advancing age.[7] These results, however, contrast with those reported by Lamichhane et al[12], who identified the 40–50 years age group as the period of maximum pituitary volume in a Nepalese population, a discrepancy that may reflect differences in sample composition and radiological technique.

While Yadav et al[6] reported the maximum mean pituitary height in males aged 11–20 years, the present study found that females in this age group demonstrated greater dimensions overall. This difference may be explained by the earlier onset of puberty and the greater estrogenic stimulation of pituitary lactotrophs in adolescent females. Similar sex-based observations have been reported by Singh et al8 in an Indian population.

The normative data generated by this study may be of practical value in radiological practice for the population of Banke District, enabling more accurate differentiation of physiological gland enlargement particularly in adolescent females from early pathological conditions such as pituitary adenoma, hypophysitis, or secondary hypertrophy due to primary hypothyroidism.

LIMITATIONS

Several limitations of this study warrant acknowledgement. The hospital based cross sectional design may introduce selection bias, as the study population comprises patients referred for MRI rather than a randomly sampled community cohort. This limits the generalizability of findings to the broader population. The sample was drawn from a single tertiary center, restricting external validity. As a purely morphometric study, no correlation was made with functional parameters such as hormone levels, nor with physiological variables known to influence pituitary size, including menstrual cycle phase, pregnancy, lactation, and body mass index. Future studies with larger, multi center samples incorporating hormonal and physiological data would further strengthen the normative reference values established herein.

CONCLUSION

This study suggested a population specific normative reference data for pituitary gland dimensions based on referred patients at Nepalgunj Medical College, Banke with overall mean AP diameter 10.01±1.60 mm, transverse diameter 13.33±2.34 mm, height 6.47±1.53 mm, and volume 461.11±203.35 mm^3 across 200 subjects (76 males, 124 females) aged 11 years and above. These parameters are significantly influenced by both age and sex. Females consistently exhibited larger pituitary dimensions and volume than males. Gland size followed a nonlinear trajectory with age, with maximum dimensions observed during the first and second decades of life likely reflecting pubertal hormonal stimulation followed by a gradual decline, with a modest secondary rise around the fifth decade. These normative values may serve as a useful baseline for the radiological assessment of pituitary pathology in this population.

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