VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 79, No. 1, pp. 28–35
DOI: 10.5603/FM.a2019.0058

ISSN 0015–5659
journals.viamedica.pl

The determination of the pituitary gland, optic chiasm, and intercavernous distance measurements in healthy subjects according to age and gender

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[Received: 11 March 2019; Accepted: 24 April 2019]

Background: *This paper was undertaken to determine the morphometry of pituitary gland diameter, pituitary gland height, intercavernous distance, optic chiasm diameter and optic chiasm height in skulls of Turkish population aged between 18 and 60 years.*
Materials and methods: *It was a retrospective study in which 292 subjects were included 187 females and 105 males, ranging from 18 up to 60 years. Subjects underwent brain magnetic resonance imaging in the Radiology Department. Statistical analysis was performed with SPSS 21.00 programme. ANOVA test, χ^2 test, and Pearson correlation analysis were used to determine the relation and significance between measurements and age group. The $p < 0.05$ value was considered as significant.*
Results: *The groups were divided into five groups according to age. The overall means and standard deviations of the measurements were: pituitary gland width, 13.09 ± ± 1.99 mm; pituitary gland height, 4.91 ± 1.10 mm; intercavernous distance, 15.93 ± 3.05 mm; optic chiasm width, 12.82 ± 1.27 mm; and optic chiasm height, 2.80 ± 0.49 mm in females, respectively whereas, the same measurements were 12.96 ± 1.74 mm; 4.79 ± 0.95 mm; 16.08 ± 3.11 mm; 13.13 ± 1.37 mm; 2.86 ± ± 0.70 mm in males, respectively. Height of the pituitary gland reached a maximum in the age group of 18 to 20 years in both females and males and there was a decrease in the pituitary gland height in the subsequent age groups.*
Conclusions: *Knowledge of the variation in the size of pituitary gland, intercavernous distance and optic chiasm is important to evaluate the dimensions of these structures for clinical and pathological processes.* (Folia Morhol 2020; 79, 1: 28–35)

Key words: pituitary gland, optic chiasm, intercavernous distance, morphometry

INTRODUCTION

Sella turcica which is found in the middle cranial fossa, is comprised of three section named as the tuberculum sella, the pituitary gland and the hypophyseal fossa [5, 19, 29]. Hypophyseal fossa is located in the deepest of the sella turcica [23]. The important structures surround the pituitary gland: sphenoidal sinus from anteriorly, dorsum sellae, basilar artery and pons from posteriorly, optic chiasm from anterior superior side, hypothalamus from inferiorly, and

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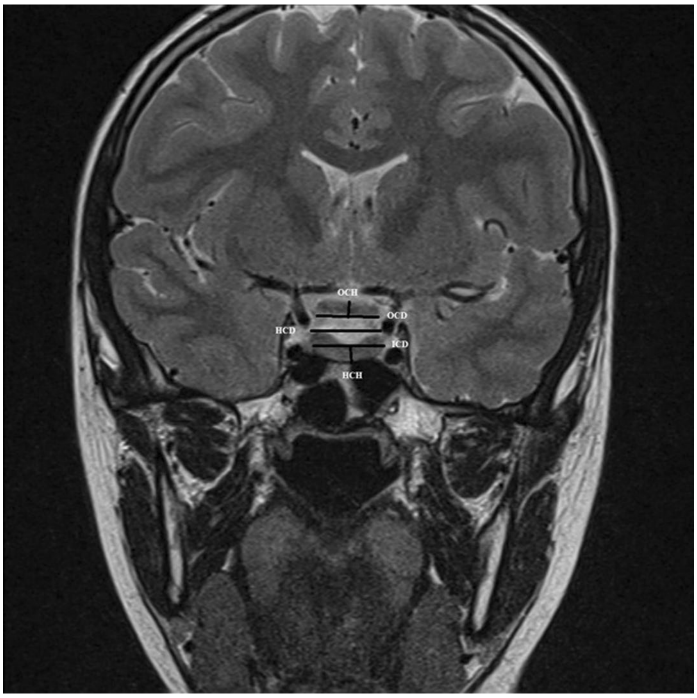

Figure 1. The measurements of pituitary gland, optic chiasm, and intercavernous distance; OCH — the greatest height of the central portion of the optic chiasm; OCD — horizontally diameter measurement at the centering point of chiasm; ICD — the distance between the two medial walls of the cavernous sinus; HCH (PH) — the greatest distance between the base and the top of the pituitary gland; HCD (PD) — the maximum distance between right and left side of the pituitary gland.

carotis artery, and cavernous sinus from lateral side, and also from lateral and superior side by the dura thin layer [3, 7, 13, 15, 16, 25, 31]. Sella turcica is a critical reference landmark related to pathologies of pituitary gland, optic chiasm, and craniofacial region. Therefore, the knowledge of this region's normal anatomy, variations or morphometry may be essential for to determine the subject's growth and evaluate orthodontic treatment results and may help neurologists and neurosurgeons in preventing damage during surgery [5, 19, 23].

In the studies of the pituitary gland, optic chiasm, and intercavernous distance's anatomy, the differences between females and males and age related changes were observed [2, 3, 9, 14, 22, 26, 27, 33]; whereas, in some studies no significant difference in dimensions of pituitary gland, optic chiasm, and intercavernous distance was found. Also, some different results have been reported regarding both pituitary gland and optic chiasm measurements in decades [3, 9, 22, 26, 27, 34]. There were very few studies assessing morphometry of the hypophysis cerebri, intercavernous distance or optic chiasm in Turkish population in literature [6, 9, 28]. Knowing the normal dimensions of pituitary gland and other structures in this critical area of the brain is very important for clinical and pathological evaluations. The purpose of this study was to reveal the normative data related to the pituitary gland, optic chiasm, intercavernous distance dependent on age groups and to determine measurements with age and sex in Turkish population.

MATERIALS AND METHODS

This study was carried out in 292 healthy adult subjects (187 females; 105 males) aged 18–60 years. The study period extended from January 2015 to 2018. This study was approved by the Institutional Review Ethics Committee at Cukurova University. This was a retrospective observational study. It was done in Department of Radiology at Medline Hospital in Turkey. Brain magnetic resonance imaging (MRI) protocol including coronal T2-weighted turbo spin echo (TR: 3600, TE: 87 ms; slice thickness: 5 mm; gap: 1.5 mm) and sagittal T2-weighted spin echo (TR: 3600, TE: 87 ms; slice thickness: 5 mm; gap: 1.5 mm) was used. The measurements of the pituitary gland width, pituitary gland height, the intercavernous distance, optic chiasm width, and optic chiasm height were shown in Figure 1. The measurements were performed with digital MRI, at a hospital, using calliper function with

Table 1. The means, standard deviations, and ranges of the sellar region measurements (mm) with magnetic resonance imaging by age groups in Turkish healthy population (n = 292)

Values	Age groups					Total (min–max)	P
Age	18–20 years	21–30 years	31–40 years	41–50 years	51–60 years		
N	15	92	115	45	25		
Pituitary gland width	13.31 ± 1.92 9.90–17.00	13.16 ± 1.78 7.50–18.50	12.93 ± 2.02 7.10–18.70	12.85 ± 1.69 10.40–16.40	13.28 ± 2.15 8.90–17.10	13.04 ± 1.89 (7.10–18.70)	> 0.05 (0.745)
Pituitary gland height	5.45 ± 1.25 2.70–7.10	5.08 ± 1.02 2.40–7.70	4.81 ± 1.01 1.80–7.20	4.58 ± 1.06 1.60–6.90	4.49 ± 0.94 2.30–6.10	4.87 ± 1.05 (1.60–7.70)	< 0.05 (0.003)
Intercavernous distance	3.32 ± 1.48 2.20–8.30	2.75 ± 0.48 1.70–4.10	2.86 ± 0.48 1.60–4.10	2.71 ± 0.48 1.20–3.50	2.80 ± 0.42 2.10–4.10	2.82 ± 0.58 (1.20–8.30)	≤ 0.05 (0.005)
Optic chiasm width	12.95 ± 1.32 10.80–15.50	12.68 ± 1.16 10.00–14.80	13.14 ± 1.31 9.10–16.50	12.88 ± 1.51 9.30–15.70	12.95 ± 1.40 10.10–15.20	12.93 ± 1.31 (9.10–16.50)	> 0.05 (0.179)
Optic chiasm height	3.32 ± 1.48 2.20–8.30	2.75 ± 0.48 1.70–4.10	2.86 ± 0.48 1.60–4.10	2.71 ± 0.48 1.20–3.50	2.80 ± 0.42 2.10–4.10	2.82 ± 0.58 (1.20–8.30)	≤ 0.05 (0.005)

×2 magnification. MRI was performed using a 1.5 T MRI system (Siemens; Essenza, Erlangen, Germany).

Healthy adult subjects were selected by criteria of optimal health. The main exclusion criteria were:
- adult subjects who had a history of endocrine disturbance, pregnancy, breast-feeding;
- those who undergone hormonal treatment such as thyroid, postmenopausal oestrogen, progesterone, steroid therapy;
- subjects who were on a medication (like phenothiazine, reserpine).

The data were divided into two groups according to gender: healthy adult female and male subjects, and age groups. Estimations were expressed as millimetre.

Table 2. Gender related changes of sellar region measurements (n = 292)

Values	Females (n = 187)	Males (n = 105)	P value
Pituitary gland width (min–max)	13.09 ± 1.99 (7.10–18.70)	12.96 ± 1.74 (8.80–16.40)	> 0.05 (0.598)
Pituitary gland height (min–max)	4.91 ± 1.10 (1.60–7.50)	4.79 ± 0.95 (1.90–7.70)	> 0.05 (0.385)
Intercavernous distance (min–max)	15.93 ± 3.05 (9.90–24.70)	16.08 ± 3.11 (9.90–25.70)	> 0.05 (0.701)
Optic chiasm width (min–max)	12.82 ± 1.27 (9.10–15.70)	13.13 ± 1.37 (9.70–16.50)	> 0.05 (0.056)
Optic chiasm height (min–max)	2.80 ± 0.49 (1.20–4.10)	2.86 ± 0.70 (1.80–8.30)	> 0.05 (0.396)

Statistical analysis

The SPSS 21.0 programme was used for statistical analysis of the measurement results. From these measurements, means, standard deviations (SD), minimum and maximum values were calculated. In all statistical analyses, a p value of less than 0.05 was considered statistically significant. ANOVA test, χ^2 test, and Pearson correlation analysis were also used.

RESULTS

The means, associated standard deviations, and range of values for the various measurements from sella turcica region were presented in Tables 1–4. No significant difference (p > 0.05) was observed in the corresponding mean values of gender, consequently the means and standard deviations of the measurements from sella turcica were calculated. The overall means and standard deviations of the measurements were: the pituitary gland width, 13.09 ± 1.99 mm; the pituitary gland height, 4.91 ± 1.10 mm; the intercavernous distance, 15.93 ± 3.05 mm; the optic chiasm width, 12.82 ± 1.27 mm; the optic chiasm height, 2.80 ± 0.49 mm in females, respectively whereas, the same measurements were 12.96 ± 1.74 mm; 4.79 ± ± 0.95 mm; 16.08 ± 3.11 mm; 13.13 ± 1.37 mm; 2.86 ± 0.70 mm in males, respectively (Table 1).

The mean of the pituitary gland height in the age group 18–20 years was the highest value (5.45 ± ± 1.25 mm). The same measurement was 5.08 ± ± 1.02 mm in the age group 21–30 years; 4.81 ± 1.01 mm in the age group 31–40 years; 4.58 ± 1.06 mm in the age group 41–50 years and, 4.49 ± 0.94 mm in the age group 51–60 years. The same value was observed

Table 3. The means, standard deviations, and ranges of the sellar region measurements (mm) with magnetic resonance imaging by age groups in Turkish healthy females (n = 187)

Values	Age groups					P
Age ranges	18–20 years	21–30 years	31–40 years	41–50 years	51–60 years	
N	12	65	66	25	19	
Pituitary gland width	13.56 ± 2.06 9.90–17.00	13.18 ± 1.87 7.50–18.50	12.89 ± 2.21 7.10–18.70	12.77 ± 1.64 10.90–16.30	13.56 ± 1.92 9.90–17.10	> 0.05 (0.533)
Pituitary gland height	5.63 ± 1.25 2.70–7.10	5.10 ± 1.04 2.40–7.50	4.83 ± 1.10 1.80–7.20	4.64 ± 1.07 1.60–6.90	4.40 ± 1.01 2.30–6.10	< 0.05 (0.010)
Intercavernous distance	18.29 ± 4.22 12,80–24,70	16.00 ± 2.62 10,60–23,10	15.43 ± 3.14 9.90–23.20	15.56 ± 2.72 11.00–21.50	16.47 ± 3.25 10.10–21.70	< 0.05 (0.039)
Optic chiasm width	12.98 ± 1.38 10.80–15.50	12.63 ± 1.15 10.00–14.80	12.98 ± 1.26 9.10–15.70	12.74 ± 1.46 9.30–15.30	12.91 ± 1.37 10.10–15.20	> 0.05 (0.568)
Optic chiasm height	2.96 ± 0.53 2.20–3.70	2.76 ± 0.48 1.70–4.10	2.85 ± 0.50 1.60–4.10	2.63 ± 0.53 1.20–3.50	2.86 ± 0.39 2.30–4.10	> 0.05 (0.220)

Table 4. The means, standard deviations, and ranges of the sellar region measurements (mm) with magnetic resonance imaging by age groups in Turkish healthy males (n = 105)

Values	Age groups					P
Age ranges	18–20 years	21–30 years	31–40 years	41–50 years	51–60 years	
N	3	26	49	21	6	
Pituitary gland width	12.33 ± 0.71 11.70–13.10	13.16 ± 1.59 9.80–15.70	12.98 ± 1.75 8.80–15.60	12.92 ± 1.74 10.40–16.40	12.42 ± 2.77 8.90–15.00	> 0.05 (0.861)
Pituitary gland height	4.73 ± 1.23 3.70–6.10	5.08 ± 1.00 3.50–7.70	4.75 ± 0.88 2.10–6.80	4.56 ± 1.06 1.90–6.10	4.78 ± 0.64 3.70–6.50	> 0.05 (0.454)
Intercavernous distance	15.00 ± 0.87 14.50–16.00	15.52 ± 2.63 12.00–22.40	16.31 ± 3.25 9.90–25.70	16.70 ± 3.27 11.70–25.00	14.92 ± 3.89 9.90–19.10	> 0.05 (0.539)
Optic chiasm width	12.87 ± 1.36 11.30–13.70	12.89 ± 1.16 11.10–14.50	13.29 ± 1.40 9.70–16.50	13.09 ± 1.55 10.00–15.70	13.07 ± 1.63 10.30–14.40	> 0.05 (0.817)
Optic chiasm height	4.77 ± 3.14 2.30–8.30	2.75 ± 0.46 1.80–3.50	2.84 ± 0.46 1.90–3.80	2.84 ± 0.40 1.90–3.50	2.60 ± 0.49 2.10–3.50	< 0.05 (< 0.001)

to be 4.87 ± 1.05 mm in both subjects (Table 1). P value for the pituitary gland height and intercavernous distance measurements were found to be 0.010 and 0.039 in females between second decade and sixth decade which were statistically significant, however p value for optic chiasm height was calculated as 0.001 in between the age groups of males which was statistically significant ($p < 0.05$) (Tables 3 and 4).

The values of pituitary gland height in different age groups and in both sexes were shown in the Tables 1, 3 and 4. The means of the pituitary gland height of female subjects in all age groups under 51 years were higher than in male subjects in all age groups under 51 years. Whereas, in female subjects above 50 years of age, the means of the pituitary gland height was lower than in male subjects in the same age groups. Moreover, the mean of these heights was found to be the highest in the age group 18–20 years, followed by age group 21–30 years (Table 1). In males the corresponding value was the highest in 21–30-year-olds (third decade), while in females the same measurement was the highest in patients aged 18–20 years (second decade). Additionally, the height of pituitary gland in females decreased gradually with increasing age, whereas there were no such gradual decrease in males (Tables 3 and 4).

Significant differences were not found in pituitary gland height and width, intercavernous distance, optic chiasm width and height according to gender (> 0.05). Pituitary gland width showed strong positive correlation with intercavernous distance ($r = 0.712$)

and weak positive correlation with optic chiasm width (r = 0.279). Intercavernous distance showed weak positive correlation with optic chiasm width (r = 0.337). There was moderate negative correlation between pituitary gland height and age.

DISCUSSION

Magnetic resonance imaging is an important, useful and accurate diagnostic technique for examination of pituitary gland. Many pathologies such as physiological hypertrophy, neoplasia (microadenoma or macroadenomas), inflammatory disease, empty sella, embryonic abnormalities and increased lobulated margin are determined with this method [22, 26, 27, 29, 33]. Moreover, the MRI can be an alternative to computed tomography (CT) measurements because it provides greater facility to the patient and with potentially lower risk [32]. Also, preoperative imaging of the tumours allows the surgical approach to be practically [6]. Additionally, MRI is more reliable than CT and it does not use any harmful ionizing radiation. It allows detailed visualization of the pituitary gland, optic chiasm, etc. [3].

The pituitary gland plays an important role in neuroendocrine regulation [3]. The height of the pituitary has a critical significance in both determination of intrasellar mass and evaluation of pituitary tumour diagnosis and prognosis [3, 32]. It also allows to be used as a guideline of response to medical therapy [32]. Argyropoulou et al. [1] reported that pituitary height is an important marker, because of a sign of the pituitary gland growth. Suzuki et al. [26] stated that if the pituitary gland height exceeds 9.00 mm in females and 8 mm in males, that means pituitary gland is abnormal. According to Elster rules which was used as a guideline for height of the pituitary, this dimension was declared as 6 mm in child; 8 mm in males or post menopause period; 10 mm in fertility period; and in 12 mm postpartum/lactation period [6, 28]. Tsounoda et al. [27] reported that pituitary height could show physiological neuroendocrine variations between both young and old subjects, and females and males. The height of the pituitary gland increased in during puberty, third and fifth decades. The reason for this increase in puberty period could be with luteinizing hormone hypersecretion. Furthermore, the height increased in the third and the fifth decades was due to more active as endocrinolologically and both fertility in females and increase in basal serum concentrations of gonadotropic hormones such as luteinizing hormone or follicle stimulating hormone [1, 14, 22, 27]. The decrease in pituitary height with age could show the endocrinology of aging and physiological pituitary atrophy [1, 27]. Moreover, the one reason of decreasing in pituitary height was reduction in basal serum concentrations of gonadotropic hormones after puberty until to the ages of 50 years [3, 27, 33]. Additionally, an another reason of decreasing in pituitary gland height was regression of pituitary gland tissue causing loss of function, and progressive compression of the pituitary gland from cerebrospinal fluid pressure and ischemic changes in the anterior lobe [26].

In studies, there were different reports about the period of peak height of the pituitary. Some authors stated the peak height of the pituitary in females was observed in second decade [6, 11, 12, 26], in the ages of 16–25 years [22], and in third decade [3, 27], whereas in males the pituitary peak height was seen in the age of 11–20 years [11], in the age of 10–29 years [26], in the ages of 16–25 years [22], in the age of 21–30 years [3, 12], in the age of 51–60 years [6] and in the age of 20–29 years [27]. In this study the peak height of pituitary was found in second decade (the ages of 18–20 years) in females and in third decade (the ages of 21–30) in males, respectively. We also found differences in females the peak values of pituitary height of above studies except the populations of Nigerian, Turkish, Japanese and Pakistan. According to this data, our results of males were similar to studies of Japanese and Pakistan populations. On the other hand, in a studying consisting of German subjects with idiopathic intracranial hypertension (IICH) and healthy subjects, the same measurements were found as 3.23 mm and 5.55 mm, respectively [10]. In other study, Wiener et al. [32] stated that pituitary height of patients with pituitary tumour was found as 15.5 mm (range 5–35 mm) in CT and 14.5 mm (range 5–32 mm) in MRI. These results are important for knowing normal values of the pituitary height to research whether a tumour is present or not [6]. In literature, pituitary height means were found as 5.52 mm and 5.66 mm in Scottish male and female subjects [22]; 4.7 mm and 4.9 mm and 5 mm and 5.2 mm in Japanese males and females [14, 26]; 5.60 mm and 5.80 mm in Pakistan male and female population [3]; 6.45 mm and 6.46 mm in Nigerian male and female population [11], and 5.37 mm and 6.27 mm in Indians, respectively [20, 24]. When we analysed our data including pituitary height was found to be 4.79 mm and 4.91 mm in males and females, respectively. According to this data, our values were lower than literature except Suzuki et al.'s study [26]. We consider that these differences could be a result of such factors like race, genetic variables, demographic variables (age, gender), the ratio of females in study, mean age of participants, hormonal status, stress and menstrual cycle. Moreover, pituitary gland diseases cause to excessive secretion or growth of the pituitary gland such as acromegaly, prolactinoma, gigantism, hyperthyroidism or diseases including diabetes insipidus, hypothyroidism, Addison's or Graves diseases cause to less secretion of gland, and the growth deficiency in genital system, or cavernous sinus infection, presence of tumour as glioma, meningioma, lymphoma etc. play a role in differences of pituitary gland dimensions [7, 15, 16, 25, 27, 31]. Furthermore, the immaturity of the hormonal feedback system between hypothalamo-hypophyseal tract and target organs is responsible for decrease in pituitary height during the first year of age. Therefore in newborn children, there are high hypophyseal concentrations and blood level of the pituitary hormones [1].

The pituitary dimensions vary across age groups. It is a sign of changes in pituitary gland's complicated hormonal milieu [11]. The means of the pituitary width measured as 8 mm [20]. These measurements were significantly different between male and female. It was known that females had larger glands [11]. Peak values of pituitary width were seen in the ages of 25–35 years, whereas the lowest value of pituitary width was obtained between 55 and 65 years [22]. In this study, there were no correlations with age in pituitary width measurements, which is in agreement with the literature [11]. In researches, the means of the pituitary width were between 11.22 mm and 13 mm in Indians [20, 23, 24]; 11.57 mm and 11.91 mm in Scottish males and females [22]; 12.4 mm and 13.5 mm in Japanese males and females [14], 9.08 mm and 9.21 mm in Nigerian males and females, respectively [11]. However, mean value of the pituitary width was found as 12.32 mm both in subjects with IICH and healthy subjects [10]. In this study, the pituitary width of females (13.09 mm) were higher than that of males (12.96 mm), which is in accordance with the literature [11, 14, 22, 24]. We also found differences in the mean values of pituitary width of above studies except Indians with our population. The Scottish, Nigerian and Japanese males have lower values, and Japanese females have greater values than ours. On the other hand, in this study, the maximum values of the pituitary width were recorded in the second and sixth decades whereas, the lowest value of pituitary width was obtained in fifth decade in females. Conversely, in males the maximum values were reached in third decade whereas the lowest value was recorded in second decade. According to above studies, we thought that the pituitary width was exposed to many variations at different periods of life. It can vary from individuals, depending on age, sex, menstrual period, race, and presence tumours or diseases.

Many critical structures are present close to optic chiasm. The optic chiasm forms with combining optic nerves anteriorly and leaving optic tracts posteriorly. Optic chiasm gets in touch with cerebrospinal fluid anteriorly, within the subarachnoid space and posteriorly within the third ventricle. It is an important parameter for comment MRI examinations of brain [2, 30]. A small optic chiasm could be a sign of many disorders or a large optic chiasm could be an indication of the glioma, meningioma, lymphoma etc. [30]. The mean of the optic chiasm width was found as 14.0 mm (range from 10.3 mm to 18.3 mm) in Americans aged between 18 to 82 years [30]. Bilal et al. [2] stated the means of optic chiasm width and height were 13.08 mm and 2.49 mm in females having abnormal brain MR respectively, whereas the corresponding values were found as 13.58 mm and 2.58 mm in males, respectively. In that study, researchers reported that the optic chiasm width ranged between 11.11 mm and 15.09 mm, whereas the optic chiasm height ranged from 2.11 mm to 2.89 mm. Furthermore, the maximum value was seen in sixth decade, whereas the lowest value was measured in fifth decade [2]. Schmitz et al. [21] measured the same dimension as 10.3 mm and 12.9 mm in subjects with albinism and healthy group. In this study, the means of the optic chiasm height and width values were found as 3.5 mm and 15.0 mm in healthy subjects, while the corresponding values were 3.5 mm and 15.00 mm in subjects with optic atrophy [17]. We found the means of the optic chiasm height and width higher in males than females with similar to literature [2].

There were very few studies about intercavernous distance measurement [9, 18, 35]. Intercavernous distance defined the distance between the two medial walls of the cavernous sinus. It was stated that the medial wall of the cavernous sinus was weakest and thinner part of the pituitary gland cover therefore allowing lateral tumoural growth into the cavernous sinus [4, 8, 9].

The mean of this dimension was measured as 14.9 mm (range 10.1 mm and 18.2 mm) by Romano et al. [18]. In Turkish female and male population, the intercavernous distance was found as 14.1 mm and 13.0 mm, respectively. There were no significant differences in between genders. Additionally, the intercavernous distances showed negative correlation with age. In the studies, it has been reported that the intracavernous distance decreases with increasing age [9]. The intercavernous distance was 12.7 mm in healthy Americans, whereas the corresponding value was 15.9 mm in subjects with sella based lesions [35]. In this study, this dimensions was measured as 15.93 mm and 16.08 mm in females and males. There were no significant differences between genders. However, in evaluation of intercavernous distance with age, there were significant differences in females. But there were no significant differences in intercavernous distance of males. Intercavernous distance decreased from second decade to fifth decade, with increasing age. Beside these findings, in fifth decade this value was increased whereas intercavernous distance was decreased in sixth decade in females.

CONCLUSIONS

As a result, according to this study data, some important differences between the Turkish population and other nations were shown. At the same time, some measurement values were different in also Turkish population with age and sex. The fact that data differences are well known in normal individuals is of great importance in evaluating the structures of organs in clinical and pathological processes.

Acknowledgements

This study was supported by a grant from Cukurova University Scientific Research Projects Coordination Unit (Project number: TSA-2018-11285).

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