Evaluation of the Volumetric Relation Between Cranial Cavity and Orbits

Kranial Kavite ve Orbitalar Arasındaki Volümetrik İlişkinin Değerlendirilmesi

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ABSTRACT Objective: The aim of the study was to determine the volume of orbits and cranial cavity and to evaluate the relation between their volumes. **Material and Methods:** Twenty dry skulls of 10 men and 10 women were used for this study. Water filling method was used to measure the volumes of cranial cavity and orbits. The holes of the both cavities had been sealed before they were filled by the jelly material. The filling jelly was poured into a graduated cylinder to measure the volume of the subjected cavities. **Results:** The mean cranial volume was 1262 ± 156.6 cm^3 (±SD) and the mean volume of the two orbits was 43.9 ± 8.4 cm^3 (±SD). The mean cranial volumes of males and females were different ($p< 0.05$). The mean volumes of the right and the left orbits did not differ between the genders ($p> 0.05$). There was a high correlation between the volumes of skull and the sum of right and left orbital volumes ($r= 0.714$; $p< 0.01$). **Conclusion:** The mean cranial volumes of males and females were concordant with the classical knowledge of the difference of the body volumes of males and females. There was a high correlation between orbital volumes and the cranial volumes; bigger craniums had bigger orbits. These findings indicate a relationship between volumes of the structures of the body.

Key Words: Skull; orbit; anthropometry; organ size

ÖZET Amaç: Çalışmanın amacı orbitaların ve kranial kavitenin hacmini belirlemek ve hacimleri arasındaki ilişkiyi değerlendirmekti. **Gereç ve Yöntemler:** Bu çalışmada 10 erkek ve 10 kadına ait 20 kafatası kullanıldı. Kranial kavite ve orbitaları ölçmek için su doldurma yöntemi kullanıldı. Her iki kavite doldurulmadan önce delikleri jelimsi bir maddeyle kapatıldı. Söz konusu kavitelerin hacmini ölçmek için jel ölçeklendirilmiş bir silindire boşaltıldı. **Bulgular:** Ortalama kranial hacim 1262 ± 156.6 cm^3 (±SD) ve iki orbitanın ortalama hacmi 43.9 ± 8.4 cm^3 (±SD) idi. Erkeklerin ve kadınların ortalama kranial hacimleri farklıydı ($p< 0.05$). Sağ ve sol orbitanın ortalama hacimleri her iki cinste de farklı değildi ($p> 0.05$). Kranial hacim ile iki orbitanın hacimlerinin toplamı arasında yüksek bir korelasyon vardı ($r= 0.714$; $p< 0.01$). **Sonuç:** Erkeklerin ve kadınların ortalama kranial hacimleri farklı bulunması cinsiyetler arasında büyüklük farkı olduğu şeklindeki klasik bilgiyle uyumluydu. Orbita ve kraniyal hacim arasında yüksek bir korelasyon vardı büyük kafatası büyük orbitaya sahipti. Bu bulgu vücut yapıları arasında bir ilişki olduğunu da ortaya koyuyordu.

Anahtar Kelimeler: Kafatası; orbit; antropometri; organ büyüklüğü

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The orbits, located between the cranial vault and face, are dominant elements of cranio-facial complex.[1,2] This complex is important for visual evaluation of the face of both a normal person and a person with developmental facial abnormality.[3,4] Volumetric relationship of the

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organs is a known scientific fact. Several studies have been performed dealing with cranio-facial skeleton and relationship between the structures constituting this region.[5-7] However, no studies up to date evaluated the relationship between the volumes of cranial cavity and orbits.

In the present study we determined the volumes of orbits and cranial cavity and evaluated the relation between theirs volumes.

MATERIAL AND METHODS

Twenty dry skulls of 10 men and 10 women were used for this study. Water filling method was used to measure the volumes of cranial cavity and orbits. A mixture of water and starch was boiled and a jelly was obtained. The holes of the both cavities had been sealed before they were filled by the jelly. The intracranial cavity and orbits were filled up with jelly. Finally, the filling jelly was poured into a measuring cylinder to measure the volume of subjected cavities. To obtain an accurate volume measurement, the cavities were rinsed with a known amount of water and it was also poured into the cylinder. The known amount of water was excluded from the measured amount to obtain the exact jelly volume.

The results were evaluated using the Pearson correlation test for the volumes of skull and orbits. The student's t test was used for gender and laterality comparisons.

RESULTS

The mean cranial volume was 1262 ± 156.6 cm^3 (±SD) and the mean volume of two orbits was 43.9 ± 8.4 cm^3 (±SD) (Tables 1 and 2). The mean cranial volumes of males and females were different ($p< 0.05$). The mean orbital volume of the males was greater than the volume of the females ($p< 0.05$). The mean volumes of the right and the left orbits were not different between two genders ($p> 0.05$). There was a high correlation between the volumes of skull and the sum of right and left orbital volumes ($r= 0.714$; $p< 0.01$) (Figure 1). The mean orbital volume was equal to 3.47% of mean cranial volume.

DISCUSSION

Progress in understanding human craniofacial growth has evolved from histological and embryologic studies, radiographic cephalometry, correlation of growth and facial anomalies, review of surgical interventions, animal research, and numerous basic science fields. The cranial volume, which is about 50% of the adult value at one year of age, reaches 75% at 3 years and 90 % at 7 years. The orbits are prominent parts of the midface. Embryologically, the eyes develop laterally in the in the head, then undergo a frontal migration of the eye fields in utero and after birth.[3]

Orbital volume and its relation to orbital structures[4,5] and cranial volume that indicate the mag-

TABLE 1: The volumes of the cranium and orbits in terms of gender.

Volume (cm^3)	N	Minimum	Maximum	Mean	S. Deviation
Cranium (male)	10	1260	1550	1382.5	104.5
Cranium (female)	10	1010	1325	1165.5	111.6
Orbit (male. sum)	10	44	60	53.2	4.9
Orbit (female. sum)	10	30	44	37.5	3.7

TABLE 2: The cranial and the right and left orbital volumes.

Volume (cm^3)	N	Minimum	Maximum	Mean	S. Deviation
Cranium	20	1010	1550	1262.0	156.6
Orbit (right)	20	15	30	22.0	4.2
Orbit (left)	20	15	30	22.0	4.2
Orbit (sum)	40	30	60	43.9	8.4

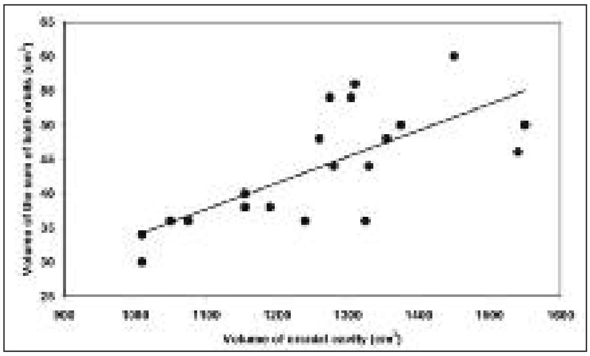

FIGURE 1: The relationship between the volumes of cranium and orbits.

nitude of the brain have been studied.[8-11] The development and the shape of the structures of body should be in a harmony for visual appearance. For this reason, there should be a relationship for the normal shape of these structures. An abnormal development in the region of the face may effect the development of the other structures. Any irregularity of the face or the skull vault or volume disturbances between them will disturb the relationship of the skull and orbits.

Despite many studies examining the orbital and intracranial volume, we have not found a study evaluating the relation between them. Moreover, there was not any study evaluating the orbital volume differences between genders.

Craniums are classified as microcephalic (<1350 cm^3), mesocephalic (1350 cm^3-1450 cm^3) and megacephalic (1450 cm^3>) according to their volumes. In our study, the mean volume of the male cranium was megacephalic and the mean volume of the female cranium was microcephalic.[12]

Beals et al.[13] examined about 20000 skulls and found that the mean cranial volumes in Eastern-Asians, Europeans and Africans were 1415 cm^3, 1362 cm^3 and 1268 cm^3, respectively. Although our findings were similar to the Africans, it may not be convenient to compare our limited data with other large series.

The mean cranial volumes of the males and females were different in our study. The mean orbital volume of the males was greater than the volume of the females. The mean volumes of the right and the left orbits were not different in two genders ($p > 0.05$). Our results were concordant with the classical knowledge of the difference of the body volumes of males and females.

There was a high correlation between orbital volumes and the cranial volumes; bigger craniums had bigger orbits ($p < 0.05$). These findings indicate a relationship between volumes of the structures of the body.

Finally, we believe that our findings will provide basic information for further studies that will evaluate volume relation between orbits and the cranium.

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