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Study on the Korean Adult Cranial Capacity

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Cranial capacity was measured in Korean adult skulls. The cavity was filled with rice seeds and the volume of the seeds were measured in a graduated cylinder. The results were 1470 ± 107 (mean ± standard deviation) in male and 1317 ± 117 cc in female skulls. These values were in good accordance with those previously reported. In addition, regression formulae were obtained with the product of the length, breadth, and height of the skull as an independent parameter and the measured capacity as a dependent one. With known external measurements, the expected cranial capacity was as follows;

when using baso-bregmatic height,

$male: capacity = 307.5 + 333 \times 10^{-6} \times (length \cdot breadth \cdot baso\text{-}bregmatic\ height)$
$female: capacity = -12.0 + 435 \times 10^{-6} \times (length \cdot breadth \cdot baso\text{-}bregmatic\ height)$

and, when using auriculo-bregmatic height,

$male: capacity = 214.6 + 429 \times 10^{-6} \times (length \cdot breadth \cdot auriculo\text{-}bregmatic\ height)$
$female: capacity = 131.6 + 461 \times 10^{-6} \times (length \cdot breadth \cdot auriculo\text{-}bregmatic\ height).$

Key Words: *Korean, Cranial capacity, Measurement*

INTRODUCTION

Cranial capacity, which is in close correlation with brain volume (von Bonin, 1934), reflects racial characteristics and thus has been thought to be one of the commonest items in physical anthropological studies (Rha, 1968). The capacity can be measured by a

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direct method, in which the cavity is packed with small filling materials (for example, mustard seeds, millet, lead-shot and so on), or indirectly calculated from external skull measurements such as length, breadth, and height. Since the first introduction of the formula for prediction of cranial capacity from external measurements by Manouvrier (Olivier, 1969), several different formulae have been presented for each racial group (Isserlis, 1914; Tildesley, 1927; Olivier, 1969).

For Koreans, the capacity was measured in 1924 (Morant) and in 1934 (Shima), and no attempts could be found in the literature thereafter. Furthermore, no formula has been given for the determination of cranial capacity from external measurements.

It is thought that a formula for cranial capacity suitable for one race would not always be applicable to other races, because not only the shape of the skull (von Bonin, 1934), but also the thickness of the skull (Isserlis, 1914) vary from race to race.

In this study, the cranial capacity was directly measured and capacity prediction formulae from external measurements were obtained in Korean adult skulls.

MATERIALS AND METHODS

1) Materials

A total of 99 skulls (64 males, 23 females, and 12 of unknown sex) with minimal destruction were selected from deposits in the Department of Anatomy, Catholic University, College of Medicine, and in the Department of Anatomy, Yonsei University, College of Medicine. The estimated ages ranged from the 30s to 80s. Skulls in the 20s were excluded in this study (Table 1). In most of the skulls, the calvaria were sawn off from the visceral cranium, because they were from cadavers for medical student's anatomy laboratories. And, we had to reconstruct them for this study before all measurements.

Table 1. Age distribution of the skulls used in this study.

	Male	Female
30s	2	
40s	3	2
50s	9	2
60s	13	5
70s	6	1
80s	1	
unknown	30	13
total	64	23

2) Direct estimation of the capacity

The orbits of a skull were packed with cotton balls and the skull was vertically oriented with the forehead facing down. Rice seeds were poured through the foramen magnum into the skull using a large-mouthed funnel. After filling to the level of the foramen magnum, the process was slowly accomplished with the skull being gradually inclined to eventual horizontal position. Then, the cavity became full of seeds. During this procedure, care was taken to make sure that the rice seeds were minimally packed (Stewart, 1934), and that no empty spaces remained in the anterior and middle cranial fossae. After the filling, the volume of the rice seeds was measured using a 2,000 ml graduated cylinder. Care was also taken not to pack the seeds tightly in the cylinder. All the processes were duplicated for each skull and the mean value was determined.

3) External measurements

Used variances for extraction of the formula were length, breadth, and height of the skull. With respect to height, both auriculo-bregmatic and baso-bregmatic heights were considered. Every measurement was made according to the method of Martin (1982) with a cephalometer made by the GPM company, Swiss. However, auriculo-bregmatic height was calculated from the values of bilateral porion-bregma distances and the distance between right and left porions. Because almost all previously presented formulae express the cranial capacity as a function of the product of length, breadth, and height (LBH) (Olivier, 1969), we also assumed a formula in which the LBH was an independent variable and the directly measured capacity a dependent one and performed a regression analysis. All the analyses were done using statistical package PC-SAS v 6.04.

RESULTS

1) Direct measurement of the cranial capacity

The average cranial capacity for Koreans was 1428 cc (Table 2). In males, the values ranged from 1715 cc to 1240 cc and the mean ± SD was 1470 ± 107 cc. In females, they were from 1515 to 1050 cc with a mean value (± SD) of 1317 (± 117) cc. The male

Table 2. Cranial capacities of Korean adults.

	n	mean	SD	minimum	maximum
Total	99*	1428	125	1050	1715
male	64	1470	107	1240	1715
Female	23	1317	117	1050	1515

*including skulls of unknown sex.

and female groups statistically differed from each other ($p < 0.05$). Therefore, a formula was obtained separately in each sex.

2) Extraction of the formulae

In male skulls, a total of 58 values of baso-bregmatic height was obtained out of 64 skulls. The regression line between the estimated capacity and the LBH showed its regression coefficient of 307.5 and intercept of 333. In females, 23 baso-bregmatic heights could be measured and the regression coefficient was 435, and the intercept, −12.0. Thus the equations employing the baso-bregmatic height were as follows ;

male : capacity(cc)=307.5+333×10^{-6}×(length • breadth • baso-bregmatic height)
female : capacity(cc)=-12.0+435×10^{-6}×(length • breadth • baso-bregmatic height)

The correlation coefficients between the measured capacity and the LBH(baso-bregmatic) were 0.78 in males and 0.91 in females.

When employing the auriculo-bregmatic height, there were 58 possible male and 22 female cases. In male skulls, the regression coefficient was 429, and the intercept was 214.6. Female skulls showed a coefficient of 461 and an intercept of 131.6. The obtained formulae were as follows ;

male : capacity=214.6+429×10^{-6}×(length • breadth • auriculo-bregmatic height)
female : capacity=131.6+461×10^{-6}×(length • breadth • auriculo-bregmatic height)

The correlation coefficients between the mesaured capacity and the LBH(auriculo-bregmatic) were 0.77 in males and 0.89 in females, which were similar in the case of employing baso-bregmatic height. This reveals that the calculated value of auriculo-bragmatic height in this study is a useful variance for the determination of cranial capacity.

DISCUSSION

As was previously noted, most of the skulls used in this study were from cadavers after student's dissection. Therefore, the calvaria were separated from the other part of the skull. Reconstruction of the skull would yield some errors in measurements. However, it has been reported that the errors resulting from reconstruction of separated crania is within the limit of instrumental error (Todd, 1923), thus, does not significantly affect the results (Ricklan & Tobias, 1986). Therefore, we did not try to correct the values in any way.

For direct measurement of the cranial capacity, we poured rice seeds into the cavity. There are two ways to fill up the cavity with granules, i.e., minimal and maximal packing methods. In general, minimal packing is known to result in less errors than maximal packing (Stewart, 1934 ; Ricklan & Tobias, 1986), and we adopted the former. Although the data are not presented, we confirmed the more excellent reproducibility of the minimal packing method. Even though this method is superior to the maximal packing method, it still has a risk of errors. To minimize such errors, the same observer measured and read the values.

The measured cranial capacity of the Korean adult skull was 1470 ± 107 cc in males and 1317 ± 117 cc in females. These are very similar to the previously reported results in Koreans, 1490 cc by Morant (Ra 1968) (the sex was not defined in this article), and 1475.5 ± 8.7 cc in males and 1330.5 ± 15.8 cc in females by Shima (1934). In the classification of Broca (Olivier, 1969), these mean values belong to medium capacity in the case of males and small capacity in the case of females. The male and female capacities statistically differed from each other and were defined to be different groups. The index of sexual dimorphism of the cranial capacity , given by the formula ((male mean-female mean)/male mean)×100%, was 10.3%, which is in the middle range among several races (Ricklan & Tobias, 1986). In a homogenous race, the individual variability in cranial capacity would be lower than that in heterogenous groups. The Eskimo could be an example. The standard deviations of cranial capacity were only 87.65 and 91.30 in males and females of the Greenland Eskimo and 61.78 and 85.35 in males and females of the Canadian Arctic expedition Eskimo, respectively (Cameron, 1928). In contrast, the values were 117.58 and 126.32

in white males and females. If these were true, the values of SD in this study could suggest the heterogeneity of Korean.

Ricklan and Tobias(1986) mentioned that neither correlation existed between the date of death and the cranial cavity, nor between the age of death and the cranial capacity in their study with Zulu crania. In contrast, another report claimed that the human crania thickened and enlarged as the age increased, thus the cranial cavity increased 3~5% from the 30s to 50s (Israel, 1973). This controversy evokes the question as to whether it is reasonable to include skulls over the 60s in extracting a cranial capacity formula , as in this study. It would be a prerequisite to compare the skulls of the 30s with those of the 50s. However, this could not be done because we did not have a sufficient number of skulls. If it is true that the cranial capacity increases with age, the formula should be developed in separate age groups even in the same sex. Such a possibility could not be excluded in this study, and must be further investigated and clarified.

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