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# The Study of Cranial Capacity and Body Mass Index in Relation to Academic Performance of Undergraduate Students

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## ABSTRACT

Cranial capacity, body mass index, age of various population groups have always been estimated in numerous reports but are hardly pull together to study their relationship with academic performance of students. The study was aimed at identifying the relationship between cranial capacity, body mass index and academic performance among Nigerian undergraduate students attending Bayero University, Kano in the northern part of Nigeria. A total of 408 participants (male: 250 and female: 158) comprising of about 50 students each from eight (8) faculties that satisfied the selection criteria were randomly selected at 5 sampling interval. Pearson's correlation was employed to test for the relationship between cranial capacity with body mass index and academic performance using SPSS version 23. The result shows a non-significant relationship ($p<0.01$) between academic performance and body mass index; academic performance and cranial capacity in the male group while a statistically non-significant relationship ($p<0.01$) between academic performance and body mass index; academic performance and cranial capacity was equally observed in the females. Also, in the combined analysis of both male and female groups, it was found that academic performance has a non-significant relationship ($p<0.01$) with cranial capacity and body mass index. Based on the findings of this present study, we concluded that cranial capacity and body mass index has no significant influence on academic performance of undergraduate students in Bayero University, Kano.

**Key words:** Academic performance, Body mass index, Cranial capacity, Undergraduate, Kano.

## INTRODUCTION

Cranial capacity is a measure of the volume of the interior of the cranium (also called the braincase or brainpan or skull) of those vertebrates who have both a cranium and a brain and the most commonly used unit of measurement is the cubic centimetre or $cm^3$ [1]. The volume of the cranium is used as a rough indicator of the size of the brain, and this in turn is used as a rough indicator of the potential intelligence of the organism [2]. However, larger cranial capacity is not always indicative of a more intelligent organism, since larger capacities are required for controlling a larger body, or in many cases are adaptive features for life in a colder environment [2].Brain volume has a close relation with skull volume and is related to racial characteristics[3]. Brain dimension can be measured by weight and sometimes by volume estimation(via MRI scans or by skull volume)and brain size is one aspect of animal anatomy and evolution [2].

Cranial capacity, which is in close correlation with brain volume, reflects racial characteristics and thus has been thought to be one of the commonest items in physical anthropological studies [4-6].

A growing body of research has demonstrated the deleterious health effects of obesity on childhood health status and across the life course. Moreover, obesity is likely to influence all aspects of children's development, including schooling [7]. There are several reasons to expect a negative relationship between body weight and academic performance [8]. First, it may be that poor academic performance causes higher body weight. This may be the case if, for example, adolescents choose to eat excessively to psychologically compensate for doing poorly in school. Second, obesity could cause a decline in academic performance [9]. This could occur if teachers discriminate against overweight students by giving them poorer grades or if obesity has adverse psychological and physiological effects that impede productive studying [9].

**Academic achievement** or **academic performance** is the outcome of education — the extent to which a student, teacher or institution has achieved their educational goals. Academic achievement is commonly measured by examinations or continuous assessment but there is no general agreement on how it is best tested or which aspects are most important — procedural knowledge such as skills or declarative knowledge such as facts [10]. Academic performance is usually measured by grading system known as the cumulative grade point average (CGPA) which is a calculation of the average of all of a student's grades for all of his or her educational career [10].

The relationships between head circumference, brain development and intelligence had been studied since the time of Broca and Galton, who concluded that variations in brain size (estimated indirectly by measuring head circumference) are related with intelligence [11].
Some authors have reported a non-signiflcant association between brain size and intelligence [12].

The work of Douglas and Shingairai [13] on Biochemistry students of University of Nebraska-Lincoln, USA shows that students in the normal BMI category ($\geq$ 18.5 kg/m$^2$ - <25 kg/m$^2$) had significantly better CGPA than students in the overweight category ($\geq$ 25 kg/m$^2$ - <30 kg/m$^2$), indicating better academic performance (mean differences for CGPA of 0.24 ($p < 0.01$).

Hoffman *et al.,* [14] found a negative significant correlation between body weight and academic performance indicating that obesity may have adverse effect on academic performance. Oketayo *et al.* [15] also reported that for overweight and obese subjects, a negative correlation was observed between academic performance and body weight respectively.

## MATERIALS AND METHODS

**Study Area and Population:** This research was conducted in the various faculties of Bayero University Kano, Nigeria.Bayero University is situated in North-Western part of Ngeria. It was established in 1977. It has three campuses and presently has 10 Faculties and runs 37 programs/courses with a population of about 37,747 undergraduate students [16]. The study was done on the students of the department of various faculties that will be selected for the research using random sampling technique.

**Study Design:** A total of 408 participants comprising of about 50 students who satisfy the selection criteria were to be selected from each of the eight (8) Faculties in Bayero University, Kano using random sampling at 5 sampling interval with the help of research assistants. 250 males and 158 female undergraduates participated in the research. Ethical permit was obtained from the ethical committee of Bayero University, Kano and approval from the various departments. Informed consent of the participants was sought before taking the data and the subject were registered students with at least two Cummulative Grade Point Average (CGPA) and devoid of physical head injury. Pregnant students, female students with thick accessory hairs, non-faculty students and active athletic individuals were excluded from this study.

**Anthropometric Measurements: Head Length (HL):** Head Length was taken as the maximum anterio-posterior length between glabella and the inion using the spreading caliper with the participants sitting upright and the head in Frankfort plane

**Head Width (HW):** Head Width was taken as the maximum biparietal diameter between two parietal eminences using the spreading caliper with the participants sitting upright and the head in Frankfort plane

**Head Height (HH):** Head Height was taken as the height measured between the external acoustic meatus to the highest point of the vertex, i.e. the bregma using the auricular head spanner with the participants sitting upright and the head in Frankfort plane

**Cranial Capacity (CC):** Measure of the volume of the interior of the cranium ($cm^3$) The value for the respective head height (HH), head length (HL) and head width (HW) were imputed in the following formula [17]:

Males: 0.000337(HL - 11) (HW - 11) (HH - 11) + 406.01 cm$^3$.

Females: 0.000400 (HL - 11) (HW - 11) (HH - 11) + 206.60 cm$^3$.

**Body Height:** The participants' height was obtained with the individual standing in anatomical position (Frankfort plane) facing the researcher with the back and buttocks touching the vertical plank of the instrument.

**Body Weight:** The weight of the participants was taking without shoes, bags, excess clothing and any external materials that may increase the weight.

**Body Mass Index (BMI):** Individual body mass divided by the square of their height ($kg/m^2$).

**Statistical Analysis:** The data were expressed as mean ± standard deviation. SPSS Version 22 Software was used for analysis. Descriptive statistics was used to describe the variables. Pearson's correlation was employed to test for the relationship between cranial capacity with body mass index and academic performance. Independent sample t-test analysis was used to compare the means of variables.

## RESULTS

Table 1 shows the descriptive characteristics of the measured variables among the male and female subjects. Male participants has higher value for cranial capacity and CGPA than the female but the BMI of the female participants is higher than males.

**Table 1:** Descriptive statistics of the assessed variables

| | All Subjects (n=408) | | Male (n=250) | | Female (n=158) | |
|---|---|---|---|---|---|---|
| Variables | Max-Min | Mean ± SD | Max-Min | Mean ± SD | Max-Min | Mean ± SD |
| HL | 160.00 – 200.00 | 184.07±8.54 | 160.00 – 200.00 | 189.02±5.81 | 160.00–193.00 | 176.22±5.90 |
| Age | 18.00 – 39.00 | 23.99±4.28 | 19.00–39.00 | 24.68±4.28 | 18.00–39.00 | 22.8924±4.06 |
| HW | 121.00 – 156.50 | 143.85±7.30 | 133.00–156.50 | 146.39±5.87 | 121.00–156.00 | 139.82±7.53 |
| HH | 103.00 – 138.50 | 121.61±7.38 | 108.00–136.50 | 125.12±5.58 | 103.00–138.50 | 116.04±6.40 |
| CC | 910.49 – 1507.52 | 1243.47±137.24 | 1088.88–1507.52 | 1333.38±72.3 | 910.49–1383.24 | 1101.20±85.35 |
| Height | 1.45 – 1.89 | 1.66±0.08 | 1.51–1.89 | 1.70±0.07 | 1.45–1.89 | 1.60±0.07 |
| Weight | 40.00 – 81.10 | 57.93±8.75 | 40.00–81.10 | 58.82±8.75 | 40.00–75.00 | 56.51±8.59 |
| BMI | 15.42 – 30.43 | 21.05±3.07 | 15.42–29.08 | 20.47±2.91 | 15.43–30.43 | 21.97±3.10 |
| CGPA | 1.65 – 5.00 | 3.04±0.78 | 1.65–4.74 | 3.07±0.74 | 1.65–5.00 | 2.99±0.85 |

**Table 2:** Comparison of male and female variables

| | Male (n=250) | | Female (n=158) | | | |
|---|---|---|---|---|---|---|
| Variables | Max-Min | Mean ± SD | Max-Min | Mean ± SD | t-value | p-value |
| HL | 160.00 – 200.00 | 189.02±5.81 | 160.00–193.00 | 176.22±5.90 | 21.553 | 0.000 |
| Age | 19.00–39.00 | 24.68±4.28 | 18.00–39.00 | 22.8924±4.06 | 4.201 | 0.000 |
| HW | 133.00–156.50 | 146.39±5.87 | 121.00–156.00 | 139.82±7.53 | 9.850 | 0.000 |
| HH | 108.00–136.50 | 125.12±5.58 | 103.00–138.50 | 116.04±6.40 | 15.122 | 0.000 |
| CC | 1088.88–1507.52 | 1333.38±72.32 | 910.49–1383.24 | 1101.20±85.35 | 29.432 | 0.000 |
| Height | 1.51–1.89 | 1.70±0.07 | 1.45–1.89 | 1.60±0.07 | 13.390 | 0.000 |
| Weight | 40.00–81.10 | 58.82±8.75 | 40.00–75.00 | 56.51±8.59 | 2.623 | 0.009 |
| BMI | 15.42–29.08 | 20.47±2.91 | 15.43–30.43 | 21.97±3.10 | -4.938 | 0.000 |
| CGPA | 1.65–4.74 | 3.07±0.74 | 1.65–5.00 | 2.99±0.85 | 1.048 | 0.295 |

All the variables except CGPA measured in the male subjects are significantly ($p<0.05$) higher than female subjects as shown in Table 2.

**Table 3**: Frequency of the various types of BMI among subjects.

| **Classification of BMI** | **Frequency** | **Percentage** |
|---|---|---|
| Under weight (< 18.5) | 78 | 19.1 |
| Normal weight ( ≥ 18.5 <25) | 300 | 73.5 |
| Over weight (≥ - <30) | 24 | 5.9 |
| Obese (≥ | 6 | 1.5 |
| Total | 408 | 100 |

**Table 4:** Correlation between cranial capacity, body mass index and academic performance of the male participants.

| | HL | Age | HW | HH | CC | Height | Weight | BMI | CGPA |
|---|---|---|---|---|---|---|---|---|---|
| HL | 1 | | | | | | | | |
| Age | 0.005 | 1 | | | | | | | |
| HW | 0.182** | 0.021 | 1 | | | | | | |
| HH | 0.022 | -0.047 | 0.067 | 1 | | | | | |
| CC | 0.522** | -0.015 | 0.668** | 0.669** | 1 | | | | |
| Height | 0.252** | 0.196** | -0.036 | 0.082 | 0.135* | 1 | | | |
| Weight | 0.149* | 0.303** | 0.149* | 0.084 | 0.201** | 0.351** | 1 | | |
| BMI | 0.038 | 0.208** | 0.177** | 0.033 | 0.139* | -0.168** | 0.861** | 1 | |
| CGPA | -0.084 | 0.294** | -0.055 | 0.019 | -0.051 | -0.170** | -0.067 | 0.028 | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

**Table 5:** Correlation between cranial capacity, body mass index and academic performance of the female participants.

| | HL | Age | HW | HH | CC | Height | Weight | BMI | CGPA |
|---|---|---|---|---|---|---|---|---|---|
| HL | 1 | | | | | | | | |
| Age | 0.107 | 1 | | | | | | | |
| HW | 0.061 | 0.169* | 1 | | | | | | |
| HH | -0.010 | 0.051 | 0.031 | 1 | | | | | |
| CC | 0.417** | 0.178* | 0.641** | 0.681** | 1 | | | | |
| Height | -0.164* | 0.365** | 0.195* | -0.280** | -0.132 | 1 | | | |
| Weight | 0.022 | 0.293** | 0.477** | -0.203* | 0.158* | 0.437** | 1 | | |
| BMI | 0.120 | 0.120 | 0.397** | -0.036 | 0.259** | -0.114 | 0.842** | 1 | |
| CGPA | 0.469** | 0.262** | 0.116 | -0.253** | 0.075 | -0.067 | 0.005 | 0.038 | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

## DISCUSSIONS

The mean cranial capacity of male and female (1333.38±72.32 $cm^3$ and 1101.20±85.35 $cm^3$ respectively) as shown by Table 1 were lower than the result obtained by Maina *et al.,* [18] in North Eastern Nigeria where cranial capacities were 1424.4±1379$cm^3$ and 1331.3±201.8$cm^3$ in males and females respectively. This could be attributed to ethnic and geographical variation. The result of this study as shown in Table 2 revealed the cranial capacity of the males to be significantly higher than that of the females with a $p < 0.001$ confirming sexual dimorphism in craniometric indices. The results of Bayat et al., [3] reported a positive correlation between brain volume and anthropometric indices such as height, weight, age and BMI in both genders and also revealed that the mean skull volume was significantly higher in males (1393.31fl 111 $cm^3$) compared to females (1168.71fl 102 $cm^3$) which is in agreement with our findings on comparison between male and female. Manjunath [19] reported skull volume in males and female to be 1152.813fl 279.16 $cm^3$ and 1117.82fl 99.09 $cm^3$ respectively while Golalipoor *et al.* [20] have reported skull volume to be 1420.60fl 85 $cm^3$ in males and 1227.2fl 120 $cm^3$ in Turkmen race of Gorgan. Acer *et al.* [21], from his study also reported the cranial capacity to be 1375.67fl fl fffl and 1237.32fl 95.12 $cm^3$ in 17-26 years males and females in Mugla University students in Turkey. Just like our results from this study, all the reports from previous studies demonstrated sexual dimorphism when analyzing head size.

The higher mean cranial capacities of the males than the females observed in this study and in other similar works reported here could be explained by the generally bigger frame of the average male than the average female as a result of the genetic and hormonal differences in both sexes [18]. Moreover, it has been shown that gender differences in brain weight could be attributed to activities in which the specific sex excelled [22, 23]. However, the observed differences that exist between the mean cranial capacity in both males and

females in this study and other studies is probably due to ecological, biological, geographical, racial, gender and age factors which have been cited to influence several bodily dimensions [24-27].

From Table 2, the mean BMI of the male (20.47±2.91) is significantly lower than that of the female (21.97±3.1) in this study which contrast the findings of Bayat *et al.* [3] on students of Arak University of Medical Sciences, Iran where the mean BMI was 23.20fl 2.43 and 21.27fl 2.69 in males and females respectively and that could be attributed to racial and genetic variations of the two populations. Table 1. shows the mean cranial capacity of all the respondents in the research as 1243.47±137.24 $cm^3$which is closer to the value of cranial capacity (1276 $cm^3$) obtained for Africans from a large study by Rushton and Ankney [28] but at variance with the cranial capacity of Caucasoids (1347$cm^3$) and Mongoloids (1364$cm^3$). The differences in value account for the racial and geographical variations that exist among different population where some researchers attributed the smaller Negroids (Blacks) cranial capacity to the evolution of the thermoregulatory model of the brain such that hot climate like Africa favours smaller brain volume since it's easier to keep it cool [29].

The academic performance of males and females are approximately the same in this study despite the difference in cranial capacity and the observation is in agreement with that of Rushton and Ankney [28] that says women have proportionately smaller average brains than men but apparently have the same intelligence test scores. Ankney [30] hypothesized that the sex difference in brain size relates to those intellectual abilities at which men excel; that is, spatial and mathematical abilities require more "brain power." Analogously, whereas increasing word-processing power in a computer requires some extra capacity, increasing three-dimensional processing, as in graphics, requires a major increase in capacity.

The non-significant negative variance of BMI and academic performance among male and female (Table 4 and 5) negates the findings of Seyi [31] in his study that body mass index has a significant negative correlation with academic performance which is an indication that the lower the body mass index, the better the academic performance. The logical explanation to our findings concerning BMI and academic performance in this study is that there is a very low percentage of overweight (Table 3), hence it could not really reveal the effect of BMI on academic performance which some authors like Hoffman *et al.,* [14]; Taras and Potts [9]; Oketayo *et al.,* [5], have reported a negative significant correlation between body mass index and academic performance which indicate that overweight and obesity may have adverse effects on academic performance.

## CONCLUSION

Cranial capacity and body mass index exhibit sexual dimorphism and has no significant role on academic performance of male and female undergraduate students which may be influenced by inter-play of so many factors including socio-economic.

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