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Research Article

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Body Components as a Determinant of Students' Academic Achievement in Mathematics in South-West Nigeria

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Abstract The paper examines the body components as determinants of academic achievement of students in mathematics. Ex-post facto research design was adopted for the study; the population for the study comprises of all the Senior Secondary school (SSS3) students, while the sample for the study was made up of 1800 students randomly selected by using multi-stage technique across five states in the South-Western part of Nigeria. The instruments used for the study consisted (i) Achievement Test in Mathematics (ATM) (ii) Standardized Body Measuring devices (SBMD) (iii) Students Body Parameters and Bio-data Inventory (SBPBI). The face, content and construct validity of the instruments were ensured. The reliability of the instruments was estimated using the split half and Crombach Alpha formula and yielded 0.89 and 0.76 reliability coefficients respectively. The findings of the study revealed that there was a positive significant multiple relationships between performance in Mathematics and body components. Also the better the sizes of the head circumference, height, arm length, neck circumference, hip circumference and BAI the better the contribution to the performance of students in Mathematics. The study further revealed that the head circumference is the best determinant of academic achievement of students in Mathematics while the BMI is the worst determinant academic performance in Mathematics. Based on the findings, it was recommended that pregnant women should henceforth continually be placed on balance diet by the medical personnel in order to enhance proper development of all the organs and bodily parts of fetuses.

Keywords Body components; academic achievement; determinants; mathematics

Introduction

Mathematics has broken out into new researches and applications in social sciences, biology, medicine and management. It seems almost every field of human endeavour, providing qualitative and quantitative techniques for planning, managerial decision making and economic, using Mathematics to fix the right peg in the right hole. Mathematics is an important subject in the school curriculum throughout the world, because it helps the child to develop analytical, critical and evaluative thinking, as well as its importance in the study of other sciences and the development of the Nations [1].

Learning Mathematics early in life could enable more brain paths to open up for knowledge. This is why early child numeracy is important. As earlier, it was stated that the goals of teaching Mathematics in the primary and secondary school levels is to generate interest in Mathematics and to provide a solid foundation for everyday living [2]. Also, Mathematics develops computational skills by fostering the desire and ability to be accurate to a degree relevant in solving any problem at hand. Mathematics enables students to develop precise, logical and abstract thinking, and to develop ability to recognize problems and solve them with related Mathematics knowledge. It provides necessary Mathematical background for further education as well as to stimulate and encourage creativity.

Students' poor performances in Mathematics remain a serious enigma in Nigeria Secondary schools. Documentation of facts about reviewing Mathematics curricula, innovation, socioeconomic characteristics, problems solving, and improvement on schools facilities and capacity building has been improved upon to some extent. Yet, poor academic performance in mathematics remains on course. The associated problems that child's performance may have with the parents' biological history, which may also interfere with any of their body components as a result of the study of genetics and heredity cannot be easily eroded. These may be manifested in physical structure, health problems, environment, hormones, and lifestyle factors and many of these factors can vary widely from family to family, as a result of nature.

Documentations on body components in the teaching of sciences and Mathematics in schools were very low. Body system requires not only the knowledge of the Body Mass Index (BMI), Body Adiposity Index (BAI), height, weight, head circumference, leg length, finger length, waist circumference and hip circumference but also how it affects academic performance in Mathematics in schools. The Canadian Pediatric Society advocated the use of growth charts for the assessment and monitoring development of health and academic status in children [2]. It has been reported that humans are uniquely adept at utilizing body systems interrelated and interconnected with self-development [3].

In some research studies, there has been evidence among elderly people where larger head sizes function better on tests of cognitive function like Mathematics [4] As noted by psychologists, an adult head size or circumference is considered to give an appropriate estimate for maximal attained brain circumference [5] such findings have been inferred as a supporting evidence of the theory which optimal neurological development in early phases of life can provide a barrier against pathological activities that can influence Mathematics performance as they reached their old age [6]. However, as the size of the head is relevant to Mathematics test scores among young adults, Mathematics educators have noted some possible relations which have been found between head circumference and the cognitive function in students [7-8].

Sub-normal head circumference is associated with poor neurological and developmental outcomes. Body Mass Index (BMI) may indicate the socio-economic status, parent's education, maternal age, parity, height, rural/urban residence, (learning ability/long-term storage and retrieval) as factors affecting Mathematics learning generally [6]. Doctors use height and weight measurements to assess a child's physical growth in relation to other kids of the same age through mathematical description. BMI uses height and weight to estimate how much body fat someone has. The measurement at that level is an indicator of the child overall health, mental and psychological history that may influence learning later in life [9-10].

According to Oginni (2013), children learn arithmetic by using various strategies in "overlapping waves," such as finger counting, verbal counting in their head, the Min strategy (taking the larger of two numbers as a base and adding the smaller number to it) even shaking their heads and nodding their neck, which eventually speed up retrieval from memory and improves with age [8]. Children gradually move from using easier, less efficient strategies to more difficult but more efficient strategies by order of their body components. Although, It was testified to the official position of the American Anthropological Association that intelligence cannot be biologically determined by race [11].

It was emphasized that the child is a whole being and should be treated based on his body trajectory so as to develop and learn within a social context that befit the simplicity and complexity of his body anatomy [12]. It was tested the effect of physical factors and cognitive levels in the 3-minute step test in Mathematics (3MST) on his students and affirmed that physique and environment may determine success in Mathematics [13]. It was affirmed that human beings are complex, unpredictable and unequal. No two individuals are exactly alike in appearance, in ability, in personality and in Mathematical understanding [14].

Based on this controversial notion that anyone who has big heads wear coconut heads (Poorer intelligent quotient equivalent), speculating that empty head is a coconut head. Meanwhile, some people were claiming that small head cannot determine performance in Mathematics. Children that are overweight suffer incessant ill health and thereby perform poorly in Mathematics, even their height for age, weight for age, sex for age determines performance in Mathematics skills and spatial reasoning. There is a dichotomous notion that linked tallness in human with Mathematics performance, claiming that Mathematical knowledge is extremely higher among the taller individual than the shorter ones [8,15-16].

The researcher observed that there is a deficiency in research-based information regarding how body components determine academic achievement in Mathematics. These, in turn inferred a new generation of research in Mathematics to reduce the level of mediocrity by putting speculations behind us, and coming into the strong grips as to whether a body system is a function of academic performance in Mathematics or not. In view of these, a general question was raised; what are the measures of the selected body parameters of secondary school students?

Purpose of the Study

The study sought to determine the degree of variation in body components (such as body weight, height, head circumference) of high, medium and low intelligent students in relation to their performance in Mathematics. The study also investigated the interaction effect of body parameters and socio economic status and environment of students in Mathematics.

Research Hypotheses

Based on the research questions raised above, the following hypotheses were formulated and tested at 0.05 level of significance

HO_1: There is no significant relationship between body parameters of students and their academic performance in Mathematics

HO_2: There is no significant multiple relationship between body parameters of students and their academic performance in Mathematics

HO_3: The body parameters would not significantly determine academic performance in Mathematics

Methodology

The design of this study was an Expost-facto design The population took care of 62,250 SSS3 students across South-West Nigeria that registered for Mathematics in Senior Secondary School Certificate Examination 2012/2013 academic session A total sample of 1800 Senior Secondary School three (SSS3) students were randomly selected from the three states at the end of 2nd term 2012/2013 academic session using multistage sampling technique. The instruments used for the study consisted (i) Achievement Test in Mathematics (ATM) (ii) Standardized Body Measuring devices (SBMD) (iii) Students Body Parameters and Bio-data Inventory (SBPBI) ATM is made up of 50 multiple choice items drawn from West African Examination Council (WAEC) past questions while SBMD and SBPB are design for measuring and recording of the head circumference, neck circumference, hip circumference, arm length, finger length, leg length, body weight and body height using tape rule (nearest 0.1 cm), personal mechanical scales (nearest 0.1 kg) and stadiometer rule (nearest 0.1 cm). Experts in Tests and Measurement and Human Kinetics ensure face, content and construct validity of the instruments, the result of this ATM concurrent validity yielded an inter-rater coefficient of 0.76. The reliability of the instruments was estimated using the split half and Cronbach Alpha formula and yielded 0.89 and 0.76 reliability coefficients respectively.

Results and Discussion

Question 1 What are the measures of the selected body parameters of secondary school students?

Table 1: Frequency counts and percentages on body components and the measures

Measure of descriptive	Weight	Height	H C	Neck	Waist	Finger	BMI	BAI	Hip Cir	Leg	Arm
Mean	54.74	2.43	48.25	31.11	65.57	8.82	19.99	76.02	86.21	64.70	36.21
Median	54.36	1.66	51.50	30.06	67.47	8.52	20.25	79.61	91.14	67.86	38.30
Mode	54	2	54[a]	30[a]	74	11	7[a]	84	91	69[a]	17[a]
Std. Dev.	3.881	2.984	8.980	11.933	12.436	2.893	2.932	14.779	16.414	14.000	7.820
Variance	15.06	8.906	80.643	142.38	154.64	8.371	8.597	218.40	269.42	195.98	61.15
Range	16	17	37	72	53	15	17	64	67	63	34
Minimum	48	2	21	13	31	5	7	36	40	22	17
Maximum	64	18	58	84	83	19	25	100	107	84	51
Sum	1861	83	1640	1058	2229	300	680	2585	2931	2200	1231

Table 1 shows the Average Body Weight (ABW) to be 54.74kg, median 54.36kg; mode 54 kg; standard deviation 3.881 kg; variance 15.060 kg. The Average Body Height (ABH) was found to be 2.43m, median 1.66m, mode 2.0m; standard deviation 2.984m, variance 8.906m. The Average Head Circumference (AHC) was found to be 48.25cm, median 51.50cm; mode 54cm; standard deviation 8.98cm; variance 80.634cm.The Average Neck Circumference (ANC) was found to be 31.11cm, median 30.06cm; mode 30cm; standard deviation 11.933cm; variance 142.387cm.

The Average Waist Circumference (AWC) was found to be 65.53cm, median 67.47cm; mode 74cm; standard deviation 12.436cm; variance 154.649cm. The Mean Hip Circumference (MHC) was found to be 76.02cm, median 79.61cm; mode 84cm; standard deviation 14.779cm; variance 218.407cm. The Average Leg Length (ALL) was found to be 86.21cm, median 91.14cm, mode 91cm; standard deviation 16.414cm; variance 269.421cm. The Average Arms Length (AAL) was found to be 64.7cm, median 67.86cm; mode 69cm; standard deviation 14cm; variance 195.989cm. The Average Finger Length (AFL) was found to be 8.82cm, median 8.52cm; mode 11cm; standard deviation 2.893cm; variance 8.371cm. The Average Body Mass Index (ABMI) was found to be 19.99, median 20.25; mode 7; standard deviation 2.932; variance 8.597. The Average Body Adiposity Index (ABAI) was found to be 36.21, median 38.3; mode 17; standard deviation 7.82; variance 61.15.

Testing of the Hypotheses

HO_1 : There is no significant relationship between body parameters of students and the academic performance in Mathematics

Table 2: Summary of correlation between body parameters and academic performance in Mathematics

Source of variation	N	r_{cal}	r_{tab}	R_{square}	Result
Body Weight	1800	0.032	0.084	0.001	NS
Body Height	1800	0.280	0. 000**	0.078	S
Head circum.	1800	0.582	0.000**	0.339	S
Neck circ	1800	0.260	0.000**	0.068	S
Waist circ	1800	0.206	0.000**	0.042	S
Hip circum.	1800	0.283	0.000**	0.080	S
Leg length	1800	0.271	0.000**	0.073	S
Arm	1800	0.289	0.000**	0.084	S
Finger	1800	0.179	0. 002	0.032	S
BM1	1800	0.081	0.003**	0.007	NS
BA1	1800	0.199	0.000**	0.040	S

S=Significant, NS= Not Significant

Table 2 shows that the body weight and BMI with r_{cal} = 0.032 and 0.081 respectively are not significantly related to the academic performance of students in Mathematics. This is because $r_{cal} < r_{tab}$ (0.084) at 0.05 level of significance. Hence the null hypothesis is upheld, which implies that there is no significant relationship in body weight, BMI and academic performance in Mathematics. For head circumference r_{cal} (0.582) > r_{tab} (0.000) for neck circumference, r_{cal} (0.260) >r_{tab} (0.000) for waist circumference r_{cal} (0.206) >r_{tab} (0.000), for hip circumference, r_{cal} (0.283)> r_{tab} (0.000), for leg length, r_{cal} (0.271)> r_{tab} (0.000), for arm length r_{cal} (0.289)> r_{tab} (0.000), for Finger r_{cal} (0.179)> r_{tab} (0.002) and for BAI r_{cal} (0.199)> r_{tab} (0.000), which are significantly related to the academic performance of students in Mathematics at 0.05 level of significance. Hence the null hypothesis is rejected, which implies that there is significant relationship between head, neck, waist, hip circumference, leg, arm, BAI and academic performance in Mathematics in each of the parameters respectively.

HO_2: There is no significant multiple relationship between body parameters of students and the academic performance in Mathematics

Table 3: Summary of multiple regressions between body parameters and academic performance in Mathematics

R	R^2	Adjusted R^2	Standard Error
0.944	0.891	0.892	6.150

Table 4: Summary of ANOVA between body parameters and academic performance in Mathematics

Source of variation	Sum of squares	Df	Mean square	F	Sig
Regression	4084.468	11	371.315		.
Residual	66904.219	1769	37.820	9.813	.000*
Total	70988.686	1780			

Table 3 shows that R_{cal} =0.944 greater than R_{tab}= 0.195 at 0.05 level of significance. Hence the null hypothesis was rejected, which implies that there was a positive significant multiple relationships between performance in Mathematics and body parameters. Which implies that body parameters was positively related to the academic performance in Mathematics Table 4 further reveals that R^2 = 0.891, which means that body parameters could accounted for 89% of the variability in Mathematics. This means that body parameters could not account for 11% of the variability in the students' academic performance. Table 5 shows that F_{cal} (9.813)>F_{tab} at 0.05 level of significance, It implies that R^2 =0.944 is not by chance but rather a confirmation of multiple relationship between body parameters and academic performance in Mathematics.

HO_3: The body parameters would not significantly predict academic performance in Mathematics

Table 5: Summary on Model of Body parameters and academic performance

Mode on Body parameters	**Unstardardized coefficient**		**standardized coefficient**		
	B	**Std. Error**	**B**	**T**	**Sig**
Constant	14.900	1.114		13.372	0.000
Body weight (x_1)	-0.004	0.032	0.006	0.133	0.895
Body height (x_2)	0.046	0.012	-.051	-3.330	0.042
Head circum. (x_3)	0.248	0.014	0.154	5.276	0.016
Neck circ.(x_4)	0.083	0.045	0.131	1.850	0.064
Waist circ.(x_5)	-0.059	0.028	-0.206	-2.109	0.035
Hip circ.(x_6)	0.022	0.037	0.102	0.579	0.563
Leg length (x_7)	-0.007	0.019	-0.032	-0.362	0.717
Arm length (x_8)	0.010	0.021	0.038	.468	0.640
Finger length (x_9)	-0.042	0.022	-0.049	-1.943	0.048
BMI (x_{10})	-0.383	0.086	-0.095	-4.452	0.037
BAI (x_{11})	0.023	0.062	0.055	0.367	0.714

Table 5 establishes the empirical relationship between the students' academic performance in Mathematics and their body parameters; Score = 14.900-0.004weight+0.046body heightt+0.248head Circumference+0.083Neck Circumference- .059Waist Circumference+0.022Hip Circumference-0.007 Leg Length+0.10Arm Length-0.042Finger Length-0.383BMI+0.023BAI The model summary shown in table 5 reveals that the dependent variables y and the independent variables x_1-x_{11} have established multiple regression models in this study

$$.Y=14.900-0.004x_1+0.046x_2+0.248x_3+0.083x_4-0.059x_5+0.022x_6---0.007x_7+0.104x_8-0.042x_9-0.383x_{10+}0.023x_{11}$$

Table 5 shows that the body parameters of body height, head circumference, neck circumference, hip circumference, arm length and BAI indicated a positive effect on the academic performance of students in Mathematics with beta weight of 0.046, 0.248, 0.083, 0.022 and 0 .023 respectively. While the weight, waist circumference, leg length, finger length and BMI indicate a negative effect on the academic performance in Mathematics with beta weight -0.004,- 0.059, -0.007, -0.042, -0..383 respectively

For the regression equation above in table 5,, It implies that

(i) For every extra 1 mark increase in students' academic performance in Mathematics there exist a corresponding increase of; 0.046m, 0.248cm 0.083cm, 0.022cm, 0.10cm and 0.023 in body height, head circumference, neck circumference, hip circumference, arm length and BAI respectively.
(ii) For every extra 1 mark decrease in the academic performance in Mathematics, there exist a corresponding decrease of -0.004kg,-..059cm, -.007cm, -.042cm, and -.383cm in body weight, waist circumference, leg length, finger length and BMI, respectively
(iii) For every unit increase in the score of the students, there exist 14.09 points variables outside the body parameters that contributed to the academic performance of students in Mathematics.
(iv) Furthermore, the table also revealed that the head circumference is the best predictor of academic performance of students in Mathematics while the BMI is the worst predictor of academic performance in Mathematics.

The t_{cal} for head circumference is 5.296, for absolute value of BMI is 4.452, which are greater than t_{tab}= 1.960, which confirmed that the beta weight of the head circumference and BMI of .248 and .383 are not by chance.

Conclusion

The finding showed that the body height, neck circumference, arm length and BAL also correlated with the academic performance of students in Mathematics. The result is in line with who discovered that the height of children is positively correlated with their academic performance and intelligence [17]. The result also supported the findings of Chinirella who observed that primary school teachers give recommendation to taller pupils, based on their academic performance in Mathematics and German language [15]. The findings equally revealed a negative relationship between body weight and academic performance in Mathematics, which corroborated Li, who found that severely obese children had significantly lower IQ on Mathematics score than those that were not obese [6]. Coincidentally, the findings of this study is in agreement with the study of Ivanovic (2002), which remarked that age, sex and social economic status, brain parameters, parental HC are the most important independent variables that determine HC and microcephalic children present multiple disorders not only related to brain volume but also to IQ [19].

The findings of the study revealed that the bigger the head the better the academic performance of students in mathematics, which is similar to the reported for infants and children by earlier literature and confirms that HC is the anthropometric indicator for brain development [11, 20-21]. However, the regression model of this study is in line with Desch et al (2000) [7].

Based on the findings, the following recommendations were made

1. Pregnant women should henceforth continually be placed on balance diet by the medical personnel in order to enhance proper development of all the organs and bodily parts of fetuses inside the womb. Hence, medical practioners (and even parents) should desist from shaping or smoothing the heads of new born babies, since this could have serious implication on the proper cognitive development of such children later in life.
2. At birth also, the centile chart should be used to measure the height of each child and if there is any indication of malfunctioning or stuntedness in growth, properly formulated growth hormonal medication should be appropriately applied to checkmate such development.
3. Mathematics teachers need to promote classroom individualistic teaching, being a measure to address the problem of cognitive impairments that may arise via the use of body parametric model, which in turns could help the teacher in categorization of teaching and learning of students, thereby reduce the current trend of underperformance that ravaging in this part of the world.

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