Influence of Blood Pressure and some Physiological Parameters of Health Importance on Adolescents' Academic Performance

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Abstract-The relationship among Blood Pressure (BP), Body Temperature (T), Body Mass Index (BMI) and Academic Performance of part two Physics students (n = 120, aged between 17 – 33 years) before, during and after the modern physics examination has been studied with a view to determining the influence of these important physiological parameters on students' performance in the course. The subjects' weights were measured using a standard electronic weighing machine while the heights were taken having the subjects stand against a calibrated wall. The systolic/diastolic blood pressure (mmHg), pulse rate (per minute), body temperature (^{o}C) were also determined using KA 114 Aneroid Sphygmomanometer, Stethoscope and clinical thermometer respectively by a trained field assistant. Using SPSS software, correlations were sought among these parameters at 0.01 and 0.05 levels of significance. Significant correlations (at 0.05 level) were obtained between students' academic performance in the course and pulse rate (r = 0.235), height (r = -0.310), systolic blood pressure (r = -0.804) as well as diastolic blood pressure (r = -0.478). When the subjects were stratified on the basis of their BP during the examination (Hyper-, Normal and Hypo-), significant differences occurred at 0.05 level from ANOVA and post-hoc test (f =115.063, p<0.0001) conducted. The results also indicated that students with normal BP performed better than those who were hypotensive and hypertensive. This indicates that the level of an individual's academic performance could be influenced by their nutritional status and these physiological parameters.

Index Terms: Blood Pressure, Physiological parameters, Adolescent Academic performance

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1.0 INTRODUCTION

A potential relationship of an individual's health to cognitive functioning may simply be explained by both physiological and psychological mechanisms [1]. The nature and magnitude of relations of systolic and diastolic blood pressures (SBP and DBP) and vascular events, which is linear down to the high-normal range, and cognitive performance is yet less clear [2]. Blood pressure is simply a measurement of the force applied to the walls of the arteries as the heart pumps blood through the body. The force and amount of blood pumped, and the size and flexibility of the arteries determine the pressure. According to [3], blood pressure refers to the force exerted by circulating blood on the walls of blood vessels, and constitutes one of the principal vital signs.With a fluid we can replace the concept of a particle with a small region of the fluid called a fluid element of density ρ moving at speed V while sweeping out a volume ΔV under the action of a differential fluid pressure ΔP. Bernoulli's equation can then be obtained by applying the work-energy theorem ($W_{net} = \Delta K$) to this fluid element. [4].

Hence the work done on a fluid element due to a change in the fluid pressure is given as

$$\Delta W_{pressure} = (P_1 - P_2)(\Delta V) \quad (1)$$

Where ΔV = change in fluid velocity

and the work done by gravity as the fluid element changes vertical level from a height y_1 to y_2 is

$$\Delta W_{gravity} = -\rho \Delta V (y_2 - y_1) \quad (2)$$

The change in the kinetic energy of the fluid element can be written as

$$P + \rho gh + \tfrac{1}{2}\rho v^2 = \text{constant}, \quad (3)$$

in this case the height, h will be almost the same while velocity will be different. Hence,

$$P_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \tfrac{1}{2}\rho v_2^2 \quad (4)$$

which we can rearrange to get

$$P_1 - P_2 = \tfrac{1}{2}\rho.(v_{12} - v_{22}) \quad (5)$$

$$\Delta k = (\tfrac{1}{2}\rho v_2^2 - \tfrac{1}{2}\rho v_1^2)\,\Delta V \quad (6)$$

Therefore, these three quantities combine to give Bernoulli's equation

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g y_2 \quad (7)$$

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Bernoulli's equations however showed that as the velocity of fluid flow increases, its pressure decreases. Bernoulli's equation says that the sum of the pressure, P, the kinetic energy per unit volume ((½) pv^2), and the gravitational potential energy per unit volume (pgy) has the same value at all points along a streamline (Raymond, 1996).Because flowing blood has mass and velocity it has kinetic energy (KE). This KE is proportionate to the mean velocity squared (V^2; from KE = ½ mV^2). Furthermore, as the blood flows inside a vessel, pressure is exerted laterally against the walls of the vessel; this pressure represents the potential or pressure energy (PE). The total energy (E) of the blood flowing within the vessel, therefore, is the sum of the kinetic and potential energies (assuming no gravitational effects) as shown below.

$$E = KE + PE \quad (\text{where } KE \propto V^2) \tag{8}$$

$$\text{Therefore,} \quad E \propto V^2 + PE \tag{9}$$

Blood flow is driven by the difference in total energy between two points. Although pressure is normally considered as the driving force for blood flow, in reality it is the total energy that drives flow between two points (e.g., longitudinally along a blood vessel or across a heart valve). Throughout most of the cardiovascular systems, KE is relatively low, so for practical purposes, it is stated that the pressure energy (PE) difference drives flow. When KE is high, however, adding KE to the PE significantly increases the total energy, E [5]. To illustrate this, consider the flow across the aortic valve during cardiac ejection. During ejection, the intraventricular pressure (PE) falls slightly below the aortic pressure (PE), nevertheless, flow continues to be ejected into the aorta. The reason for this is that the KE of the blood as it moves across the valve at a very high velocity ensures that the total energy (E) in the blood crossing the valve is higher than the total energy of the blood more distal in the aorta. In addition, blood flowing at higher velocities has a higher ratio of kinetic energy to potential (pressure) energy [5].Chronically low blood pressure is accompanied by a variety of complaints including brain fatigue, reduced drive, faintness, dizziness, headaches, palpitations, and increased pain sensitivity [6].

Normal Pulse Rate For Humans is the rate at which the heart beats when we are at rest (for 10 minutes).The pulse rate of a person is influenced by several underlying factors, with age, weight and activities that the person indulges in being the most prominent of them all. Immense variations are observed in the heart rate when the person indulges in different physical activities. In adults, the normal pulse rate ranges somewhere between 60-90 bpm - though its average tends to differ in accordance with gender. While the normal pulse rate for men is approximately 68-75 bpm, the normal pulse rate for women is approximately 72-80 bpm. As the normal pulse rate for adults, at rest or during some physical activity, depends on their age and weight, a younger woman is more likely to have a higher heart rate as compared to an older woman. Similarly, a woman with more weight is more likely to have a higher pulse rate compared to her counterpart with considerably less weight [7]. The question is whether or not the quality of an individual's academic performance could be determined by nutritional status and other physiological parameters such as stress, pulse rate and body temperature.

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The study was to examine the relationship between blood pressure, body mass index (BMI) and academic performance in undergraduate adolescents. Specifically, the research sought to identify the relative contributions of high or low blood pressure, BMI, pulse rate to academic performance in modern physics, an undergraduate course for part II students.

2.0 MATERIALS AND METHODS

Ethical approval was obtained from the college health centre and verbal consent were obtained from 90 subjects concerned (male = 59, female = 31) aged 17 to 33 years, before commencing the research. The subjects were from physics department, Part 2 in Adeyemi College of Education, Ondo. The teachers and students as well as staff involved, were well informed of the scope and extent of the research. Subjects who met the criteria were eventually recruited into the study. Those who had no history of any neurological disease/axis psychiatric diagnosis/drug abuse and not on medications or drugs such as antihypertensive medication. Subjects who have eaten, emotionally stable and not under the influence of any physical activity that would increase their blood pressure.

2.1 Data Collection

After collecting data on the subjects' age and sex by the researcher, the subjects' blood pressures were measured according to a written protocol (BP, using a mercury sphygmomanometer and listening through a stethoscope). In measuring BP, each student was made to relax in a sitting position with uncrossed legs. Systolic and diastolic blood pressures were measured twice after 5 to 10 minutes of rest in the supine position, with an appropriately sized cuff at heart level. In Nigeria and elsewhere, this procedure has been viewed as the gold standard in clinical settings for many decades and is still the most prevalent.

For each subject, the height was measured to the nearest 0.1 cm by having the subject stand erect, looking straight ahead, against a calibrated wall. Their body weight (using a beam balance scale), and with minimal clothing and without foot wears was obtained to the nearest 0.1 kg. The body temperature of the students was taken twice using well-calibrated clinical thermometers. All readings were taken by trained field assistants, and the BMI was determined from the weight (kg) and height (metres) of the subjects. The student's performance was determined by finding the percentage score for each student in the modern physics course. Adolescents were asked questions on their education, health, family, romantic relationships, pear group, dietary pattern, neighborhoods and sexual relationship to cater for potential biases caused by unmeasured heterogeneity.

3.0 RESULTS AND DISCUSSION

The descriptive statistics of students' age, BMI and the physiological parameters of health importance determined in this study is shown in Table 1, while Tables 2 and 3 show Blood Pressure (before, during and after the examination) and BMI Analysis respectively. Table 4 shows the correlation coefficient between the subjects' academic performance and the variables determined.

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Table:1 The descriptive statistics of students' age, BMI and the physiological parameters determined

Physiological Parameters	All subjects (n=90)		Hypotensive (n=2)		Normal (n=57)		Hypertensive (n=37)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Age (yrs)	17-33	28.84 ± 3.05	23-24	23.5 ± 0.70	17-29	22.53 ± 2.87	18-33	23.24 ± 3.36
Weight (kg)	37-89	57.83 ± 8.79	55-58	56.5 ± 2.12	37-89	57.29 ± 9.43	43-81	58.64 ± 8.62
Height (m)	1.49-1.92	1.69 ± 0.77	1.71-1.72	1.71 ± 1.41	1.49-1.92	168.04 ± 7.21	1.58-1.89	1.72 ± 0.07
BMI (kg/m^2)	13.03-29.39	20.02 ± 2.87	18.48-19.95	19.21 ± 1.03	13.03-29.39	20.28 ± 3.03	13.36-29.12	19.72 ± 2.70
Body Temp. (^{o}C)	35.0-37.7	36.16 ± 0.13	36.2 – 36.5	36.35 ± 0.21	35.1-33.7	36.15 ± 0.54	35.0-37.7	36.15 ± 0.53
Systolic BP (mmHg)	140-145	121.92 ± 11.54	110-115	112.5 ± 3.53	100-120	113.43 ± 6.81	125-145	128.00 ± 9.52
Diastolic BP (mmHg)	60-100	82.17 ± 9.39	55-60	57.1 ± 3.5	60-90	76.76 ± 7.73	80-100	86.74 ± 5.56
Pulse rate (per min.)	44-120	81.82 ± 20.19	44-54	49.00 ± 7.07	44-114	80.98 ± 19.36	44-120	84.27 ± 2.06
Academic Performance (%)	12-71	48.02 ± 12.5	33-34	33.66 ± 0.47	15-72	50.23 ± 2.59	12-69	45.27 ± 11.60

Table:2 Blood pressure analysis

BP Group	Before the Examination (No of Students & %)	During the Examination (No of Students & %)	After the Examination (No of Students & %)
Hypotensive	0 (0 %)	2 (2.2 %)	0 (0 %)
Normal	78 (86.6 %)	51 (56.7 %)	88 (97.8 %)
Hypertensive	12 (13.3 %)	37 (41.1 %)	2 (2.2 %)

Table:3 BMI analysis based on WHO classification (2009)

BMI Range	(No of Students and the %)	Comment
< 18.5	28 (31.1 %)	Underweight
> 18.5 and < 25.0	58 (64.4 %)	Normal
> 25.0 and < 29.9	4 (4.4 %)	Overweight
> 30	0 (0 %)	Obese

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The mean adolescents' pulse rate increased from 81.62 to 84.27 while the mean body temperature decreased from 36.16 to 36.15 during the examination. At 0.05 level of significance, positive significant correlation was obtained between pulse rate before the examination and academic performance (r =

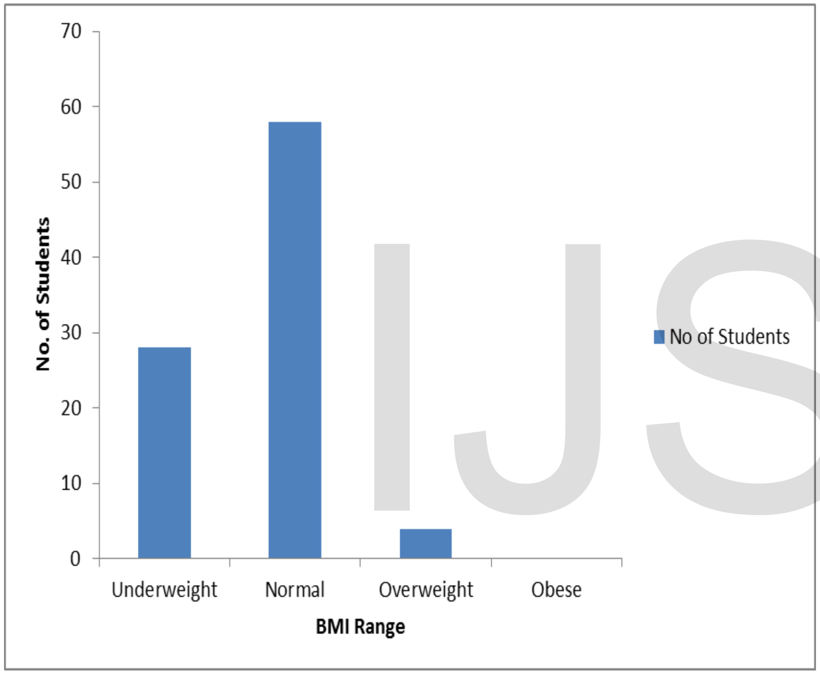

Figure 1 : Frequency distribution of Subjects' BMI

(0.235*). This was expected since the rise or fall of a person's pulse rate could depend on other health related factors. Although, no significant correlation was obtained between the two parameters during and after the examination. Body temperature also has no significant correlation with academic performance before, during and after the examination. The graphs below show the relationship with the students' pulse rate, body temperature and academic performance. This is in agreement with the result observed by [8]. This is because the pulse rate of a person is influenced by several underlying factors, with age, weight and activities. An additional important finding is the blood pressure by age interaction. Although there is no significant correlation among the students' age and their performance in the examination, in line with previous studies [9], our analyses indicate that the most pronounced relationship between elevated blood pressure and diminished cognitive performance was observed among the younger individuals. One possibility is that this reflects increased severity of CNS autoregulatory responses to higher blood pressure in a subset of adults particularly vulnerable to development of hypertension and its future health consequences. Twenty-eight (31.1 %) of the students under this study were underweight, fifty-eight (64.4 %) of them has normal BMI, four (4.4 %) of them were overweight, while none of the students was obese, zero (0 %). Figure 1 represents the frequency distribution of the number of students based on their BMI while Figure 2 depicts the frequency distribution of the subjects' BP before, during and after the examination

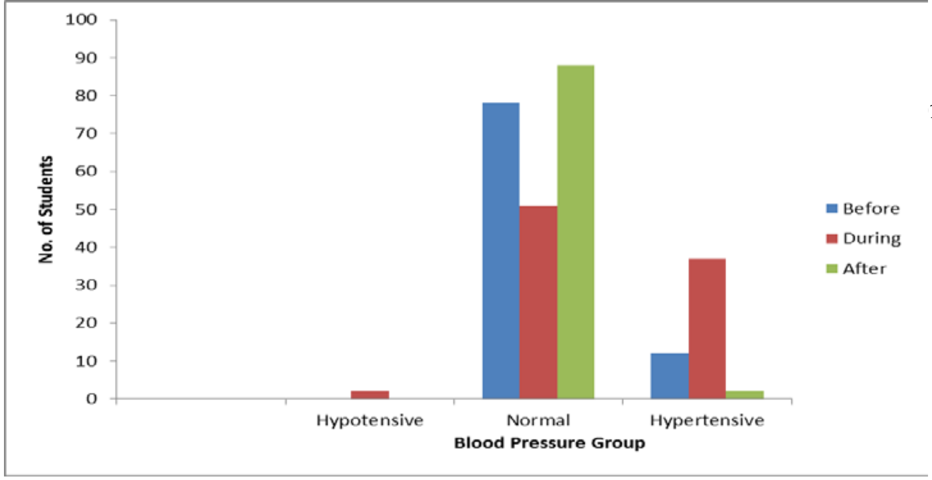

Figure 2: Frequency distribution of the subjects' BP before, during and after the examination

Figures 3 and 4 represent the graphs of the students' academic performance in the course against their pulse rate (i.e. before examination) and body temperature respectively.

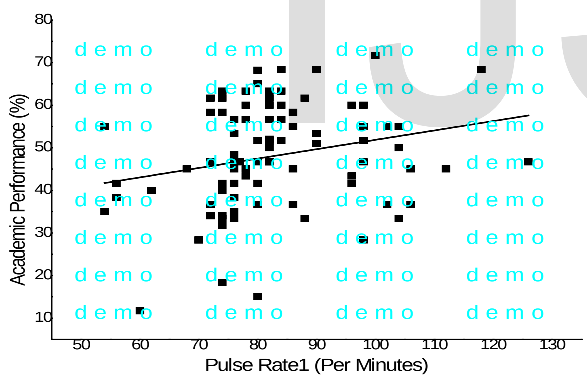

Figure:3 Adolescents' Pulse rate (before the exam.) and academic Performance

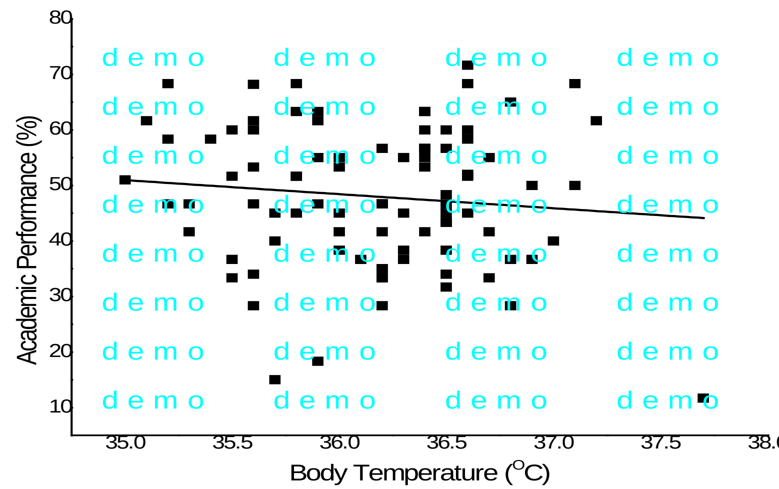

Figure:4 Aadolescents body temperature and their academic performance

4.0 CONCLUSION

In this study, the relationship between adolescents' academic performance and some physiological parameters has been studied. The data obtained before, during and after the examination were analysed using SPSS software. The results obtained showed that students' academic performance can be influenced by some of these parameters.

The strong correlation (negative) between blood pressure and cognitive performance observed in this study in magnitude may have some important implications. One significant implication of the current findings is that blood pressure-related cognitive deficits may be observable in a wide range of the population, including young, healthy adults.

The findings by [10], which was based largely on older populations (with multiple medical conditions) agrees with the current results that there is a relationship between elevated blood pressure and diminished cognitive performance. Thus even among young adults with little or no medications or on drugs, neurological impairment, psychiatric diagnosis, cardiovascular disease, diabetes, alcohol use, fatigue and effort during the examination the strong negative correlation between diastolic and systolic blood pressures may indicate a poor cognitive performance, which may result in a poor academic performance.

The longitudinal change that was observed during the examination in these young adults are consistent with a literature which indicates that the BP-related pathophysiological processes adversely affecting the brain may begin earlier in the adult lifespan than previously thought [11].

The adolescent BMI correlates positively with the weight (r = .813**). As expected, this shows that BMI is a function of weight. Moreover, the adolescent' academic performance was positively correlated (r = .235*) with pulse rate only before the examination. It was also observed that the students' performance correlates negatively with height (r = -.310**) at 0.05 level of significance. Systolic Blood Pressure before the examination (SBP1), (r = -.229*), Systolic Blood Pressure during the examination (SBP2) (r = -.804**) and Diastolic Blood Pressure during the examination (DBP2) (r = -.478**) had strong negative correlation with the adolescents' academic performance. No significant relationship was obtained between the adolescents' academic performance and any of these parameters after the examination.

The findings from the present study provide evidence that increased SBP or lowered DBP are related to poorer cognitive and academic performance as discovered by Williams [13]. These findings provide an important extension to the existing literature on older adults and suggest that comprehensive testing with younger populations may provide important insights into the range and severity of cognitive deficits that can predate the development of hypertension.

Results of this study also indicate that examination of effect modifiers is critical to understanding the relation of BP to cognitive function and highlights the need to further understand factors that increase individuals' vulnerability to the cognitive consequences of high or low BP. Furthermore, persons who display cognitive dysfunction or decline in association with hypertension or hypotension should be followed-up for future incidence of mild cognitive impairment and academic performance decline.

The present cross-sectional analysis revealed a linear negative correlation between systolic blood pressure and academic performance. Notably, this relation also held for diastolic blood pressure suggesting a continuum of brain damage beginning at per-hypertension levels. Because the relation was driven by results in young adolescents or midlife, these findings link tight control of medical parameters early in life to the growing epidemic of cognitive impairment and lower performance in academic works. The present findings raise the concern that increased awareness is needed that the brain is an early target organ of both high and low Blood Pressure.

The main importance of our findings lies at the adolescent university population level. Blood pressure lowered by just 20 mmHg SBP or 10 mmHg DBP, or from "Hypertensive" to "Normal" by WHO classification would have a considerable beneficial effect on the preservation of cognitive abilities in the population as a whole [13]. Given that younger adults appear at least as vulnerable to BP-related cognitive decline as are older adults, these benefits would be seen among young as well as middle-aged and older adults. It is important to continue and expand clinical trials relating the lowering of BP to cognitive performance. To the extent that BP effects on cognition are not reversible, it is therefore important to prevent an increase in BP levels as early as possible in the life cycle.

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