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Correlation between Body Mass Index and Hematological Indices in Young Adult Nigerians with Different Hemoglobin Genotypes

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Abstract

In view of the association of various haemoglobin electrophoretic patterns with different pathological conditions and obesity with its attendant risk factors for cardiac and pulmonary disorders, the present study evaluated the relationship between body mass index and haematological indices by randomly selecting young adult Nigerians with different haemoglobin electrophoretic patterns within the age group of 17-45 years and mean age of ±31 years old. 215 participants were enlisted for this study with their BMI and other anthropometric indices measured and grouped into different BMI categories as recommended by the World Health Organization. Haematological indices such as packed cell volume, total and differential white blood cell count, and platelets as well as haemoglobin (Hb) electrophoresis were assessed in relation to their anthropometric measurements using standard methods. We observed a significantly increased neutrophil and platelet counts in the subjects with BMI > 25 kg/m^2. BMI was also observed to be positively correlated with the neutrophil, monocyte counts and MCV of haemoglobin AS and SS genotype groups in this study. This study showed a higher percentage of overweight and obesity among females, and haematological dyscrasias in mostly the HbSS subjects. Knowledge of the relationship between BMI and hematological indices of apparently healthy individuals within any population is therefore essential in healthcare planning, as a justification for early prognosis and genetic counselling policy strategically reducing the incidence of obesity, its attendant conditions and haemoglobinopathies in Nigeria.

Keywords: Body Mass Index, Haematological indices, Haemoglobin Genotypes, Obesity, Leukocytosis

1. Introduction

Body Mass Index (BMI) is regarded as the most popular of many anthropometric indices. Indeed, it is accredited as an internationally accepted index for assessing obesity [1] and is a measure of weight adjusted for height, calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Overweight and obesity are defined as abnormal or excessive fat accumulation in the body that may impair health, so BMI of >25 kg/m^2 and ≥30 kg/m^2 are considered to be overweight and obese respectively in adults irrespective of gender and age [2]. BMI can be used to determine weight status and has been described as a simple, inexpensive, and non-invasive surrogate measure of the amount of body fat [3]. Studies have revealed that BMI levels correlate with body fat and with future health risks as a high BMI predicts future morbidity and death. BMI therefore can be regarded as an appropriate measure for screening for obesity and its numerous health risks [4]. The relationship between BMI and some haematological indices in young adult Nigerians of differing haemoglobin electrophoretic pattern is a topic of much discussion, which dwells on the relevance of BMI.

Reports from previous studies have revealed that a low BMI is associated with iron deficiency anemia [5,6]. Iron deficiency anemia is characterized by a wide range of hematological and non-hematological symptoms and regarded as one of the most common nutrition-related problems in Nigeria and many other underdeveloped/developing countries of the world [5]. Red blood cell (RBC) indices are part of the complete blood count (CBC) used to diagnose the cause of anemia, a condition in which there are too few red blood cells. Haematological parameters are good indicators of the physiological status of humans and animals generally [7] and these parameters are related to the blood and blood forming organs [8, 9]. BMI and haemoglobin genotypes having been reported by a number of researchers in different parts of the world as factors predisposing to some pathological conditions, therefore justifies the need to establish possible correlation between these two and the haematological parameters of young adults in Nigeria.

Haemoglobin genotype is an important blood component that determines haemoglobinopathies [10]. Various studies have associated abnormal haemoglobin and blood group systems with different disease condition in different parts of the world [11]. Some of these studies revealed that dominant homozygotes (HbAA) are more susceptible to plasmodial parasite infection than sickle heterozygotes (HbAS), while recessive homozygotes (HbSS) are most vulnerable to malaria than the other two members of genotypic groups [12]. Albeit, some level of association of BMI and haematological parameters in young adults have been established in some African populations including Nigeria [13], there is yet a dearth of information regarding correlation between BMI and haematological indices in young adult Nigerians with varying haemoglobin genotypes.

Haematological investigations are essential tests for diagnosing health disorders, disease staging and monitoring of response to treatments [14]. This present study was therefore aimed at investigating the importance of BMI and hematological indices among young adults, in order to establish possible relationship between these parameters in various haemoglobin genotypes.

2. Material and Method

2.1 Study Design

Two hundred and fifteen (215) subjects were randomly selected among students and staff of Achievers University, Owo. Study was approved by the Federal Medical Centre (FMC) Joint Ethics Review Committee (FMC/EC/380/XXXI/71) and written informed consent (approved by the FMC Ethics committee) was obtained from each subject.

2.2 Study Subjects

From February 2015 to May, 2015, we conducted a community-based study focused on

215 apparently healthy young adult students and staffs within the age range of 18 and 45 years old comprising of males and females from the students and some of the staff of the University community. Subjects with BMI <18.5kg/m^2, 18.5-25kg/m^2, >25kg/m^2 and >30kg/m^2 were classed as underweight, normal weight, overweight and obese respectively according to the WHO guidelines [2]. In view of gender differences in autonomic regulation, data of male and female subjects were analyzed separately.

2.3 Physical examinations

Height (m) was measured using a Stadiometer while body weight (kg) was taken using a body weight weighing scale with the subject wearing light clothing and without shoes. Body mass Index (BMI) was calculated as the ratio of weight (kg) to the square of height (m^2).

2.4 Exclusion and Inclusion criteria

Subjects with conditions such as clinical evidence of haemorrhage, iron or folate or vitamin B12 deficiency, blood donation within the previous six months, concomitant infections, chronic diseases, and diabetes mellitus were excluded from the study. While apparently healthy individuals between ages 18-45 years were recruited for the study [13].

2.5 Sample Collection

Five (5) ml of venous blood was collected from all the subjects into EDTA anti-coagulated tubes between 9.00 am and 12.00 noon for analysis of the haematological parameters and haemoglobin electrophoresis assay. All blood specimens were analyzed within six hours of sample collection.

2.6 Hematological Investigations

The haematological parameters comprising of packed cell volume (PCV), white blood cell (WBC), MCV, MCH and MCHC counts were determined using the Automated Haematologic Analyzer, Sysmex, KX-21N (Japan); a method described by Akinbo *et al*.[14, 15]. Haemoglobin genotype pattern was carried out using the haemoglobin electrophoresis on cellulose acetate strips described by Okoroiwu *et al*. [16].

2.7 Statistical Analysis

Data in the text and tables were expressed as mean ± standard deviation. Results compared between various groups were evaluated by Student t-test, one-way ANOVA analysis and Mann–Whitney U test. The level of significance was taken at 95% confidence interval and P-value less than 0.05 was considered significant. All statistical analyses were performed using SPSS software (SPSS version 19.0; SPSS Inc, Chicago, IL, USA).

3. Results

A total of two hundred and fifteen (215) randomly selected students and staff of the Achievers University comprising of 93 males and 122 females were enlisted for this cross-sectional study form February 2015 to May, 2015. Set out in Table 1 are the descriptive statistics of the haematological indices, demographic characteristics and anthropometric measurements. In Table 1, the mean levels of neutrophils and platelets were significantly higher in the obese group compared to the other groups.

The subjects were classified into four different groups based on their BMI into Group A, Group B, Group C and Group D with BMI <18.4kg/m^2, BMI 18.5-24.9kg/m^2, 25.0-29.9kg/m^2 and >30kg/m^2 representing the underweight, normal weight, overweight and obese respectively. The body weight categories were defined using WHO cut-offs as follows: underweight= BMI <18.4kg/m^2; normal weight= BMI >18.5 < 24.9 kg/m^2; overweight= BMI>25.0 <29.9kg/m^2; obesity= BMI> 30.0 kg/m^2 [17]. The mean values of the haematological indices of different haemoglobin genotype categories are shown in Table 2. 5.6% of the total study population was underweight, 57.2% were normal weight, 26.5% were overweight and 10.7% were obese.

Table 1: The relation between mean values of haematological indices with different BMI in the young adults

Parameter	Group A (N= 12)	Group B (N= 123)	Group C (N= 57)	Group D (N= 23)
RBC ($x10^6$/µl)	5.13 ± 0.25	5.03 ± 0.06	5.17 ± 0.07	5.80 ± 1.77
PCV (%)	39.58 ± 1.69	39.15 ± 0.42	40.05 ± 0.60	39.22 ± 0.58
HAEMOGLOBIN (g/dl)	12.56 ± 0.73	12.87 ± 0.15	13.19 ± 0.22	12.94 ± 0.19
MCV (fl)	77.18 ± 2.46	77.48 ± 0.65	77.86 ± 0.70	77.95 ± 1.13
MCH (pg)	24.73 ± 0.65	25.50 ± 0.21	25.49 ± 0.25	25.60 ± 0.31
MCHC (g/dl)	32.22 ± 0.58	32.93 ± 0.19	32.68 ± 0.23	32.74 ± 0.22
WBC ($x10^3$/µl)	7.61 ± 0.46	6.35 ± 0.34	6.71 ± 0.34	6.40 ± 0.43
NEUTROPHIL (%)	48.42 ± 4.63	48.94 ± 1.21	53.09 ± 1.41ŋ	54.17 ± 1.71ŋᵇ
LYMPHOCYTE (%)	38.58 ±4.63	40.19 ± 1.08	37.91 ± 1.23	37.74 ± 1.61
MONOCYTE (%)	13.00 ± 2.27	10.85 ± 0.62	8.51 ± 0.89*ŋ	7.96 ± 1.15*ŋ
PLT ($x10^3$/µl)	232.50 ± 20.92	227.13 ± 6.25	240.42 ± 8.59	254.17 ± 11.33ŋ
WAIST CIRCUMFERENCE (cm)	65.5 ± 1.83	79.60 ± 0.62*	88.42 ± 0.92*ŋ	103.09 ± 3.45*ŋᵇ
BMI	16.98 ± 0.35	21.85 ± 0.16*	26.80 ± 0.17*ŋ	36.80 ± 1.15*ŋᵇ
AGE (Year)	20.25 ± 0.72	22.21 ± 0.45*	24.98 ± 0.94*ŋ	31.52 ± 2.13*ŋᵇ

Abbreviation: RBC=Red Blood Cells, WBC=White Blood Cells, HB=Haemoglobin, PLT=Platelets, MCV=Mean Cell Volume, MCH=Mean Cell Haemoglobin, MCHC=Mean Cell Haemoglobin Concentration, BMI=Body Mass Index, N=Sample size

*p≤ 0.05 indicates significant different when group A is compared with the other groups.

ŋp≤ 0.05 indicates significant difference when group B is compared with the group C and group D.

ᵇp≤ 0.05 indicates significant difference when group C is compared with group D.

Table 2: Comparison of the mean values of haematological indices of different haemoglobin genotypes

Parameter	HBAA	HBAS	HBAC	HBSS
RBC ($x10^6$/µl)	5.08 ± 0.05	5.05 ± 0.11	4.95 ± 0.26	2.047 ±0.58ŋᵇ
PCV (%)	39.60 ± 0.36	39.17 ± 0.64	37.67 ± 1.56	19.17 ±1.79ᵇ
HAEMOGLOBIN (g/dl)	13.02 ± 0.13	12.67 ± 0.26	12.63 ± 0.45	6.82 ±0.63ᵇ
MCV (fl)	77.99 ± 0.51	76.52 ± 0.93	76.52 ± 2.65	92.78 ±3.12ᵇ
MCH (pg)	25.57 ± 0.16	25.13 ± 0.37	24.83 ± 0.58	33.66 ±1.44ᵇ
MCHC (g/dl)	32.81 ± 0.14	32.56 ± 0.33	33.20 ± 0.21	36.62 ±0.47
WBC ($x10^3$/µl)	6.51 ± 0.26	6.37 ± 0.38	7.48 ± 0.64	13.57 ±0.98ᵇ
NEUTROPHIL (%)	50.91 ± 0.95	48.89 ± 2.23	56.17 ± 1.97	53.8 ±2.47
LYMPHOCYTE (%)	38.90 ± 0.83	40.60 ± 2.10	36.67 ± 2.45	45.9 ±4.1ᵇ
MONOCYTE (%)	10.03 ± 0.52	10.51 ± 1.18	6.83 ± 2.54	2.8 ±0.81*ᵇ
PLT ($x10^3$/µl)	230.21 ± 5.05	242.89 ± 11.67	283.33 ± 19.41*	421.3 ±34.7*ᵇ
WAIST CIRCUMFERENCE (cm)	85.80 ± 0.90	81.20 ± 1.25*	84.50 ± 3.23	65.5 ±3.81*ᵇ
BMI	24.85 ± 0.46	23.25 ± 0.68	26.40 ± 2.02	21.01 ±1.69ᵇ
AGE (Year)	24.35 ± 0.57	21.69 ± 0.71*	25.83 ± 1.47ŋ	29.7 1±2.32*ŋᵇ

*p≤ 0.05 indicates significant difference when HBAA is compared with HBAS and others.

ŋp≤ 0.05 indicates significant difference when HBAS is compared with HBAC.

ᵇp≤ 0.05 indicates significant difference when HBAC is compared with HbSS.

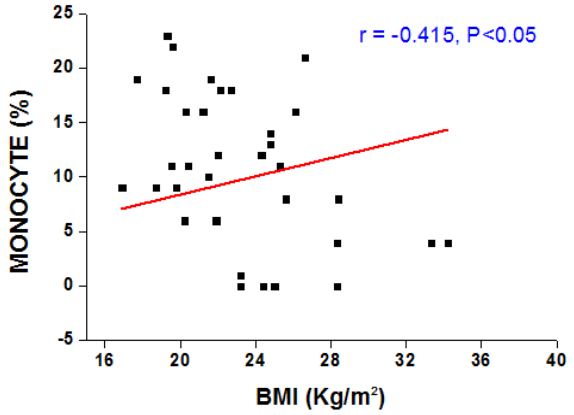

Figure 1: Correlation graph between BMI of Hb AS and Monocyte counts

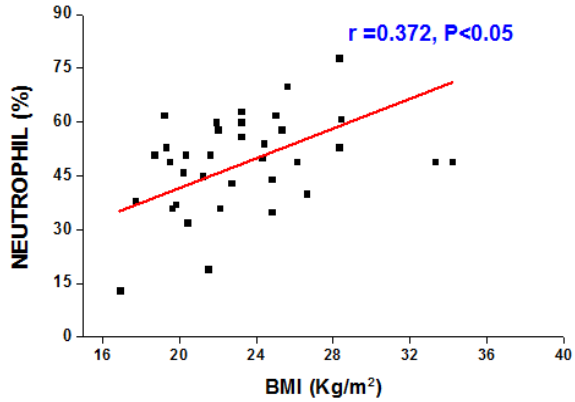

Figure 2: Correlation graph between the BMI of Hb AS and Neutrophil counts.

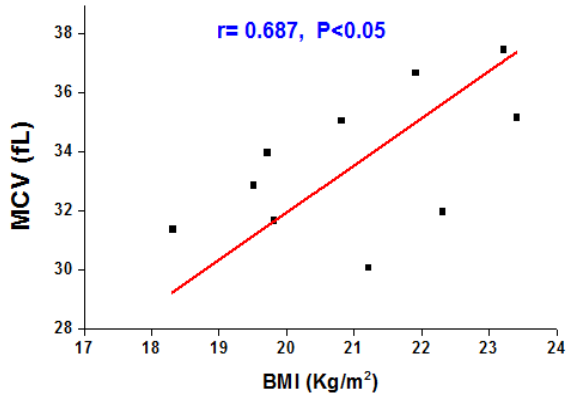

Figure 3: Correlation graph between the BMI of Hb SS and MCV

4. Discussion

Obesity is a global problem characterized by many pathological conditions such as hypertension, heart diseases, stroke, dyslipidemia, osteoarthritis, gynecological problems, sleep apnea, and respiratory problems [18]. Some studies have also shown that obesity presents an adverse effect on iron status with possible inflammatory state [19]. The assessment of height, weight and body mass index (BMI) proffers significant information on the nutritional and subsequently the level of social health care of any particular individual at a given time in a country [20]. Dietary patterns such as a high consumption of nutrient-dense foods such as cereals, fruits, vegetables and low-fat meat and dairy products have been related to a number of favorable health outcomes in adults including a decreased prevalence of obesity [21].

Differences in weight of the participants in this study were statistically significant using the WHO standard for weight classification [22]. From the study, more females had higher BMIs than the males which does not complement with the societal layout and differs from what is obtainable in other societies [23, 24]. There were more females with BMI above 25.0 and 30.0 when compared with their male counterparts even as BMI. This difference may have probably stemmed from the nutritional habits among females and possible sedentary lifestyle.

Previous studies revealed that obesity has an adverse effect on the iron status of individuals [25, 19]. The results of our study however showed that BMI had no association with haemoglobin, MCV, and other red cell indices. This result contradicts other previous studies [26, 27] but is in correlation with other recent works by Akram et al. [28] and the work of Manal et al. [29]. Our observation is directly backed by the apparent lack of increase in the red blood cells, haematocrit or haemoglobin in the BMI subgroup analyses. There was also no association between the red blood cell counts, haemoglobin concentration, haematocrit and BMI in our different BMI subgroups. Obesity has however been linked with a chronic low grade inflammation state by other previous studies [21] which was also

observed in this study by an attendant increase in the platelet counts.

There was a varying ratio between the different leukocyte types in our study, presented by the higher value in the percentage of neutrophils with the overweight and obese groups. A significant decrease in the percentage of monocytes was also observed in the overweight and obese groups when compared to the other BMI groups in the study which were similar to results recorded by other previous studies [30, 31]. Leukocytosis has often been linked with atherosclerotic disease and has also been accepted as a risk factor for cardiovascular disease (CVD) [32]. The association between leukocyte count and risk of atherosclerotic disease is plausible because leukocytes present a major contribution to the rheologic properties of blood. This is achieved by altering their own adhesive properties under stress and participating also in the case of endothelial injury [33]. More so, the recruitment of monocytes and lymphocytes to the artery wall is characteristic of atherosclerosis [34]. It is worthy of note for us to emphasize that in this study, the positive correlations found between monocyte, neutrophil counts and BMI in the sickle cell trait; Hb AS (Figure 1, 2) are in agreement with those obtained by Kim and Park [35] which they reported in female obese adolescents aged 10-19 years.

The use of Complete blood count alongside red cell indices is essential in the preliminary investigation of haemoglobinopathies [36]. In comparison with the other haemoglobin groups, mean haemoglobin concentration, red blood cell counts and packed cell volume in the group with Hb SS were lower than the others. This condition could be as a result of the inability of the bone marrow to compensate rapidly for the depleting erythrocytes attendant upon chronic haemolysis [37]. There was also a positive correlation among the MCV values and BMI of the Hb SS genotype as the MCV value increases with the increasing BMI (Figure 3). Over all, there was a change in cell volume represented by the production of reticulocytes to counter the ongoing hemolysis inherent in the Hb SS individuals. In this current study, a higher mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) in SS subjects was demonstrated respectively than the other Hb genotypes in line with previous reports [38, 39].

In our research also, it was observed that the Hb SS group possessed significantly higher platelet and total white blood cell counts when compared to the other Hb groups. This finding is consistent with other previous studies which linked white cell and platelet counts with disease severity in sickle cell disease [40, 41]. Current patho-physiologic mechanism of vaso-occlusion in sickle cell disease has been found to involve the white cells and platelets as well as the expression of their inter-cellular adhesion molecules [42, 43]. A high platelet count was observed to positively correlate with a tendency to develop avascular necrosis (AVN). Our study revealed a significant decrease in the BMI and waist circumference of the HbSS group when compared to the other Hb genotypes. Some of the reasons for this decreased growth and BMI are multifactorial with contributions from abnormal endocrine function [44], sub-optimal nutrition [45]; an increase in metabolism because of hyperactivity of the bone marrow and chronic inflammation [46] and hypogonadism [47]. Despite the limitations of our sample size, further research work using a community-based study with a larger sample size will make the study better.

5. Conclusion

The findings of this study established a higher percentage of overweight and obesity among females, and haematological dyscrasias in the Hb SS subjects. Knowledge of the relationship between BMI and hematological indices of apparently healthy individuals within any population is therefore essential in healthcare planning, as a justification for appropriate early prognosis and genetic counselling policy strategically reducing the incidence of obesity, its attendant conditions and haemoglobinopathies in Nigeria.

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