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Linking the Levels of Ferritin and Haematological Indices with Variations in Body Mass Index and Waist Circumference of Apparently Healthy Adults in Port Harcourt.

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Abstract

Background: The risk of some diseases associated with excessive adiposity and the impact it has on health care cost, makes it imperative for this study to aim at linking variations in body mass index and waist circumference to the levels of ferritin and some haematological indices in apparently healthy adult residents in Port Harcourt. We hypothesized therefore, that high body mass index and waist circumference might influence the amount of stored iron in the body.

Materials and Methods: Two hundred and fifty adults aged 18- 50 years who were resident in Port Harcourt, Nigeria were recruited which includes 67 (53.60%) female and 58 (46.40%) males for test and control. 125 subjects with normal weight according to world health organization standard were used as control group, 56 overweight subjects, and 69 obese subjects were the test groups. Five milliliter blood sample was collected by standard venipuncture from each subject, 3mls was dispensed into plain tubes and spun to obtain the serum meant for ferritin assay using STAT FAX-2100 by awareness technology, 2mls of the blood was used for the analysis of complete blood count using automated haematology analyzer. Body Mass index and Waist Circumference were taken using a stadiometer (for height), weighing scale (for weight) and a measuring tape. A well-structured questionnaire was also used in this study.

Results: There was no statistically significant difference in the mean levels of mean corpuscular haemoglobin ($p=0.3057$) and mean corpuscular volume($p=0.4860$) between the normal weight and overweight /obese subjects. Mean level of ferritin was higher in the overweight and obese subjects compared to normal weight but not statistically significant. However, the mean levels of haematocrit ($p=0.0002$), haemoglobin ($p=0.0001$) and red blood cell counts ($p<0.0001$) were significantly higher in the overweight and obese group compared to the normal weight subject. The mean of waist circumference was significantly higher in the overweight and obese subjects

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compared to control subjects p<0.0001. Additionally, it was observed in this study that body mass index and waist circumference is associated with age.

Conclusion: Based on this study, it may be stated that overweight, and obesity is increasing in Port Harcourt. Neither anaemia nor iron overload was observed in this study. Furthermore, normal ferritin level among overweight and obese people does not necessarily indicate normal iron storage, therefore, serum ferritin should be used in conjunction with haematological indices for the diagnosis and monitoring of iron deficiency anaemia or iron overload in obese people. Further research with larger sample size is recommended to study the correlation between serum ferritin, complete blood count, other Anthropometric indices, with body mass index in apparently healthy adults in Rivers State Nigeria.

Keywords: Body mass index, overweight, obesity, haematological indices, waist circumference**.**

1.0 Introduction

The prevalence of overweight and obesity has increased drastically worldwide [32]. According to world health organization [41], there are just under two (2) billion overweight adults in the world, more than 600 of them are considered obese. A survey data from world health organization 2010 shows that the prevalence of overweight and obesity increased at 20% between 2002 and 2010 in Nigeria. The data reported that the prevalence of overweight for men was 26% while that of women was 37% whereas obesity was 3% for men and 8.1% for women in Nigeria. In another study by [12] the prevalence of overweight ranged between 20.3 to 35.1% while obesity ranged between 8.1 to 22.2% showing that prevalence of obesity in Nigeria is of epidermic proportion.

Obesity is a medical condition defined as disproportionate fat storage in the body that might adversely affect health [32]. Report shows that overweight and obesity increase the risk for non-communicable diseases such as diabetes, cardiovascular diseases, cancers, hypertension and chronic respiratory diseases [40]. There are several classification and definitions of obesity, however, the one commonly adopted is the definition by the World Health Organization [40] which defines obesity as a body mass index (BMI) of 30kg/m^2 or more and overweight is body mass index of 25kg/m^2 or more [7].

Body Mass Index (BMI)is a screening tool approved internationally for assessing obesity in a population. Its calculated using weight in kilograms divided by the square of height in meters. Measuring Body Mass Index (BMI) can help determine whether a person has a normal weight, underweight, overweight or obese. Body mass index (BMI) has been shown to correlate with health risks as high BMI may predict future morbidity and death [13]. High body mass index can also increase the risk for non-communicable diseases. However, some studies have shown that when assessing disease risk, the distribution of fat on the body is more important than the amount, using body mass index alone is limiting, for this reason, the waist circumference is thought to be a better predictor of health risk than body mass index [11];[25]; [4]. The National Heart, Lung and Blood Institute (NHLBI) recommended that body mass index should be

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complemented with estimates of abdominal fat through measurement of waist circumference [20]. Waist circumference (WC) is an accurate and uncomplicated measure of abdominal obesity. It is a stronger predictor for global obesity particularly in females. It gives information on the general nutritional status of an individual. Table 1 below shows the Identification of disease risk associated to Body Mass Index and waist size.

Iron is an essential component of hemoglobin, an erythrocyte (red blood cell) protein that transfers oxygen from the lungs to the tissues [36] However, its ability to form highly insoluble oxides when it is in contact with oxygen reduces its bioavailability. The body needs iron for the synthesis of its oxygen transport proteins, in particular hemoglobin and myoglobin, and for the formation of heme enzymes and other iron-containing enzymes involved in electron transfer and oxidation-reductions [2]. Almost two-thirds of the body iron found in the hemoglobin is present in circulating erythrocytes, 25% is contained in a readily mobilizable iron store, and the remaining 15% is bound to myoglobin in muscle tissue and in a variety of enzymes involved in the oxidative metabolism and many other cell functions [2]. According to WHO, Iron deficiency is the most common nutritional disorder in the world [42].

Ferritin is a protein that stores iron. In the human body, small amounts of ferritin are secreted into the plasma. The concentration of this plasma ferritin corresponds with the size of the total body iron stores in the absence of inflammation. Ferritin store iron in an insoluble form and it is synthesized in the liver, spleen, and bone marrow [39]. Apoferritin (a protein, commonly found in the intestinal mucosa and liver that interacts with ferric hydroxide-ferric phosphate complex to form ferritin) is the storage form of iron in cells and is readily available for use when needed. Apoferritin binds to free ferrous iron and stores it in the ferric state [35] Serum ferritin concentrations are quite stable from day-to-day, in contrast to iron [21] Thus, measurement of ferritin can be used to confirm cases of iron deficiency or iron overload [32] Several studies, with contradictory findings have detected an association between ferritin and high body mass index with few reports concluding that high ferritin levels were associated with increased weight [5][17][19]. However, others reported either similar or even lower ferritin concentration in obese versus normal weight adults.

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Table 1: **Identifying disease risk associated to Body Mass Index and waist size. (National Institute of Health, 1994). Increased waist size can also be a marker for increased risk even in individuals of normal weight**.

Category	BMI (Kg/m^2)	obesity class	men 102cm (40 in) or less women 88cm (35in) or less	Men >102cm(40in) women >88cm (35 in)
Underweight	<18.5			
Normal weight	18.5-24.9			
Overweight	25.0-29.9		increased	high
Obesity	30.0-34.9	I	high	very high
Obesity	35.0-39.9	ii	very high	very high
Extreme obesity	40.0+	iii	extremely high	extremely high

Haematological indices can be used to evaluate iron concentration and give useful information about the state of an individual. Report from previous studies across the globe have showed that there are changes in hematological profile of overweight and obese individuals [13]. In that respect, haematological parameters have been proposed to be good indicators of physiological states of humans [28]. Obesity has also been associated with anaemia of chronic diseases especially systemic iron deficiency and hypoferremia [16].

Nigeria just like some other countries is experiencing an epidemiological and nutritional transition which involves changes in diet pattern from food rich in fruits and vegetables to refined, energy-dense, and fatty foods as well as physical inactivity. This has led to an increase in the incidence of obesity in adults. The association between poor nutrition and anemia has been well established, however, its association with high body mass index (BMI) has been scarcely explored in Nigeria. Therefore, this research was conducted to compare the potential contributory role of a high BMI and waist circumference to iron status in apparently healthy adults in Port Harcourt, Rivers State, Nigeria.

2.0 Materials and Methods

2.1 Experimental Design

This is a cross sectional study carried out in Port Harcourt, Rivers State Nigeria. A total of 250 apparently healthy adults (male and females) between the ages of 18 and 50 years and resident in Port Harcourt were recruited in this study; 125 subjects had normal weight and were used as control group, A total 56 subjects were overweight, while 69 subjects were obese which includes the male and females and they were used as test group. Informed consent was gotten from participants recruited in this study. Relevant information from each subject was obtained using a well-structured questionnaire.

Individuals with high body mass index and waist circumference were included in the study as the test subject while the control subjects were apparently healthy individuals whose body mass index and waist circumference were within the normal range and not on any medication or

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suffered bleeding for the past two weeks. Pregnant women, menstruating women, subjects less than 18 and above 50 years and individuals that declined consent were excluded from this study.

2.2 Blood Sample Collection

Five (5mls) milliliters of whole blood was collected from the antecubital fossa of each subject using a standard venipuncture technique. Three milliliters (3mls) of blood was dispensed into a plain tube, it was spun to obtain the serum which was used for assay of ferritin by ELISA technique, while two milliliters (2mls) of whole blood was used for the analysis of complete blood count using a 3-parts automated haematology analyzer. Anthropometric measures (BMI and WC) were taken using a stadiometer (for height), weighing scale (for weight) and a measuring tape.

2.3 Sample Analysis

Serum ferritin was analyzed using STAT FAX-2100 by awareness technology while the complete blood count was analysed using a 3-parts automated haematology analyzer SYSMEX manufactured by Kobe Japan, Model No: kx-21N.

2.4 Statistical analysis

Results were analyzed using Graph-pad prism version 8.02 and $p<0.05$ was considered statistically significant. Test of relationship was performed using Pearson's correlation. One-way analysis of variance (ANOVA) was used for comparison of means (mean ± SD) in the various group with level of significance set at $p<0.05$.

3.0 Results

3.1 Comparison of BMI, WC, Ferritin, and Blood Counts in the Study Population

The mean and standard deviation of Body Mass Index, waist circumference, and some haematological indices in control male, control females, test male and test females using one-way analysis of variance (ANOVA) showed that the mean standard deviation of age (27.79±4.87years, 27.43±4.44years, 33.48±7.48 years, 33.31±7.37years, $p<0.05$), BMI(22.79±1.87kg/m^2, 22.69±1.83 kg/m^2, 30.94±3.62 kg/m^2, 30.91±3.86kg/m2, $p<0.05$) , waist circumference (81.14±10.53cm, 80.36±11.36cm, 92.23±11.20cm, 90.61±11.04cm), ferritin(52.80±45.70ng/ml, 51.40±23.57ng/ml, 130.70±125.40ng/ml, 137.50±127.80ng/ml), haematocrit,(37.43±3.82%, 35.77±2.84%, 38.78±4.08%, 37.24±4.38%) haemoglobin,(12.37±1.41g/dl, 11.79±1.14g/dl, 12.87±1.49g/dl, 12.05±1.55g/dl) and red blood cell count (4.28±0.53x10^{12}/l, 4.05±0.32x10^{12}/l, 4.52±0.71x10^{12}/l, 4.39±0.68x10^{12}/l) parameters were statistically significantly different at $p<0.05$. whereas there was no statistically significant difference in mean standard deviation of the mean corpuscular volume (80.32±7.83fl, 80.86±6.55fl, 80.90±6.65fl, 79.18±7.29fl) and mean corpuscular haemoglobin (27.96±2.15pg, 28.14±2.20pg, 28.24±2.15pg, 27.58±3.19pg) at $p>0.05$. Details of the ANOVA result of Body Mass Index, waist circumference, and haematological indices in control male, control females, test male and test females are shown in table 2 below.

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Table 2: Comparison of Mean ±SD of BMI, WC, Ferritin, and some Haematological Indices in the Study Population.

Exp. Groups	Parameters								
	Age (years)	BMI (Kg/m^2)	WC (cm)	FERR. (ng/mL)	HCT (%)	HGB (g/dL)	RBC ($x10^{12}/L$)	MCV (fl)	MCH (pg/cell)
Control Males (n=58)	27.79±4.87[b]	22.79±1.87[a]	81.14±10.53[b]	52.80±45.70[a]	37.43[b]±3.82	12.37±1.41[b]	4.28±0.53[ad]	80.32±7.83	27.96±2.15
Control Females (n=67)	27.43±4.44[b]	22.69±1.83[a]	80.36±11.36[b]	51.40±23.57[a]	35.77±2.84[a]	11.79±1.14[a]	4.05±0.32[b]	80.86±6.55	28.14±2.20
Test Males (n=58)	33.48±7.48[a]	30.94±3.62[b]	92.23±11.20[a]	130.70±125.40[b]	38.78±4.08[ab]	12.87±1.49[ab]	4.52±0.71[ac]	80.90±6.65	28.24±2.15
Test Females (n=67)	33.31±7.37[a]	30.91±3.86[b]	90.61±11.04[a]	137.50±127.80[b]	37.24±4.38[b]	12.05±1.55[b]	4.39±0.68[a]	79.18±7.29	27.58±3.19
F value	24.03	225.0	23.78	15.39	6.842	7.095	8.260	0.8156	1.212
P value	<0.0001****	<0.0001****	<0.0001****	<0.0001****	0.0002***	0.0001***	<0.0001****	0.4860	0.3057

Key: BMI= body mass index, WC= waist circumference, FERR. = ferritin, RBC= red blood cell, HGB= haemoglobin, HCT= haematocrit, MCV= mean corpuscular volume, and MCH= mean corpuscular haemoglobin. *=Significance. Within each parameter, mean ±SD is significantly different at $p<0.05$.

4.0 Discussion

Nigeria is experiencing different transitions – epidemiological, nutritional, and economic transitions, and consequently, there is a double burden of communicable and no communicable diseases. Obesity (a no communicable disease) is a leading preventable cause of death globally with increasing rates in adults and children [42]. The obesity epidermic deploys a detrimental impact on the economy of the country with its high health care cost [38] Body mass index (BMI) is considered as the most accurate anthropometric index, and its internationally accredited for the assessment of obesity. Waist circumference is also a very important anthropometric index, as it is an indicator of visceral fat and high levels could increase the risk of cardio metabolic disease. In this study, we used only BMI and waist circumference to assess for overweight and obesity.

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In this study, it was observed that there are overweight and obese adults in Port Harcourt; the prevalence of overweight for men was 19.20% while that of women was 25.60% whereas the prevalence of obesity for men was 27.20% while that of women was 28% showing that the prevalence of overweight and obesity is of epidermic proportion in Port Harcourt. This increase trend of overweight and obesity observed in Port Harcourt could be as a result of increase physical inactivity due to prolonged working hours that propels workers to eat fast foods instead of homemade meals, lack of access to iron-rich diet due to inflation leaving the less privileged with the option of junk foods, change in modules of operandi in most jobs with the use of technology, working overtime just to meet up with bills and thereby having little time to sleep. it was also observed that there are few underweight individuals' resident in Port Harcourt. These observations agree with the reviews carried out by [24], [37] and [32] on causes of overweight and obesity in recent years.

The assessment of body mass index proffers significant information on the nutritional and subsequently the level of social heath care of any individual at a given time in a country [28]. 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 [43].

Previous studies have revealed that BMI levels have relationship with body fat and subsequent health risk as high levels of BMI may cause morbidity and death [1]. Waist circumference is a very important tool when considering obesity. This study revealed a statistically significant large waist circumference in the obese females as compared to the obese male subjects. Large waist circumference is due to abnormal accumulated fat around the waist region and may have been caused by wrong eating pattern or lack of exercise. Larger waist circumference is associated with higher risk of metabolic diseases. The large waist circumference observed in the females may be as a result of wrong nutritional pattern and possibly sedentary lifestyle. This work is in agreement with that of [33] which showed a larger waist circumference and higher body mass index in female when compared to male. This finding is also in agreement with the work of [4]. This finding also agrees with the work done by [28] and [44]. It was observed in this study that there is a relationship between body mass index and waist circumference, the higher the body mass index, the larger the waist circumference. This observation agrees with the work of [25]. It was also observed that the waist circumference increased with age in females but there was no significance increase in males, this increase in females may be due to childbirth. This work revealed that there is an association between body mass index and age, the overweight and obese participants had higher body mass index as their age increase compared to the normal participants in this study.

A significant difference was observed in this study in the body mass index of females when compared to males, this may be due to eating habit and possibly lifestyle of the males. This result agrees with the work of [28] in which there was significant difference in the body mass index of the females as compared to the males.

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The relationship between overweight and iron status has gained a lot of attention in years past and still counting. Some studies suggests that obesity or overweight has an adverse effect on iron status of an individual and it's also associated with subclinical inflammation which may lead to development of anaemia [29]; [34]. This study revealed a higher mean serum ferritin level in the overweight and obese subjects especially the female subjects when compared to the normal weight subjects, but it was statistically insignificant. This observation agrees with the findings of [17] [30] and [45] whereas the work of [18][31] and[19] disagrees with this study.

Ferritin concentration levels differ with age sex and body composition. The result of this study showed that the mean level of ferritin was significantly higher in age 30-34 years and 35-39 years but low in age 40+ years and lower in 25-29years and 20-24years of normal weight males. This may be due to the fact that ferritin level in men peak between 30-39 years of age [26]. While in overweight and obese females, the mean and standard deviation of ferritin was higher in 35-39 years this may be because serum ferritin level is relatively low in females, they approach menopause and begin to increase. This observation is in agreement with the work of [26].

Red cell indices are part of a complete blood count (CBC) which gives useful information about the state of an individual, it is also used to diagnose anaemia, a condition in which there are very few red blood cells. Iron deficiency anaemia is characterized by a wide range of haematological and non-haematological symptoms and regarded as one of the most common nutrition-related problems in Nigeria and many other underdeveloped/developing countries of the world [8]. Report from previous studies have showed that Body Mass Index is associated with iron deficiency anaemia [8].

The mean values of Haemoglobin (HGB), haematocrit (HCT), and red blood cell count (RBC) for the overweight and obese subjects were significantly high compared to the normal weight subjects. This may be due to the action of hepcidin which impairs the mobilization of iron from erythrocytes but does not decrease red cell survival, which may compensate iron reduction. These finding is in line with a recent work done by [15]. However, the work of [28] contradicts this work which stated that there was no association between Body Mass Index and haematocrit, haemoglobin, Red Blood Cell, Mean Corpuscular Haemoglobin and other red cell indices. Their observation was directly backed by the apparent lack of increase in the red blood cells, haematocrit or haemoglobin in the Body Mass Index subgroup of the analyses. The study carried out by [6] and [22] also disagrees with the finding in this study. There was no significant difference in the mean corpuscular volume and mean corpuscular haemoglobin of both test and control male and female of this study. This observation agrees with the work of [28]

Conclusion

High body mass index and waist circumference is associated with increased risk of communicable and non-communicable diseases. It was observed in this study that Overweight, and obesity is increasing in Port Harcourt. Iron is an essential element in the production of healthy red blood cells and its deficiency or overload is associated with body mass index. There was neither anaemia nor iron overload among the subjects that participated in this study,

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however, the values of some of the haematological parameters were below the lower limits of the conventionally accepted range for the age and sex. The study revealed that there is relationship between ferritin and elevated body mass index but it's insignificant. Some of the haematological indices were elevated with high body mass index and waist circumference. Additionally, age is associated with levels of ferritin, body mass index and waist circumference, and women are at high risk. Dietary patterns such as a high consumption of nutrient-rich foods such as fruits, vegetables and low-fat meat and dairy products have been related to several favorable health outcomes in adults including a decreased prevalence of obesity. Furthermore, increase physical activity and routine health check will help individuals stay healthy and fit.

Ethical approval and Consent to Participate

Approval for this study was obtained from the Rivers State Ministry of Health. The Participants provided written informed consent.

Competing Interests.

The authors declare that they have no competing interest

Authors' Contributions

IE contributed to the methodology, acquisition and investigation. NCI and SUK contributed to designing the work, methodology, supervision, reviewing and editing the manuscript. NCI, SUK and IE contributed to writing original manuscript and interpretation of data. All authors have read and approved the manuscript for publication

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