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A baseline studies on the nutritional interplay between HIV drugs and kidney, liver and heart indices in patients receiving HIV treatment in North-Central Nigeria

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Abstract

Malnutrition is one of the major problems among those infected with HIV/AIDS receiving Antiretroviral Therapy (ART). Various studies have shown that HIV infection and malnutrition are intricately linked to each other. In the absence of proper nutrition and treatment, HIV infection can lead to malnutrition which in turn impairs the immune system there by progressing HIV to AIDS, conversely use of ART has been reported to have significant effect on people living with HIV. This study aims at assessing the nutritional interplay between HIV drugs and kidney, liver, and heart indices among subjects undergoing HIV treatment at medical out-patient department of Federal Medical Centers in North Central part of Nigeria. A hospital based cross-sectional study was conducted where 677 people living with HIV attending the ART clinic were selected using a systematic random sampling technique. Nutritional status among these people was assessed through anthropometry Body Mass Index (BMI) and were classified accordingly; Underweight (BMI < 18.5 kg/m2) and overweight/obesity (BMI > 23 kg/m2). Patients information's including HIV associated risk factors, opportunistic infections, ART regimen, etc. were collected from the medical record department. Socio-demographic data were collected using structured questionnaire. Blood samples were collected to access kidney, liver and heart indices as well as levels of Vitamin D and trace elements such as Zinc and Selenium. Chi-square was used to test for a significant difference between sociodemographic characteristics and BMI, while ANOVA was used to compare the levels of kidney, liver and heart indices as well as vitamin D, Zn and Se based on BMI status at 95% C.I. Most of the study participants were overweight 201 (29.7%) and obese 211 (31.2%), a large number had a normal BMI 32.9%. The prevalence of underweight was found to be 42(6.2%). there was a significant increase in the level of some kidney, liver and cardiac indices in participants who were overweight and obese compared to those who were normal and underweights, these significant increase was observed in the levels of Na, K, Cl, HCo3, ALP, AST, ALT, Cholesterol, LDL and TG. There was a significant decrease in levels of Vitamin D, Zn and Se in participants who were underweight. Underweight, overweight and obesity are emerging problem among HIV patients on ART. Patients undergoing ART should be placed under strict nutritional monitoring and be subjected to nutritional supplementation to avert untimely death, also effort should be made to address the burden of malnutrition by addressing identified determinants.

Keywords: Antiretroviral Therapy (ART); HIV; Underweight; Overweight; Obese; Nutrition; Body Mass Index (BMI)

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1. Introduction

Human immunodeficiency virus(HIV) and Acquired Immunodeficiency Syndrome (AIDS) began in 1981, and is an ongoing worldwide public health issue, according to the World Health Organization (WHO), as of 2021, HIV/AIDS has infected about 37.7 million people and killed approximately 36.3 million people globally (WHO, 2022). Of these 37.7 million people, 73% have access to antiretroviral treatment, and 16% do not know they were infected. There were about 770,000 deaths from HIV/AIDS in 2018, and 680,000 deaths in 2020. The 2015 Global Burden of the disease Study estimated that the global incidence of HIV infection peaked in 1997 at 3.3 million per year. Global incidence fell rapidly from 1997 to 2005 to about 2.6 million per year. Incidence of HIV has continued to fall decreasing by 23% from 2010 to 2020, with progress dominated by decreases in eastern and southern Africa. As of 2020, there are approximately 1.5 million new infections of HIV per year globally (WHO, 2020). Sub-Saharan Africa is the region most affected by HIV. In 2018, an estimated 61% of new HIV infections occurred in this region, and as of 2020, more than two thirds of those living with HIV are living in Africa. HIV rates have been decreasing in the region from 2010 to 2020, new infections in eastern and southern Africa fell by 38%. Still, South Africa has the largest population of people with HIV than any country in the world at 7.06 million representing 19.1% of the population as of 2020 (Nasidi and Harry, 2021).

In Nigeria a total of 220, 0000 new HIV infections was reported in 2014. Most cases were adults over the age of 15 years. A substantial number of new HIV-infected children (<15 years) was also noted in 2014. Notably, previous data had linked the infections of a substantial number of HIV-infected children to their mothers' infections (Nigeria National Agency for the Control of AIDS, 2021). 1.6 million AIDS orphans were estimated to be in the country in 2014. The number of people estimated to be receiving ART was 747,382 with 3.0 million adult populations estimated to be living with the disease as of 2014. Albeit due to its population size, Nigeria is now the second largest HIV disease burden in the world with 3.2 million after South Africa which has 6.8 million burden of the disease, though prevalence is stable at 1.4 % (Federal Ministry of Health, 2021. By states, the highest numbers of HIV prevalence were found mostly in Akwa Ibom state(5.6%) and Benue state located in the region were this study was carried out ranked second with(4.9%), and next is Taraba(2.7%) respectively (Nasidi and Harry, 2020). These marked differences in the prevalence rates among these states could be due to a number of factors including but not limited to cultural differences, varying levels of education, religion and differing socio-economic structures. The variations in socio-cultural and religious practices among about 400 different ethnic groups in Nigeria have implications on the risk of HIV transmission. Notably, some practices that include multiple and concurrent sex partners, delivery outside the health facility without a skilled birth attendant, female genital mutilation, unsterile traditional bloodletting and traditional marking and tattooing will lead to an increase in the risk of HIV transmission (National Agency for the Control of AIDS, 2010).

HIV is a member of the lentivirus subfamily of retroviruses. Two distinct groups of viruses are pathogenic in humans: HIV-1 and HIV-2. Both are transmitted sexually and known to cause immunodeficiency disease. HIV enters the cell through the use of the CD4 receptor and chemokine co-receptors, primarily CCR5 and CXCR4. The viral genome is transcribed and integrated into the host genome by integrase. The HIV genome encodes 15 proteins, comprising three categories: Structural, regulatory, and accessory. After budding from the host cell, the virus matures into its infectious form through cleavage of viral precursor protein by protease Schuyler *et al*., (2017). According to WHO a substantive cure for HIV is not yet established, but there is available Antiretroviral therapy (ART) that aids in reducing the viral load to an undetectable level. (WHO, 2019). An undetectable viral load means that the level of HIV in the blood is too low to be detected by a viral load test, this intervention has become a breakthrough in the management of HIV patient's Schuyler *et al*., (2017). Even with the effective use of ART in managing people living with HIV, some complications, such as vitamins and mineral deficiencies arises. Malnutrition is one of the major problems among those infected with HIV/AIDS. Various studies have shown that HIV infection, and malnutrition are intricately linked to each other. Even in the era of ART, weight loss, lipodystrophy, imbalance in some electrolytes, enzymes and severe acute malnutrition (SAM) remain common problems for HIV infected subgroups especially those diagnosed late or those with failed or non-adherent antiretroviral regimens (Berhe, *et al*, 2013). Abnormalities in vitamin D and trace elements such as Selenium (Se) and Zinc (Zn) might be an important concern in management of HIV patients especially those receiving ART, as there seems to exist an association of the use of ART with worsening hypovitaminosis D and micronutrient deficiencies (Mehtas *et al*.,2010; Giusti *et al*, 2011). In addition, trace elements especially (Zn) and (Se) are important for healthy immune system, Zinc deficiency accounts for decline in T-cells generation and depress humoral and cell mediated immunity (Stambullian *et al*.,2007: Sprietsma, 1997), vitamin D plays a crucial role in bone mineralization and calcium hemostasis, its essential not only to the skeletal but also to the immunologic response as it has been noted of vitamin D deficiency to be more frequent among HIV positive patients(Ross and McComsey). In the absence of proper nutrition and treatment, HIV infection can lead to malnutrition which in turn impairs the immune system thereby progressing HIV to AIDS (TFNC, 2016). Underweight is a condition where macro and /or micronutrient supply are below the minimum dietary requirement which eventually leads to changes in body composition and diminished function (Seres DS, 2005; Soeters *et al*., (2008). People living with HIV (PLHIV) with undernourishment manifests different conditions

such as weight loss, muscle wasting, compromised immune system, micronutrient deficiency etc. and hence susceptible to opportunistic infection, where supplementation may prevent mortality and associated complications (TFNC, 2016).

2. Material and methods

2.1. Study design

A hospital based cross-sectional study design was used to assess the nutritional status and the associated factors.

2.2. Collection

Six hundred and seventy-seven (677) HIV/AIDS patients aged 18 - 80 years recruited from patients attending medical out-patient department of Federal Medical Centers located in north central (Middle belt), Nigeria for participation in the study. Participants included those whose HIV/AIDS status have been confirmed (Western blot), whether symptomatic or asymptomatic and were receiving ART. Excluded from the study were patients with family history of kidney, liver, and heart disease. The purpose of the study was explained to the patients after which informed consent were obtained. Patients that were diabetic, hypertensive or have any other conditions that may interfere with the result were also excluded.

2.3. Sample Collection Technique

Case records of patients whose names were randomly selected from the clinic register were retrieved and reviewed for analysis. Information obtained from the case notes includes socio demographic characters, baseline anthropometric parameters like weight, height and Body mass index (BMI), baseline value of lipid profiles such as LDL, HDL, TG, Vitamin D, Se, Zn and results of serological markers for HIV, Hepatitis B surface antigen (HBsAg) and for Hepatitis C were collected for each of these patients. Two different results were extracted for each parameter from the patients' case notes. After which socio demographic characters, baseline anthropometric parameters like weight, height and Body mass index (BMI) were again collected from each of the patients to check for variability and confirm data uniformity. Blood samples were then taken by venipuncture from the HIV/AIDS patients. Serum was prepared by centrifugation using MSE minor centrifuge model at 1500 rpm for 5 min. The serum samples were stored at −20˚C until needed for analysis.

2.4. Determination of Plasma Electrolytes

A 5 ml portion of venous blood was collected from each subject by venipuncture and allowed to clot. This was later centrifuged in a Wisperfuge (Model 684) centrifuge at 2500g for 5 min and then analyzed for the difference using the method of Igwe *et al*., (2020). Bicarbonate by titration as described by Tietz, N.W. (1987). Serum sodium, potassium and chloride levels were determined by ion selective electrode method using Humalyte machine (Human, Germany) Tietz, N.W. (1987), Chloride concentration was determined using the mercuric nitrate method while bicarbonate was assayed by back titration. Potassium and sodium were analyzed with the flame photometer Tietz, N.W. (1987). Serum Zn and Se levels was measured using atomic absorption spectrophotometer. Zn deficiency was defined as a serum level of <67mcg/dL, using the cut off referenced by Bender and Bender for normal plasma Zn(67-18mcg/dL). Selenium deficiency was defined as level<85mcg/L which is the cut-off associated with increased mortality (Bender, 1997, Seres, 2003)

2.5. Lipid Profile

Venous blood sample drawn from consented subjects after adequate disinfection of the area was separated to obtain plasma which was then frozen stored till analyzed. TC was determined using ferric perchlorate method while HDL was determined after precipitation of LDL with phosphotungstane and magnesium was calculated from Friedwaldís formula LDL = TC x HDL (TG/5) Friedwald *et al*., (1972). TG was measured using the colorimetric enzymatic method. Each data for each patient was obtained in triplicate, and the average taken to minimize error and enhance precision.

2.6. Statistical Analysis

Chi-square analysis was used to test for significant difference between the sociodemographic characteristics and BMI, ANOVA was also used to compare the levels of kidney, liver and heart indices as well as vitamin D, Zn and Se with BMI status at 95% C.I using Statistical Package for Social Sciences Version 22.0. Results was presented using contingency tables. Values were given as mean and standard error of mean.

3. Results

3.1. Nutritional status of the study participants

A baseline studies to determine the nutritional interplay between HIV-drugs and kidney, liver, and heart indices, was carried out on patients undergoing treatment in North Central Nigeria, with a sample size of 677 on both male and female who tested positive and have been on ART for over 12 months.

Table 1 presents the proportion of study participants with different nutritional status. Our study revealed that 6.2% of the study participants were underweight with BMI less than 18.5 kg/m2. Furthermore, 29.7% of the study participants were overweight with BMI of (23.0–27.4 kg/m2), while 31.2% were obese with BMI (> 27.5 kg/m2). 32.9% of the study participants had a normal BMI (18.5–22.9). The nutritional interplay between HIV drugs and kidney, liver and heart indices in patients receiving HIV treatment is shown in (Table 2, 3, 4a, 4b and 5)

Table 1 Nutritional status of study participants (N = 677)

Nutritional status	N	Percentage (%)	95%CL
Underweight (BMI < 18.5)	42	6.2	13.5-12.7
Normal (BMI 18.5–22.9)	223	32.9	11.2-9.5
Overweight (BMI 23.0–27.4)	201	29.7	17.3-16.2
Obese (BMI > 27.5)	211	31.2	6.2-4.1

Table 2 Socio-demographic characteristics of the study participants by nutritional status (N = 677)

Variables		No. Observed	underweight (<18.5)	Normal (18.5-22.9)	Overweight (23.0-27.4)	Obese (>27.5)	P-value
Age(years)	<20	33	7(21.2)	11(33.3)	7(21.9)	8(24.2)	0.001
	20-40	231	7(3.0)	81(35.1)	69(29.9)	74(32.0)	
	41-60	331	28(8.5)	106(32.0)	94(28.4)	103(31.1)	
	61-80	82	-	25(30.5)	31(37.8)	26(31.7)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Sex	Male	140	5(3.6)	49(35.0)	50(35.7)	36(25.7)	0.110
	Female	537	37(6.9)	174(32.4)	151(28.1)	175(32.6)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Marital Status	Married	329	19(5.8)	94(28.6)	97(29.5)	119(36.2)	0.001
	Single	122	14(11.5)	30(24.6)	39(32.0)	39(32.0)	
	Divorced	32	4(12.5)	10(31.3)	4(12.5)	14(43.8)	
	Widow	194	5(2.6)	89(45.9)	61(31.4)	39(20.1)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Religion	Christian	295	20(6.8)	92(31.2)	95(32.2)	88(29.8)	0.594
	Islam	370	22(5.9)	127(34.3)	104(28.1)	117(31.6)	
	Others	12	-	4(33.3)	2(16.7)	6(50.0)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Edu. Level	Primary	159	12(7.5)	54(34.0)	51(32.1)	42(26.4)	0.108
	Secondary	223	10(4.5)	70(31.4)	79(35.4)	64(28.7)	
	Tertiary	140	8(5.7)	51(36.4)	37(26.4)	44(31.4)	

	None	155	12(7.7)	48(31.0)	34(21.9)	61(39.4)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Employment	Employed	251	27(10.8)	72(28.7)	87(34.7)	65(25.9)	0.001
	Unemployed	426	15(3.5)	151(35.4)	114(26.8)	146(34.3)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Alcohol	YES	56	3(5.4)	17(30.4)	15(26.8)	21(37.5)	
	NO	621	39(6.3)	206(33.2)	186(30.0)	190(30.6)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Smoking	YES	50	-	18(36.0)	19(38.0)	13(26.0)	0.581
	NO	627	42(6.7)	205(32.7)	182(28.0)	198(31.6)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	

Result is significant were ($p<0.05$)

Table 3 HIV related clinical characteristics of the study participants by nutritional status (N = 253)

Variables		**No. Observed**	**underweight (<18.5)**	**Normal (18.5-22.9)**	**Overweight (23.0-27.4)**	**Obese (>27.5)**	**P-value**
ART Drugs	Yes	625	40(6.4)	207(33.1)	187(29.9)	191(30.6)	0.639
	No	52	2(3.8)	16(30.8)	14(26.9)	20(38.5)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
ART Regimen	First	644	40(6.2)	217(33.7)	190(29.5)	197(30.6)	0.001
	Second	7	-	-	7(100.0)	-	
	None	26	2(7.7)	6(23.1)	2(15.4)	14(53.8)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Opportunistic Infections							
HBV	YES	151	15(9.9)	46(30.5)	47(31.1)	43(28.5)	0.151
	No	526	27(5.1)	177(33.7)	154(29.3)	168(31.9)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
HCV	YES	96	13(13.5)	22(22.9)	33(34.4)	28(29.2)	0.003
	No	581	29(5.0)	201(34.6)	168(28.9)	183(31.5)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
TB treatment	Yes	3	3(100.0)	3(100.0)	-	-	0.105
	No	674	42(6.2)	220(32.6)	201(29.8)	211(31.3)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Hemoglobin Level	Normal	279	15(5.4)	85(30.5)	87(31.2)	92(33.0)	0.520
	Anemic	398	27(6.8)	138(34.7)	114(28.6)	119(29.9)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Proteinuria	Yes	95	4(4.2)	31(32.6)	30(31.6)	30(31.6)	0.838
	No	582	38(6.5)	192(33.0)	171(29.4)	181(31.1)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	

Diabetic	Yes	10	4(4.2)	6(60.0)	-	2(20.0)	0.032
	No	667	40(6.0)	217(32.5)	201(30.1)	209(31.3)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	
Physical Activity	Yes	24	-	8(33.3)	10(41.7)	6(25.0)	
	No	653	42(6.4)	215(32.9)	191(29.2)	205(31.4)	
	TOTAL	677	42(6.2)	223(32.9)	201(29.7)	211(31.2)	

Result is significant were (p<0.05)

Table 4a Nutritional interplay between kidney, liver and cardiac indices in patients receiving HIV treatment

BMI (kg/m2)	Systolic BP	Diastolic BP	RBG	T. Bil	AST	Creatinine	ALT
Reference Range	≤120(mm/Hg)	≤80(mm/Hg)	6.9-11.0	(0.1 - 1.2 mg/dl)	(8 - 48 U/L)	(72 - 126 mmol/L)	7 - 55 (U/L)
underweight (<18.5)	116.19±1.40	75.14±0.71	108.64±0.40	1.65±0.17	15.64±0.54	98.0±0.1	11.83±1.8
Normal (18.5-22.9)	119.83±1.35	76.73±0.81	107.35±0.07	2.01±0.79	23.14±0.20	82.0±0.02	16.05±0.93
Overweight (23.0-27.4)	122.50±1.50	73.29±0.93	105.05±0.87	2.31±0.22		78.0±0.03	18.71±1.9
Obese (>27.5)	125.19±1.58	81.15±0.99	106.58±0.98	1.83±0.10	20.54±0.13	92.0±0.06	15.85±1.0
P-value	0.017	0.001	0.814	0.108	0.056	0.003	0.002

Result is significant were (p<0.05); Values are mean ± SEM

Table 4b Nutritional interplay between kidney, liver and cardiac indices in patients receiving HIV treatment

BMI (kg/m2)	ALP	Cholesterol	LDL	HDL	Triglyceride	D. Bil	Urea
Reference Range	(40 - 129 U/L)	(3.5 - 6.0 mmol/L)	(2.58 - 4.89 mmol/L)	(0.39 - 1.83 mmol/L)	(0.59 - 1.75 mmol/L)		(2.5 - 6.6 mmol/L)
underweight (<18.5)	77.76±0.26	4.38±0.06	2.99±0.15	0.96±0.07	1.78±0.13	1.46±0.14	4.92±0.33
Normal (18.5-22.9)	86.36±0.43	4.23±0.19	2.58±0.04	0.85±0.03	1.35±0.08	1.30±0.06	4.77±0.19
Overweight (23.0-27.4)	101.22±0.75	5.82±0.71	3.07±0.07	0.92±0.04	1.59±0.09	1.28±0.05	4.59±0.20
Obese (>27.5)	87.30±0.29	28.13±0.16	9.72±0.05	0.83±0.03	2.41±0.13	1.28±0.06	5.10±0.24
p-value	0.023	0.001	0.001	0.248	0.026	0.558	0.403

Result is significant were (p<0.05); Values are mean ± SEM

Table 5 Nutritional interplay between kidney indices, associated deficiencies of vitaminD and trace elements in patients receiving HIV treatment

BMI (kg/m2)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)	Selenium (mcg/L)	Zinc (mcg/dL)	Vitamin D (nmol/L)
Reference Range	134-145	3.5-5.5	96-106	21-31	110-165	(67-183)	(>50)
underweight (<18.5)	141.5±0.05	4.0±0.06	107.4±0.04	26.2±0.02	90.0±0.03	61.0±0.66	45.0±0.71
Normal (18.5-22.9)	139.8±0.07	3.6±0.09	99.4±0.01	22.4±0.08	120±0.63	135±0.51	65.0±0.92
Overweight (23.0-27.4)	145.2±0.02	5.0±0.01	105.5±0.09	30.1±0.07	111±0.39	101±0.87	83.0±0.1.4
Obese (>27.5)	147.6±0.09	5.7±0.06	108±0.05	33±0.01	150±0.93	72±0.21	66.0±0.45
p-value	0.027	0.001	0.001	0.248	0.006	0.001	0.003

Result is significant were ($p<0.05$); Values are mean ± SEM

4. Discussion

Our study shows an estimated proportion of nutritional status among People Living with HIV (PLWHIV) receiving ART from different federal medical centers in North Central, Nigeria. The study revealed that 6.2% of the study participants were underweight with BMI less than 18.5 kg/m2, 29.7% of the study participants were overweight with BMI of (23.0–27.4 kg/m2), while 31.2% were obese with BMI (> 27.5 kg/m2). 32.9% of the study participants had a normal BMI (18.5–22.9). Several studies have reported weight gain when people living with HIV(PLWHIV) commence ART, according to Crum-Cianflone *et al*., (2010) and Koethe *et al*., (2016) reported that there was a BMI increase ranging from 0.4-1.3kg/m^2 in patient who were on ART for a period of 12-24 months, also a study carried out by Andrea *et al*., (2016) in South Africa revealed that short term use of ART (> 2 years) is associated with a large weight gain compared to either no ART or short-term use.

Based on socio-demographic characteristics (Table 2) those who were age <20 years had the highest number of underweight 7(21.2%), age group 61-80 years had the highest number of overweight 31(37.8%) while 21-40 years had the highest number of obese 74(32.0%) participants this was similar to a study carried out by Samip *et al*., (2020) in Kathmandu, Nepal were age of the study participants showed significant association with nutritional status. The prevalence of overweight and obese among participants was much higher in female 175(32.6%) as compared to their male counterpart 36(25.7%), The lower BMI among male study participants in our study might be due to their smoking habit compared to female, other studies also suggest that males are likely to be undernourished compared to female because of the fact that they present late for HIV treatment and care with advanced HIV disease and low CD4 counts Li N *et al*., (2012). Low educational level 61(39.4%), and use of alcohol 21(37.5%) were groups with higher number of overweight/obese participants receiving ART while participants who smoke had a lesser number of obese participants 13(26.0%). One of the reasons for the lower BMI among smoker might be due to the fact that smoking increases the chance of opportunistic infection, as it suppresses the host defenses and alters respiratory environment and thereby indirectly contributing to malnutrition through bacterial pneumonia Samip *et al*., (2020). Furthermore, smoking impedes the long-term quality of life in this group of population. The inverse relationship between cigarette smoking and BMI may also be explained by the biological function of nicotine. Nicotine found in cigarette smoking acutely increases energy expenditure and reduces appetite which could explain the lower body weight found in smokers Liao *et al*., (2016).

0ut of the 677 participants 625 were either in their first or second regimen of ART, although there may be greater tendency of increasing BMI after initiation of ART, our study shows 100% of overweight patient who were in their second stage of regimen and a 14(53.8%) of persons who were not on any regimen. The findings from different study have shown that the relationship between ART duration and BMI is inconsistent Li N *et al*., (2012)

According to Akinboro *et al*., (2013) there is a positive association between hemoglobin level, BMI and use of ART, in this study those who were anemic and obese were 119(29.9%) which was consistent with the study of Khatri *et al*., (2020). The trend analysis from various studies explains the fact that increase in the hemoglobin level are associated

with increase in CD4 count. Higher CD4 count improves immune reconstitution, slows disease progression, thereby improving the BMI of the study participants Kwsantwi *et al*., (2010).

With respect to the systolic and diastolic blood pressure with a reference range of ≤120(mm/Hg) for systolic and ≤80(mm/Hg) for diastolic (table 4), all participants who were underweight had systolic BP lower than the normal reference range, those who were overweight and obese had systolic BP higher than the normal reference range of 122.50±1.50mmhg and 125.19±1.58 mmHg respectively, this may be due to the nature of their diet, lifestyle, genetic predisposition which may contribute to rise in BP, this similar trend was also observed on the diastolic blood pressure(BP) of participants who had normal BMI and were underweight. Those who were obese had a diastolic BP of 81.15±0.99 mmHg this may be explained by the association of obesity with hypertension. With respect to the Random Blood Glucose (RBG), all participant had their glucose level lower than the upper limit of normal reference range for study population which was at (6.9-11.0mmol/l), this may be explained by insignificant effect of ART to blood glucose. Participants at all BMI viz (Normal, underweight, overweight, obese) had total bilirubin level higher than the normal reference range (0.1 - 1.2 mg/dl), however the highest was observed on participants who were overweight (2.31±0.22 mg/dl).

AST (25.50±0.64), ALP (101.22±0.75), ALT (18.71±1.9) all showed significant higher values above the upper limit of normal reference range when compared to participants with underweight and normal BMI, this may be due to the metabolic process of the ART which may induce an increase in level of some of the liver indices(enzymes) as noticed in overweight individuals. According to Hurlimaan *et al*., (2015), ART is known to disturb liver cells in various ways some of which include metabolic abnormalities, mitochondria toxicity which is associated with elevation of liver enzymes. Similarly, Kohler *et al*., (2007) in his study reported that rise in the level of liver indices in HIV patient receiving ART could be attributed to mitochondrial toxicity caused by some of the ART such as NRTIs (Nucleoside Reverse Transcriptase Inhibitors) most notably stavudine known to affect mitochondria DNA replication and cause DNA depletion

Some kidney indices were also seen to increase with use of ART in overweight/obese participants, Sodium (147.6±0.09mmol/L), Potassium(5.7±0.06mmol/L), Chloride (108±0.05mmol/L), Bicarbonate (33±0.01mmol/L),

Levels of Vitamin D (45.0±0.71nmol/L), Selenium (90.0±0.03mcg/L) and Zinc(61.0±0.66mcg/dL) showed a significant decrease in their values below the lower limit of normal reference range in underweight participants when compared with participants who were normal, overweight or obese. The decrease in the level of these vitamins and trace elements may be largely due to the use of ART such as tenofovir which is one of the commonest ART often associated with hypovitaminosis and renal dysfunction with eminent changes in in values of some the electrolytes such as sodium, potassium, chloride and bicarbonate out of their normal range Zimmermann et al., (2006). A significant increase was observed in participants who were obese in the level of their serum Cholesterol (28.13±0.16mmol/L), similarly LDL (9.72±0.05 mmol/L), and Triglyceride (2.41±0.13mmol/L) were obviously elevated, no significant changes in the level of HDL was observed.

5. Conclusion and Recommendations

The result of this study provides data on the, Nutritional Interplay between HIV Drugs and Kidney, Liver and Heart Indices and associated deficiencies in vitamin D and some trace elements in Patients Receiving HIV Treatment in North-Central Nigeria. baseline changes in level of kidney, liver and cardiac indices associated with different BMI score was observed as well as deficiency in vitamin D, Zinc and selenium. In our study the prevalence of overweight and obesity was found to be lower among the study participants compared to being underweight or normal. However, there was a significant increase in the level of kidney, liver and cardiac indices in participants who were overweight or obese. Overweight/obesity has become an emerging problem among People living with HIV which is the major risk factor for non-communicable diseases (NCDs). Hence there is an urgent need to integrate the screening program for NCDs into HIV treatment and care services before any further complication arises. Male participants who smoke cigarette are at higher risk of being underweight, hence they particularly need to reduce their smoking habit. Married participants are protected group however the divorced/separated participants are at higher risk of being underweight. Effort should be made to encourage them to consume diversified food. Vitamin D, Zinc and Selenium supplementation should be encouraged in management of patients on ART who may show deficiency.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors declared that there is no conflicting interest.

Statement of ethical approval

Ethical approval was obtained from the ethical review committee of all the federal medical centers involved in the study, North Central, Nigeria.

Statement of informed Consent

A written Informed consent was administered to all subjects to voluntarily participated or opt out of the study.

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