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# Correlating Serum IL-6 and hs-CRP with Components of Metabolic Syndrome among Patients with Human Immunodeficiency Virus on First-Line Highly Active Antiretroviral Therapy in Sokoto North-Western, Nigeria

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## Abstract

Inflammation plays a very important role in the development of non-communicable diseases in the general population, while it remains the leading cause of morbidity and mortality among HIV-positive patients treated with HAART. We aimed to investigate the association between IL-6 and hs-CRP with the components of metabolic syndrome among HIV-positive patients on HAART. We conducted a prospective study among HIV-positive HAART naïve patients. Eighty-six HIV-positive HAART naïve patients and eighty-six HIV-negative subjects to serve as controls at baseline were recruited. The baseline data was taken and recorded before commencing the patients on HAART. Then, the patients were placed on lamivudine, tenofovir and dolutegravir (DTG) HAART regiment and followed up for 24 months. Both serum IL-6 and hs-CRP are higher among HIV-positive patients than healthy control and among patients with and without MetS. Both age, gender, anthropometric and blood pressure FBC and LDL-c show an inverse correlation with the development of MetS at baseline, but not IL-6 and hs-CRP. However, 24 months post-HAART hs-CRP shows a significant correlation with MetS (P= 0.010) but IL-6 has a weak positive correlation with MetS (P= 0.055). In regression model, IL-6 has a strong negative correlation with the development of MetS (r –0.085 p= 0.042), while hs-CRP have a strong positive correlation with the development of MetS (r 0.117 p= 0.008). Interleukin-6 and hs-CRP are found to be highly elevated among patients with HIV than healthy controls, as well as in patients with MetS than those without MetS. Both IL-6 and hs-CRC are associated with the development of MetS among HIV patients on HAART than HAART naïve.

**Keywords**: IL-6, hs-CRP, Metabolic Syndrome, HAART, HAART Naive and HIV.



## INTRODUCTION

The exert pathogenesis of cardiovascular complications in HIV patients on combing antiretroviral therapy (cART) is not fully elucidated [1]. It seems to have a multifactorial cause and its includes metabolic derangements leading to the development of some or all components of MetS, pro-inflammatory and atherogenic condition[2]. It has been observed that People with MetS in the general population have a higher risk of developing cardiovascular disease and diabetes mellitus than those without the syndrome [2]. It is expected seropositive patients with MetS who are on drugs have the same cardiovascular risk as seronegative individuals with syndrome [1]. Guo *et al*., [3] reported in the population of China various non-modifiable and modifiable risk factors for metabolic syndrome such as drinking, smoking and eating certain food like red meat, fresh milk, vegetables and fruits with age as a non-modifiable factor. There is a high amplification rate of MetS risk with advancing age [3-5]. Studies indicate the relation of cardiovascular events with dyslipidaemia, hyperglycaemia, smoking as well as family history and D-dimer levels among HIV seropositive patients [6]. There is an inconsistent report on whether there is an association between gender and MetS, some reported females are being more at risk [3-7], while other report indicated males are at high risk [8]. In HIV infection disease progression and mortality are linked to increased

serum levels of IL-6 and other inflammatory biomarkers, but this has been confirmed by some studies [9]. It has been postulated diabetes mellitus is an indicator of the current acute phase inflammatory response and higher levels of serum IL-6 and hs-CRP are related to the development of diabetes among the general population [10]. The relationship between the elevated level of IL-6 and diabetes is reduced with prolonged follow-up and there is a weak association with IL-6 compared with hs-CRP as observed in women's health and nurses' health study [11]. However, the motivation to study deep into this area was due to the observation that inflammatory markers were considerably elevated among HIV-positive individuals on drugs when compared with HIV-negative counterpart [12], and chronic inflammation serves as a significant predictor of diabetes among HIV seropositive patients which could explain their greater risk of developing diabetes than those without the disease. Higher levels of IL-6 and P-selectin were related to increased risk of cardiovascular disease [13]. The study by Borges *et al*., [14] reported that increased serum concentration of IL-6 was related to higher BMI, older age, HIV replication and lower serum lipid concentration as well as the type of cART use by the patients. Furthermore, HIV replication has significantly increased IL-6, hs-CRP and D-dimer levels, with hs-CRP and D-dimer levels correlating with IL-6 levels positively and independently [14]. Genetic evidence in humans indicated that interleukin-6 receptors (IL6R) signalling appears to have a role in the development of coronary heart disease (CHD) and its blockade might provide a unique therapeutic approach to the prevention of CHD [15]. Likewise, Boulware *et al*., [16] reported that measurement of biomarkers in HAART naïve at baseline and one month later is associated with adverse outcomes during the first year of HAART, the result revealed that hs-CRP, IL-6 and other biomarkers might be of great importance in finding HAART naïve patients at risk of AIDS or death after the HAART commence. However, studies suggest IL-6 and some markers of coagulation pathway activation were found to be strong predictors of mortality after controlling CD4+ counts and viral load [17]. Activation of inflammatory and coagulation pathways associated with morbidity and mortality that include other conditions apart from AIDS, CVD, and non-AIDS cancers with effective inflammation-dampening intervention could greatly affect the health of people living with HIV [18].

## MATERIALS AND METHODS

We conducted a prospective study among HIV-positive HAART naïve patients. One hundred and seventy-two subjects were recruited, eighty-six HIV-positive HAART naïve patients and eighty-six HIV-negative subjects as controls. The research was conducted on HIV seropositive HAART naïve patients. The participants were recruited at entry before the commencement of HAART and the baseline data was taken and recorded. Then, the patients were placed on lamivudine, tenofovir and dolutegravir (DTG) HAART regiment and followed up for twenty-four months (24 months). Repeated sample collection was done at six months intervals. High-sensitivity C-reactive protein and interleukin-6 were analysed with Accubind and PARS Biochem ELISA kit respectively. Rayto 2100 microplate reader C was used for the estimation of hs-CRP levels [19]. Semi-automated non-competitive (sandwich) ELISA method was used to estimate serum Interleukin-6, in HIV-positive patients [19]. Glucose and lipids were estimated with Mindary BA88a chemistry semi-auto analyser using Randox reagent. Serum glucose was measured using the glucose oxidase method of Trinder [20]. The serum triglyceride (TG) concentrations were estimated using the method of Trinder (1969b)[21], using Kits procured from Randox laboratories in England. The serum concentration estimation of total cholesterol was done by the enzymatic method of Allain *et al*., (1974) [22]. Using reagent Kits which was procured, from Randox laboratories in England. The serum HDL-C Concentration was estimated by the method of Burstein *et al*., (1970) [23], using reagent Kits procured, from Randox laboratories in England. Precipitation of LDL-C was done by the addition of heparin to obtain HDL-C and very low-density lipoprotein (VLDL in the supernatant after centrifugation and are measured enzymatically by the CHOD-PAP method. The LDL-C concentration is calculated as the difference between total cholesterol and supernatant.

The ethical clearance was obtained from Specialist Hospital Sokoto (SHS) research and ethical committees. Likewise, written informed consent was also obtained from the individual subjects. All the participants who fulfilled the inclusion criteria were eighteen years and above.

### Statistical Analysis

The data obtained was entered into Excel broad sheath and analysed using SPSS IBM version 23v. The mean difference in serum concentration of IL-6 and hs-CRP between the two groups was determined by an independent t-test. The association between IL-6 hs-CRP and MetS was determined using Spearman correlation and linear regression model. A p value $<0.05$ was considered statistically significant.

## RESULTS

Table 1: Show the characteristic of MetS components among cases and controls, there is no significance statistical mean difference in age, BMI, waist circumference, waist to hip ration and diastolic blood pressure. But there is significance difference in hip circumference, systolic blood pressure, total cholesterol, Low density lipoprotein and triglyceride as well as high sensitivity CRP but not hig-density lipoprotein, fasting blood glucose, interleukin-6 and other analytes. All the mean values are higher in controls than in cases except for LDL and hs-CRP. Even though IL-6 is not statistically significance between the two groups it's still

higher in case than in controls which may show evidence of inflammation in HIV patients.

**Table 1: Characteristic of Component of Metabolic Syndrome among the Study Population in Cases and Controls**

| | Total | HIV Naïve | Controls |
|---|---|---|---|
| n | 172 | 86 | 86 |
| BMI | 21.6±0.37 | 19.2±0.49 | 23.9±0.43 |
| Age(years) | 32.9±0.77 | 34.9±1.06 | 30.8±1.09 |
| WC(cm) | 75.8±0.97 | 72.3±1.32 | 79.5±1.31 |
| HC(cm) | 90.1±0.94 | 85.4±1.20 | 94.8±1.27▲ |
| WHR(cm) | 0.84±0.01 | 0.84±0.006 | 0.84±0.009 |
| SBP(mmHg) | 113.3±1.22 | 110.6±2.04 | 116.0±1.29** |
| DBP(mmHg) | 76.1±0.84 | 75.3±1.25 | 76.9±1.12 |
| TC(mmol/l) | 3.4±0.09 | 3.0±0.07 | 3.9±0.14** |
| TG(mmol/l) | 1.6±0.06 | 1.9±0.10* | 1.4±0.06 |
| HDL(mmol/l) | 1.1±0.0.03 | 1.0±0.04 | 1.2±0.05 |
| LDL(mmol/l) | 1.7±0.08 | 1.3±0.08 | 2.1±1.12▲ |
| FBG(mmol/l) | 4.7±0.08 | 4.6±1.11 | 4.7±1.11 |
| UMA(µg/min) | 32.7±2.25 | 34.3±2.82 | 31.1±3.50 |
| Urine Creat(mg%) | 93.6±4.02 | 85.7±5.90 | 101.6±5.30 |
| ACR(mg/mmol) | 0.45±0.04 | 0.53±0.06 | 0.36±0.05 |
| hs-CRP(µg/ml) | 14.4±0.83 | 18.3±1.12* | 10.1±1.03 |
| IL-6(ng/ml) | 11.3±0.74 | 12.1±0.83 | 10.5±1.22 |

BMI, Body mass index; WC, Waist circumference; HC, Hip circumference; WHR, Waist to hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; TC, Total cholesterol; TG, Triglyceride; HDL, High density lipoprotein cholesterol; LDL, Low density lipoprotein cholesterol; FBG, Fasting blood glucose; UMA, Urine microalbumin; ACR, Albumin creatinine ratio; hs-CRP, High sensitivity C-reactive protein; IL-6, Interluekin-6. Data are mean ±SE, * *p <0.001, *p <0.01, ▲p<0.05 and others p >0.05 for cases vs controls subjects. Statistics by independent t test.

Table 2: Shows the correlation between the presence of metabolic syndrome with Age and gender which shows a statistically significant negative correlation (-0.293) and (-0.248) for Age and sex respectively. Likewise, anthropometric and clinical parameters such as weight, BMI, Hip circumference, WHR, SBP and DBP show significant inverse (negative) correlation with MetS (r = -0.350, -0.348, -0.476, -0.389, -0.259, -0.315 and -0.284) respectively (p-value <0.001). However, there is no correlation between height and presence of MetS among study subjects (0.029) p value= 0.703.

**Table 2: Correlation of Age, gender weight, height, body mass index, hip circumference, waist circumference waist to hip ratio, systolic blood pressure and diastolic blood pressure with MetS among HAART Naïve patients.**

| Parameter | r | p-value |
|---|---|---|
| Age(years) | -0.293 | 0.0001** |
| Gender | -0.248 | 0.001** |
| WT (cm) | -0.350 | 0.0001** |
| HT (cm) | 0.019 | 0.806 |
| BMI (kg/m$^2$) | -0.348 | 0.0001** |
| WC (cm) | -0.348 | 0.0001** |
| HC (cm) | -0.476 | 0.0001** |
| WHR (cm) | -0.389 | 0.0001** |
| SBP (mmHg) | -0.315 | 0.0001** |
| DBP (mmHg) | -0.284 | 0.0001** |

r, Correlation coefficient; WT, weight; HT, Height; BMI, Body mass index; WCIR, Waist circumference; HC, Hip circumference; WHR, Waist to hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure. (** p value <0.001) Statistic by Spearman correlation.

Table 3: Correlation of hs-CRP, IL-6, TC, TG, HDL, LDL, FBG, UMALB, UCRT, and ACR concentration with the presence of MetS among HIV HAART-naïve patients. There is no significant correlation between hs-CRP and IL-6 and the presence of MetS (-0.025 and -0.071) and p values of 0.741 and 0.357, respectively. Likewise, lipid profile parameters showed no significant correlation except for LDL-C, which has a significant inverse relationship (negative) correlation with the presence of MetS (-0.151), p-value

0.042, but with TC, TG, and HDL-C, no correlation was observed (-0.136, 0.042, and -0.05), respectively. Fasting blood glucose (FBG) correlates positively with the MetS (0.236) and a p-value of 0.003. Urine microalbumin, urine creatinine, and albumin creatinine ratio (ACR) have no statistically significant relation with MetS.

**Table 3: Correlation of hs-CRP, IL-6, TC, TG, HDL, LDL, FBG, UMALB, UCRT and ACR concentration with presence of MetS among HIV HAART naïve patients**

| Analytes | r | p-value |
|---|---|---|
| hs-CRP (µg/ml) | -0.025 | 0.741 |
| IL-6 (ng/ml) | -0.071 | 0.357 |
| TC (mmol/l) | -0.136 | 0.076 |
| TG (mmol/l) | 0.042 | 0.592 |
| HDL-C (mmol/l) | -0.051 | 0.592 |
| LDL-C (mmol/l) | -0.156 | 0.042* |
| FBG (mmol/l) | 0.236 | 0.003* |
| UM ALB. (mg/min) | -0.086 | 0.370 |
| U CRT. (mg %) | -0.086 | 0.267 |
| ACR (mg/mmol) | 0.115 | 0.132 |

r, Correlation coefficient; hs-CRP, High sensitivity CRP; IL-6, Interluekin-6; TC, Total cholesterol; TG, Triglycerides; HDL, High-density lipoprotein; LDL, Low-density lipoprotein; FBG, Fasting blood glucose; UM ALB, Urine micro-albumin; U CRT, Urine creatinine and ACR, Albumin creatinine ratio statistic by Pearson correlation (* p <0.05).

Table 4: Shows the association of MetS with IL-6 and hs-CRP and lipid profile parameters in the prediction of MetS. Both hs-CRP, triglyceride and HDL-C show a strong significant positive correlation with MetS. While IL-6 and FBG showed a strong significant negative correlation with MetS. While, Total cholesterol, low-density lipoprotein cholesterol, urine micro-albumin and albumin creatinine ratio have no significant correlation.

**Table 4: Pearson correlation coefficient showing the association of MetS with IL-6, hs-CRP and lipid parameters at the Baseline in the regression model**

| Parameter | r | p value |
|---|---|---|
| hs-CRP(µg/ml) | 0.117 | 0.008 |
| IL-6(ng/ml) | -0.085 | 0.042 |
| TC(mmol/l) | 0.007 | 0.442 |
| TG(mmol/l) | 0.148 | 0.001 |
| HDL-C(mmol/l) | 0.218 | 0.0001 |
| LDL-C(mmol/l) | -0.078 | 0.055 |
| FBG(mmol/l) | -0.272 | 0.0001 |
| UMALB(µg/min) | 0.074 | 0.064 |
| ACR (mg %) | 0.076 | 0.061 |

r, Correlation coefficient; hs-CRP, High sensitivity CRP, IL-6, Interleukin-6, TC, Total cholesterol, TG, Triglyceride, HDL-C, High density lipoprotein cholesterol, LDL-C, Low density lipoprotein cholesterol, FBG, Fasting blood glucose, UMALB, Urine micro albumin, ACR, Albumin creatinine ratio. Statistic by linear Regression model enter method

Table 5: The correlation of hs-CRP with MetS, IL-6, and other MetS traits such as gender, BMI, and other risk factors of cardiovascular disease among HIV-positive HAART exposed patients. High sensitivity C reactive protein levels showed a positive and significant correlation with the development of MetS and triglyceride levels (p values 0.010 and 0.008, respectively). Whereas, FBG, UMALB, SBP, DBP, DOD, and DODR show a significant negative correlation with hs-CRP level p values of 0.0001, 0.034, 0.0001, 0.0001, 0.0001, and 0.0001, respectively. Similarly, there is no statistically significant correlation between hs-CRP levels and IL-6, HDL-C, age, and WHR.

**Table 5: The correlation of hs-CRP with IL -6, FBG, Lipid parameters, BMI and other risk factor of cardiovascular disease and other MetS trait among HIV positive HAART exposed patients**

| Parameters | r | p value |
|---|---|---|
| MetS | 0.125 | 0.010* |
| IL-6 (ng/ml) | -0.093 | 0.055 |
| TG (mmol/l) | 0.189 | 0.008* |
| HDL-C (mmol/l) | -0.068 | 0.165 |
| FBG (mmol/l) | -0.190 | 0.0001** |

| | | |
|---|---|---|
| UMALB (µg/min) | -0.098 | 0.043* |
| AGE (years) | -0.026 | 0.591 |
| SEX | -0.082 | 0.091 |
| BMI (kg/m$^2$) | -0.045 | 0.357 |
| WHR (cm) | -0.002 | 0.974 |
| SBP (mmHg) | -0.235 | 0.0001** |
| DBP (mmHg) | -0.236 | 0.0001** |
| DOD (years) | -0.211 | 0.0001** |
| DODR (years) | -0.220 | 0.0001** |

r, Correlation coefficient; MetS, Metabolic syndrome; IL-6; Interleukin-6; TG, Triglycerides; HDL-C, High-density lipoproteins; FBG, Fasting blood glucose; UMALB, Urine micro-albumin; BMI, body mass index; WHR, Waist to hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; DOD, Duration of disease; DODR, Duration of drugs (** p < 0.0001, * p<0.05) statistics by spearman's correlation.

Table 6: The correlation between IL-6 levels with hs-CRP, and other MetS traits such as BMI, age, gender, TG, HDL-C, and other risk factors of cardiovascular disease among HIV-positive patients. High-density lipoprotein, FBG, BMI, and SBP show a strong positive correlation with IL-6 level with p values (0.016, 0.0001, 0.001, and 0.0001), respectively. However, triglycerides, UMALB, and DOD show a strong negative correlation with the IL-6 level p value (0.0001, 0.0001, and 0.048), respectively.

**Table 6: The correlation of IL-6 with MetS, hs-CRP, FBG, Lipid parameters, BMI and other risk factor of cardiovascular disease and other MetS trait among HIV positive HAART exposed patients.**

| Parameters | r | p value |
|---|---|---|
| MetS | -0.093 | 0.055 |
| hs-CRP (µg/ml) | -0.093 | 0.055 |
| TG (mmol/l) | -0.249 | 0.0001** |
| HDL-C (mmol/l) | 0.117 | 0.016* |
| FBG (mmol/l) | 0.317 | 0.0001** |
| UMALB (µg/min) | -0.347 | 0.0001** |
| AGE (years) | -0.012 | 0.811 |
| SEX | -0.062 | 0.203 |
| BMI (kg/m$^2$) | 0.154 | 0.001** |
| WHR (cm) | 0.090 | 0.066 |
| SBP (mmHg) | 0.197 | 0.0001** |
| DBP (mmHg) | 0.076 | 0.118 |
| DOD (years) | -0.096 | 0.048* |
| DODR (years) | -0.075 | 0.122 |

r, Correlation coefficient; MetS, Metabolic syndrome; hs-CRP, High sensitivity CRP; TG, Triglycerides; HDL-C, High density lipoproteins; FBG, Fasting blood glucose; UMALB, Urine micro-albumin; BMI, body mass index; WHR, Waist to hip ratio; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; DOD, Duration of disease; DODR, Duration of drugs(** p < 0.0001, * p<0.05) statistics by spearman's correlation.

## DISCUSSION

Serum IL-6 is a marker of inflammation whose relationship with MetS is not fully understood. Both IL-6 and hs-CRP demonstrate an association with components of metabolic syndrome in our study. The present study reveals that serum IL-6 levels are higher among patients with MetS than those without the syndrome. The findings agree with [24, 25], that IL-6 levels were significantly higher among the metabolic syndrome group than controls.

The serum hs-CRP concentration is significantly higher among HIV HAART Naïve patients than healthy controls (p<0.001) but not IL-6. Interleukin 6 shows a positive correlation with fasting blood glucose in the current study (r =0.317, p =0.0001) which may explain the relationship of IL6 level with the development of diabetes mellitus. This was reported by Donath and Shoelson [10], that high levels of interleukin 6 and hs-CRP are related to the development of diabetes mellitus among the general population. Even though the relation may reduce with follow up as reported by Baker *et al*., [11]. Similarly, Neuhaus *et al*., [12], reported higher levels of inflammatory markers among HIV patients on drugs when compared to HIV-negative individuals. This corroborates with the finding of the current study that shows a statistical increase in hs-CRP levels among HIV-positive HAART naïve patients and controls (p 0.006) but not interleukin 6 (p 0.690). Likewise, hs-CRP shows a significant positive correlation with MetS (r = 0.125 p 0.010) but a negative correlation with duration of HIV infection and its treatments (r= -0.211, p =0.0001 and -0.220, p= 0.0001)

respectively. However, IL-6 have a weak negative correlation with MetS (r= -0.093 p=0.055) and negative correlation with duration of HIV disease (r= -0.095 and p= 0.048) but no correlation with duration of treatment (r= -0.075 p= 0.122) respectively. This agrees with the finding Nixon and Landay [9], who reports a link between HIV disease progression and mortality to increased serum levels of IL-6 and other inflammatory biomarkers. Similarly, the study by Donath and Shoelson [10], report the relationship between the development of diabetes mellitus in the general population with elevated serum levels of IL-6 and hs-CRP. This corroborates with the finding of the current study which shows a significant positive correlation between FBG and IL-6 (r= 0.317, p= 0.0001) but a negative correlation with hs-CRP (r= -0.190, p =0.0001) respectively.

However, after commencing HAART, there is an increase in triglyceride and reduced high-density lipoprotein that shows a statistically significant difference among HIV patients with MetS than those without MetS (p <0.005). This agrees with the work of [26-28], whose reports indicate an increase in triglycerides later in HIV Patients on HAART. Though there was a significant decrease in viral load in all the patients there was a significant change in lipids at different levels of the study. Metabolic irregularities are associated with prolonged HAART use among HIV-positive patients such as glucose and lipid abnormalities as reported by Gallagher [29]. This agrees with the current study that shows a high increase in FBG level within six months of commencing HAART from 5.8% to 61.9% respectively. Studies among young healthy adult [8-30], both report significantly higher FBG among males than females which contradicts our study that reports significantly higher FBG levels among females than male patients. The reports from a previous study by Dooko, De Wit [31], show that Inflammation plays a major role in the progress of diabetes mellitus among HIV-positive and inflammatory markers such as IL-6 and hs-CRP tend to be elevated among HIV positive patients who developed diabetes when compared to non-diabetic patients. Human immunodeficiency virus has been reported to induce expression and secretion of IL-6 by monocytes and macrophages, even among individuals with virologically suppressed diseases has been reported to have higher plasma levels of IL-6 than uninfected controls [12]. The current study reports no statistically higher IL-6 levels among HIV-positive patients than controls (p= 0.690). Likewise, the current study demonstrates that IL-6 have a positive correlation with BMI (r =0.154, p=0.001), HDL-C, TG and duration of the disease. This agrees with Borges *et al*., [14], who report a link between high plasma levels of IL-6 with BMI, HIV replication and low serum lipid. However, activated inflammation may have profound and far-reaching clinical implications as demonstrated by high plasma levels of IL-6 [14].

The mean serum concentration of hs-CRP among HIV positive HAART naïve patients and control at baseline were 8.94±0.95 and 18.25±1.12 p=0.006 and IL-6 of 10.48±1.22 and 12.97±0.83 p=0.690 respectively. This is higher above the normal value of ≥3µg/ml for high risk of cardiovascular disease for hs-CRP. However, the value of hs-CRP was fluctuating after commencing HAART and decline between patients with and without MetS. This agree with Syed *et al*., [32], that report a sustained decline in hs-CRP due to decline in inflammation process after ART. High sensitivity CRP significantly correlated with the development of MetS among patients on HAART treatment but not HAART naïve patients (r 0.125 p 0.010 and -0.025 p 0.741) respectively, also reported by other studies [10-34], that shows a positive correlation between hs-CRP level with fasting blood glucose and insulin sensitivity. Likewise, hs-CRP level was correlated with elevated levels of Triglycerides, low-density lipoprotein, Rifai and Ridker [35]. Similarly reported in other cross-sectional studies indicate the association of hs-CRP level with TG, LDL and FBG which are major components of NCEP ATP III metabolic syndrome definition Festa, D'Agostino Jr [36].

The study by Dooko *et al*.,[31] , reported that the development of diabetes mellitus among HAART-exposed patients is linked to high plasma levels of hs-CRP, IL-6 and systemic inflammation, this agrees with the current study that shows a statistically positive correlation between FBG level and IL-6(r= 0.317, p=0.0001), while hs-CRP shows statistically negative correlation with FBG (r= -0.190, p=0.0001). However, the current study indicated a positive correlation of IL-6 with other components of MetS such as fasting blood glucose, which is demonstrated by studies on type 2 diabetes and the development of type 2 diabetes among HIV patients [10-31]. Furthermore, IL-6 levels correlated with TG and HDL-C in our study, this finding agrees with some scholarly reports that IL-6 levels had an inverse relationship with HDL-C in subjects with mild obesity [37], but contrary to the findings of other studies that report an insignificant correlation of IL-6 level with HDL-C [38].

## CONCLUSION

Interleukin-6 and hs-CRP are found to be highly elevated among patients with HIV than healthy controls, as well as in patients with MetS than those without MetS. Both IL-6 and hs-CRP are associated with the development of MetS among patients living with HIV treated with HAART than HAART naïve. Likewise, IL-6 and hs-CRP have shown significant association with other components of MetS.

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**Conflict of Interest**: Authors have no competing interest to declare.

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