GENDER-RELATED ALTERATIONS IN FREE FATTY ACIDS AND OXIDATIVE STRESS IN HYPERTENSION CO-MORBIDLY OCCURRING WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Increase in plasma free fatty acids (FFAs) concentrations may cause cellular damage via the induction of oxidative stress. The aim of this present study was to investigate FFAs and oxidative stress in hypertension co-morbidly occurring with Type 2 Diabetes Mellitus (T2DM). Age and sex matched control subjects (n=150) and patients (n=470) [hypertensive nondiabetics (HND, n=179), normotensive diabetics (ND, n=132), hypertensive diabetics (HD, n=159)] presenting at the Medical Out-Patient Clinic of the State Hospital, Abeokuta, Nigeria were recruited. Fasting plasma glucose, creatinine, urea, FFAs, thiobarbituric acid reactive substances (TBARS) were determined spectrophotometrically. The presence of either or both diseases resulted in significant increase (p<0.05) in the plasma FFAs and oxidative stress marker-TBARS in different compartments (plasma, erythrocytes andlipoproteins) for both male and female patients when compared with their control counterparts. The increase in FFAs was more marked in comorbidity female when compared with other female patients. There was significant (p<0.05) difference in gender FFAs concentrations. In both controls and patients, FFAs in plasma are significantly (p<0.05) higher in male when compared with their female counterparts. This research revealed biochemical variations in hypertension co-morbidly occurring with T2DMcharacterised by gender-related elevation in FFAs and enhanced oxidative stress. Plasma FFAs might be a good biomarker predicting the occurrence and development of hypertension and/or T2DM.

Key words: Free fatty acid, oxidative stress, hypertension, type 2 diabetes mellitus, gender

INTRODUCTION

All over the world, cardiovascular diseases (CVD) and the metabolic syndrome are major causes of morbidity and mortality, including sudden death. CVD is emerging as a significant health problem in sub-Saharan countries such as Nigeria, with a population of over 180 million (Oladapo *et* *al.*, 2010). These countries are undergoing epidemiological transition from communicable to non-communicable diseases. Epidemiological transition has been closely linked to changes in the demographic, social and economic status of various populations, causing a global rise in chronic diseases, especially CVD (Oladapo *et*

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al., 2010). The World Health Organization estimates that the number of people with type 2 diabetes mellitus (T2DM) will increase to 366 million by the year 2030 (Arnetz *et al.*, 2014). The steep rise of communicable diseases such as hypertension and T2DM and associated complications go along with increasing evidence of clinically (epidemiology, pathophysiology, treatment, and outcomes) important sex differences. While T2DM in men is more frequently diagnosed at lower age and body mass index; the most prominent risk factor, which is obesity, is more common in women (Kautzky-Willer *et al.*, 2016). Hypertension, type 2 DM, oxidative stress, endothelial dysfunction and inflammation play significant roles in the pathogenesis of cardiovascular diseases. Plasma free fatty acids (FFAs) as the main source of energy in the liver, heart, kidney, muscle, lung, testis, brain and the adipose tissue; can enhance the reaction of oxidative stress, cause endothelial dysfunction (Chinen *et al.*, 2007), induced atherosclerosis (He *et al*, 2014) and links with increased insulin resistance (Gruzdeva *et al.*, 2013). It has been shown that increased plasma FFAs can predict development of CAD in healthy men. Also increased free fatty acid level is known to have a causal relationship with oxidative stress and endothelial dysfunction (Yamato *et al.*, 2007; Du *et al.*, 2006; Furukawa *et al.*, 2004; Yamaguchi *et al.*, 2006). In hypertension pathogenesis, angiotensin I is converted to angiotensin II by angiotensin converted enzyme (ACE), angiotensin II activates the NADPH oxidase which in turn catalyzes the oxidation of NADPH to $NADP^+$, in the process of O_2 accepting electrons from NADPH, ROS are generated which inhibit endogenous nitric oxidixe synthase (eNOS). eNOS catalyses the synthesis of NO, the endogenous derived re-

laxing factor from L-arginine. It has been shown that elevated FFAs behave like angiotensin II by activating NADPH oxidase over expression, which caused increased ROS generation, which in turn decreased the synthesis of NO and so resulted in the endothelial dysfunction (Chinen *et al*, 2007, Zhou *et al.*, 2009). It has also been reported that insulin resistance is an independent predictor of cardiovascular disease (An *et al.*, 2012) and the increased plasma FFAs levels were a significant cause of obesity-associated insulin resistance (Boden, 2011). Furthermore, elevated FFAs promotes uptake of oxidized LDL in macrophages, an essential step in development of atherosclerosis (Ishiyama *et al.*, 2010). This study aims to investigate the plasma FFAs and oxidative stress marker in hypertension, type 2 diabetes mellitus, and their co-morbidity, and also to determine if FFAs varies with gender.

MATERIALS AND METHODS
Study area and subjects
The study was carried out in Abeokuta the capital city of Ogun State, Nigeria. They basically consume typical Nigerian low fat, high carbohydrate and protein diets. Apart from this, they live an active life-style in the community (Akamo *et al.*, 2015). Patients presenting at the Medical Out-patient Clinic, State Hospital, Ijaiye, Abeokuta, Ogun State, Nigeria were used for the study. The protocol for the study was approved by the Research and Ethics Committee of the State Hospital as well as the Postgraduate Committee of the Department of Biochemistry, Federal University of Agriculture, Abeokuta. Patients (diagnosed by a Consultant Physician in the Department of Internal Medicine of the State Hospital) were made of age and sex-matched indigenous Nigerian normoglycaemic hypertensives; normotensive type 2 diabetes mellitus and patients with co-

morbidity of hypertension and type 2 diabetes. The diagnosis of diabetes mellitus was based on the WHO criteria (Akamo *et al.*, 2015). Patients on oral hypoglycaemic drugs or whose diagnosis of diabetes was made at the age of 40 years and above with no record of ketosis were considered to have type 2 diabetes mellitus. Hypertensive patients were diagnosed based on World Health Organisation-International Society of Hypertension Guideline cut-off point of 140 mmHg and above for systolic blood pressure (SBP) and/or 95 mmHg and above for diastolic blood pressure (SBP), and also if it was previously detected and the subject was on treatment (Idogun *et al.*, 2007). Pulse pressure (PP) was calculated as SBP minus DBP. Mean arterial pressure (MAP) was estimated as (SBP+2DBP)/3 (Akamo *et al.*, 2015). Inclusion criteria included being hypertensive for $\geq$ one year, use of neutral antihypertensive agents such as calcium channel blockers, angiotensin converting enzyme inhibitors, and angiotensin II receptor blockers. Excluded from the study during routine interviews, clinical investigations and laboratory tests were patients with a history of smoking, drinking alcohol, human immunodeficiency virus (HIV), systemic lupus erythematosus, systemic inflammation or systemic infection, taking oral contraceptives, lipid lowering drugs. Age and sex-matched volunteers certified clinically and biochemically to be healthy, on no medication; normotensive and normoglycaemic served as controls. They were made of staff and students of Federal University of Agriculture, Abeokuta, Nigeria. They were recruited in the study at the same period with the patients. Participation in the study by individual subject was voluntary. Before enrollment in the study, all subjects were informed about the objectives and requirements of the study, as well as the risks and discomfort that might be involved in participating in the study. Demographic data including age, sex, race, and duration of hypertension and diabetes were collected using questionnaire (Akamo *et al.*, 2015). Table 1 summarizes the study population.

Table 1. Study population

Subject	Male	Female
Control	74	76
Hypertensive non-diabetics	76	103
Normotensive diabetics	64	68
Hypertensive diabetics	68	91

Collection of blood samples

Blood samples (10.0 ml) were collected between 08.00 a.m. and 11.00 a.m. on each clinic day from the antecubital vein of the participants after an overnight fast for 12-14 hours. The blood was transferred into a lithium heparin anti-coagulated tube, and mixed gently by inverting the stoppered tube several times. The blood samples were stored in a cooler box and transferred to the laboratory for analyses. Plasma was separated from erythrocytes. Both plasma and erythrocytes were stored at -20^{0}C for further analyses.

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Determination of free fatty aids

Plasma free fatty acids (FFAs) were determined according to the method of Soloni and Sardina (1973) as modified by Brunk and Swanson (1981). Briefly, to 100 μl of plasma was added 300 μl of copper reagent and 2 ml of chloroform. This was shaken with a vertical shaker for 10 min and centrifuged. After centrifugation, the chloroform layer was removed and to this were added 1 ml of cuprizone and 100 μl of ammonia reagent. The contents were shaken briefly by hand and absorbance read at 620nm 10 min after adding ammonia reagent. A standard curve of palmitic acid taken through the same procedure was used to calculate the concentrations of FFA in the plasma samples.

Determination of lipid peroxidation

Plasma, erythrocytes and lipoproteins lipid peroxidation was estimated colorimetrically by thiobarbituric acid reactive substances (TBARS) method of Buege and Aust (1978). Plasma/erythrocytes/HDL/LDL+VLDL (0.1 ml) was treated with 2.0 ml of TBA‑TCA‑HCl (1: 1: 1, v/v/v) reagent (thiobarbituric acid 0.37%, 0.25 N HCl and 15% TCA) and incubated in a water bath at 95 °C for 15 minutes. The tube was then placed on ice, centrifuged and the absorbance of clear supernatant was measured against blank at 535 nm. TBARS (malondialdehyde, MDA) content was estimated using the equation:

MDA concentration (μM) = A / (1.55 X 10^6 x b). Where A is the absorbance and b is the path length.

Statistical analysis

Data obtained were entered into SPSS (Statistical Package for Social Sciences) software for Window version 16 (SPSS Inc., Chicago, Illinois, USA). Data were expressed as Mean±S.E.M. Analysis of Variance (ANOVA) was carried out to test for the level of homogeneity among the groups. Where heterogeneity occurred, the groups were separated using Duncan Multiple Range Test (DMRT), p values of < 0.05 were considered to be statistically significant.

RESULTS

The demographic and clinical characteristics of patients and controls are shown in Table 2. The controls, hypertensive non-diabetics (HND), normotensive diabetic (ND) and hypertensive diabetics (HD) were similar (p > 0.05) in age. The duration of diagnosis of hypertension was 5.04±2.19 years among the HND male and 4.87±1.60 years among the HD male; it was 5.26±1.66 years vs 4.94±1.62 years among the HND female and HD female respectively (p < 0.05). The duration of diagnosis of diabetics was also similar (p > 0.05) between the ND male, HD male, ND female and HD female; 4.07±1.55 years, 4.05±1.48 years, 4.22±1.19 years and 3.98±1.09 years respectively. In the diabetic patients fasting plasma glucose (FPG) was similar (p > 0.05) among the ND male and ND female (196.42±3.66 mg/dLvs 188.97±4.43 mg/dL (p > 0.05) but significantly (p < 0.05) higher when compared with HD male and HD female patients (174.39±3.73 mg/dLvs 172.24±3.71 mg/dL). Blood pressure increased significantly (p < 0.05) among the HND male, HD male, HND female and HD female (171.26±3.79/109.25±2.12 mmHg, 177.69±3.16/111.13±2.17 mmHg, 168.98±2.80/105.17±1.80 mmHg and 173.54±3.08/106.01±1.97) respectively when compared with their corresponding controls. In both sexes, the pulse pressure (PP), mean arterial pressure (MAP) and heart rate were significantly (p < 0.05) increased in HND and HD when compared with their

respective control counterparts. While no significant difference ($p > 0.05$) was observed in the mean packed cell volume (PCV) and haemoglobin (Hb) values of ND male, ND female and HD female when compared with their control counterparts; PCV and Hb values of HND male and HND female increased significantly ($p > 0.05$). However, the PCV and Hb of HD male decrease significantly ($p < 0.05$). Plasma creatinine increased significantly ($p < 0.05$) as a result of the presence of either or both diseases. The increase was more marked in HD male. While ND male plasma urea has no significant ($p > 0.05$) difference when compared with their control counterparts, plasma urea in other patients increased significantly ($p < 0.05$), the increase was more marked in HND male. Quantitatively plasma urea of the male and female patients was between 8% to 18% and 20% to 33% respectively higher than their control counterparts. There was significant ($p < 0.05$) difference in gender creatinine and urea concentration. In both controls and patients, plasma creatinine and urea were significantly ($p < 0.05$) higher in male when compared with their female counterparts.

Figure 1 illustrates theeffects of hypertension and/or type 2 diabetes mellitus on plasma FFAs. Thepresence of either or both diseases resulted in significant alterations in the plasma FFAs of the subjects ($p < 0.05$). In the plasma of the patients, there were statistically significant ($p < 0.05$) increase in the mean values of FFAs for both male and female patients when compared with their control counterparts. The increase was more marked in comorbidity female when compared with other patients. Quantitatively plasma FFAs contents of the male and female patients were between 62.42 % to 78.62 % and 19.57 % to 60.74 %higher than their respective control counterparts. There was significant ($p < 0.05$) difference in gender FFAs concentration. In both controls and patients, FFAs in plasma are significantly ($p < 0.05$) higher in male when compared with their female counterparts.

Table 3 shows the oxidative stress as measured by the levels of thiobarbituric acid reactive substances (TBARS) in different compartment (plasma, erythrocytes andlipoproteins) of the subjects. The presence of hypertension, T2DM or comobidity resulted in significant ($p < 0.05$) increase in TBARS levels in the entire different compartment except in the plasma and HDL of hypertensive non-diabetics where a similar ($p > 0.05$) TBARS levels was observed when compared with the CF. Quantitatively, plasma TBARS levels of the male and female patients was between 71% to 91% and 14% to 70% higher respectively than their control counterparts, while that of erythrocytes TBARS was between 77% to 95% and 40% to higher 175% respectively than their control counterparts, whereas HDL TBARS of the male and female patients was between 1.88 to 2.54 times and 1.36 to 3 times higher than their respective control counterparts. Also LDL+VLDL TBARS of the male and female patients was between 2.47 to 2.94 times and 2.14 to 2.76 times higher than their respective control counterparts.

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Table 2: Demograhic and clinical characteristics of the subjects

	Control male	Hyperten-sive non-diabetics male	Normotensive diabetics male	Hypertensive diabetics male	Control female	Hypertensive non-diabetics female	Normotensive diabetics female	Hypertensive diabetics female
Age (years)	42.58±1.36 a	43.29±1.31 a	46.45±1.35 a	46.33±1.52 a	42.70±11.61a	46.75±1.17 a	42.46±11.49 a	44.80±1.32a
SBP (mmHg)	117.16±1.20 a	171.26±3.79c	114.88±1.24a	177.69±3.16d	113.51±1.11a	168.98±2.80b	117.71±2.79a	173.54±3.08c
DBP (mmHg)	77.50±0.98a	109.25±2.12b	78.62±0.76a	111.13±2.17b	76.12±1.15a	105.17±1.80b	78.97±0.79a	106.01±1.97b
PP (mmHg)	39.66±1.30a	62.01±1.96b	36.25±1.08a	66.56±1.47bc	37.39±0.96a	63.81±1.56bc	38.74±2.65a	67.18±1.96c
MAP (mmHg)	90.72±0.86a	129.92±2.63b	90.71±0.81a	133.32±2.45b	88.58±1.04a	126.44±2.05b	91.88±1.20a	128.52±2.21b
Heart rate (beats/mins)	84.60±0.92a	123.76±1.38b	82.86±0.93a	124.96±1.70b	84.14±0.87a	123.40±1.57b	84.06±0.87a	123.04±1.81b
FPG (mg/dL)	71.04±1.32a	77.84±1.40a	196.42±3.66c	174.39±3.73b	75.36±1.41a	75.36±1.73a	188.97±4.43c	172.24±3.71b
Duration of HTN (yrs)	0.00±0.00a	5.04±2.19b	0.00±0.00a	4.87±1.60b	0.00±0.00a	5.26±1.66b	0.00±0.00a	4.94±1.62b
Duration of DM (yrs)	0.00±0.00a	0.00±0.00a	4.07±1.55b	4.05±1.48b	0.00±0.00a	0.00±0.00a	4.22±1.19b	3.98±1.09b
PCV (%)	43.34±0.72b	46.60±0.85c	43.44±0.72b	39.26±0.46a	39.16±0.68a	41.84±0.48b	39.24±0.67a	38.58±0.57a
Haemoglobin (g/dL)	14.41±0.23b	15.41±0.28c	14.42±0.23b	13.07±0.15a	13.17±0.25a	14.16±0.19b	13.23±0.24a	12.84±0.19a
Plasma creatinine (mg/dL)	0.97±0.03ab	1.14±0.04cd	1.10±0.04cd	1.20±0.05d	0.88±0.04a	1.05±0.03bc	1.10±0.04cd	1.09±0.04cd
Plasma urea (mg/dL)	29.24±0.81b	34.59±1.08d	31.53±1.30bc	33.88±0.92d	24.25±1.106a	32.45±1.04cd	29.12±1.04b	30.67±0.97bc

Each value represents the mean±S.E.M.Values within the same row with different superscripts are significantly different at p<0.05

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean aterial pressure; FPG, fasting plasma glucose.
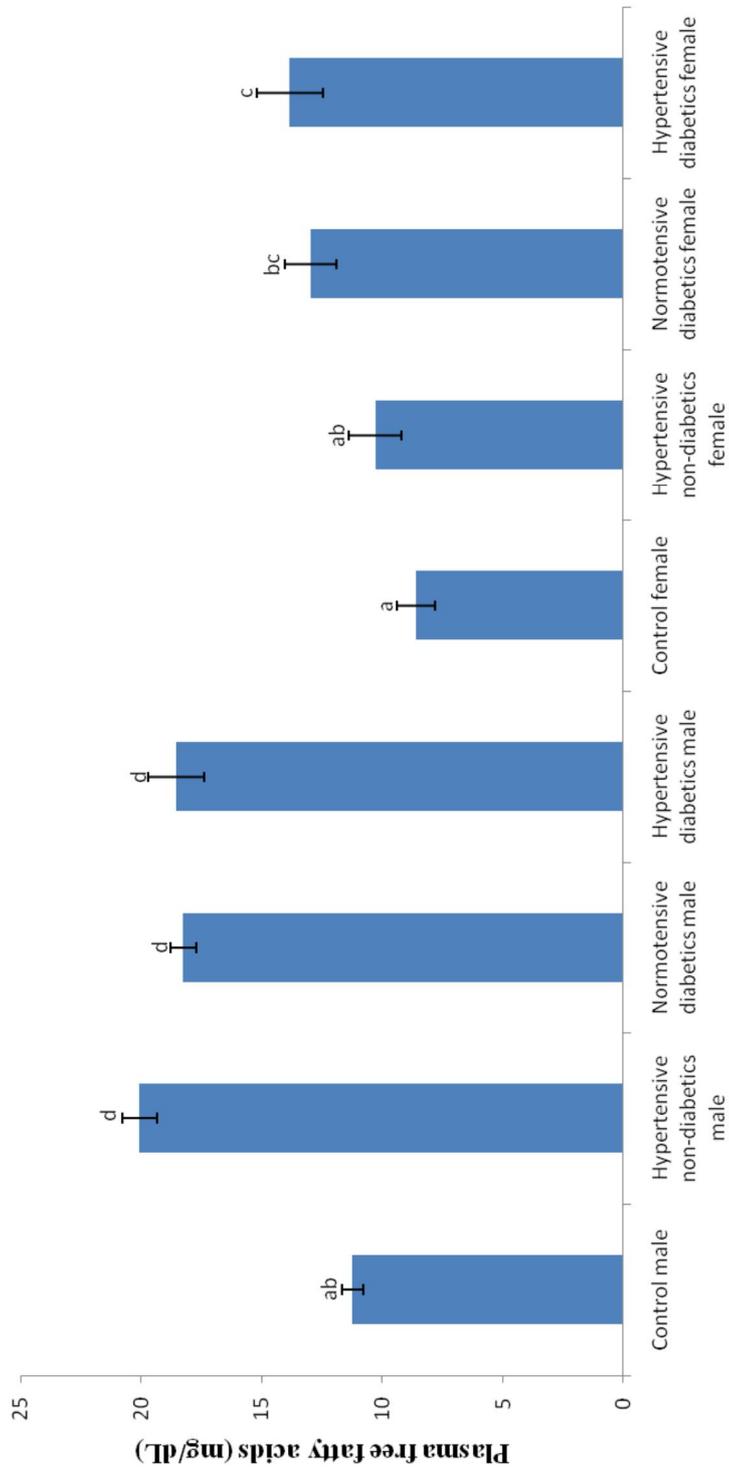
Figure 1: Effects of hypertension and/or type 2 diabetes mellitus on Plasma free fatty acids

Each bar represents the mean±S.E.M. Bars with different alphabets are significantly different at p<0.05

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Table 3: Oxidative stress in the plasma, erythrocytes and lipoproteins of the subjects

	Control male	Hypertensive non-diabetics male	Normotensive diabetics male	Hypertensive diabetics male	Control female	Hypertensive non-diabetics female	Normotensive diabetics female	Hypertensive diabetics female
Plasma (nmol TBARS/ml)	1.37±0.70a	2.34±1.06d	2.46±0.93d	2.61±1.45d	1.19±0.91a	1.35±1.41a	2.02±1.25c	1.82±1.68b
Erythrocytes (nmol TBARS/ml)	1.75±0.83a	3.09±1.62c	3.41±1.42c	3.32±1.74c	1.52±1.13a	2.12±2.20b	3.27±2.00c	2.19±2.01b
HDL (nmol TBARS/ml)	0.50±0.20b	0.94±0.26e	1.27±0.28g	1.10±0.60f	0.31±0.27a	0.42±0.48ab	0.93±0.63d	0.72±0.69c
LDL+VLDL (nmolTBARS/ml)	0.53±0.02a	1.32±0.03c	1.56±0.03e	1.43±0.03d	0.50±0.02a	1.07±0.04b	1.36±0.03cd	1.38±0.03cd

Each value represents the mean±S.E.M. Values within the same row with different superscripts are significantly different at $p < 0.05$

DISCUSSION

Due to the large and growing literature regarding hypertension, diabetes and hyperlipidaemia as a risk factor for cardiovascular disease in African populations, and the increasing incidents of death due to cardiovascular disease in both urbanized and under-developed rural countries in Africa (Glew *et al.*, 2002, Oladapo *et al.*, 2010), it is imperative to determine possible risk factors accounting for this scenario. One of such risk factors is abnormal lipid profile; hence we were compelled to characterize the plasma free fatty acids (FFAs) and we also compare our data with that for population outside Africa.

The major finding of this study was that the presence of hypertension and/or T2DM perturbs the metabolism of FFAs in the plasma of the patients. These perturbations were reflected as up-regulation of the concentrations of the free fatty acids and oxidative stress.

The significant elevated FFAs implies increased mobilization of triacylglycerols from the adipose tissue; decrease hepatic uptake of FFAs hence decrease energy metabolism (production); enhanced oxidative stress, endothelial dysfunction, increased inflammation; and increased uptake of oxidized LDL in macrophages which is an essential step in development of atherosclerosis.

To maintain normal homeostasis, the organism must maintain physiological levels of metabolites in its diverse metabolic process. A distortion of these levels might have serious physiological consequences for the organism. In this study, an increase was observed in patients' plasma FFAs. FFAs in plasma are derived from hydrolysis of adipose tissue's triacylglycerols. Hence, elevation of plasma free fatty acids also implies increased mobilization of these lipids from the adipose tissue (Newsholme and Start, 1981). Mobilization of fatty acids is known to occur in higher animals in response to both psychological and physiological stress (Newsholme and Start, 1981, Ademuyiwa *et al.*, 2008).

Increased free fatty acid level is known to have a causal relationship with oxidative stress (Yamato *et al.*, 2007; Du *et al.*, 2006; Furukawa *et al.*, 2004; Yamaguchi *et al.*, 2006). Oxidative stress as measured by thiobarbituric acid reactive substances increased significantly in different compartments (plasma, erythrocytes and lipoprotiens) of the patients. Thus, the observation of elevated plasma FFAs in the patients suggest a hypertension and T2DM-indused augmentation of triacylglycerols hydrolysis resulting into FFAs by the triacylglycerols lipase and the attendant increased mobilization of the FFAs into the plasma. The physiological consequences of this elevated plasma FFAs could be diverse and could be viewed from the metabolic role of FFAs. Free fatty acid is the major source of metabolic fuel in many tissues including the liver, heart, kidney, muscle, lung, testis, brain and the adipose tissue, although the brain cannot extract them from the blood (Kurokawa *et al.*, 1985). Thus, the increased plasma FFAs in the hypertension and T2DM patients indicate that hepatic uptake of these lipids was inhibited by these diseases, hence compromising energy metabolism (production) in the liver (Ademuyiwa *et al.*, 2008).

There is growing evidence that FFAs contribute to sudden cardiac death, also an excess of FFAs has been implicated in insulin

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resistance and hepatic steatosis (Oliver, 2006; Blaak, 2003). Furthermore, elevated FFAs are associated with atherosclerosis and hypertension. Fatty acid oxidation supplies the heart with ~70% of its energy but an overwhelming delivery of plasma FFAs to the heart, as it is observed in acute coronary syndrome and heart failure, may contribute to myocardial dysfunction (Pilz *et al.*, 2007). High FFAs and subsequent increased utilization of fatty acids for energy generation in the ischaemic myocardium may cause a 'metabolic crisis' in patients with CAD because fatty acid oxidation requires more oxygen when compared with the use of glucose (Pilz *et al.*, 2007). Also elevated FFAs may be directly involved in the development of atherosclerosis because it was reported that FFAs are associated with endothelial dysfunction and induce endothelial apoptosis and the expression of endothelial adhesion molecules (Oram and Bornfeldt, 2004). Further, pro-atherosclerotic features of FFA involve their contribution to macrophage to foam cell formation and their pro-inflammatory effects (Oram and Bornfeldt, 2004). Apart from this, high concentrations of FFAs have been shown to exert pro-arrhythmic actions (Oliver, 2006). The population-based Paris Prospective study has already shown that elevated levels of FFA are predictive for sudden cardiac death (Pilz *et al.*, 2007) which is one of the outcomes of hypertension.

Oxidative stress as measured by TBARS increased in plasma, erythrocytes and lipoproteins. The greatest increase was observed in concurrent hypertensive T2DM patients in all the compartments (plasma, erythrocytes and lipoproteins). It is well demonstrated that increased oxidative stress underlies the pathophysiology of hyperten-

sion by directly influencing vascular cell walls and oxidative stress has been associated with the onset of cardiovascular complications in subjects with the metabolic syndrome (Shin *et al.*, 2009). Several observational and experimental studies showed impaired antioxidant systems with decrease in antioxidant capacity and increase in lipid peroxidation in MetS (Shin *et al.*, 2009), which is consistent with our results. Hyperglycemia, a key component of the MetS, might trigger oxidative stress by several mechanisms either independently or associated with other conditions. It includes glucose auto-oxidation, advanced glycated end product (AGE) formation, abnormal arachidonic acid metabolism and its coupling to cyclooxygenase catalysis (Grattagliano *et al.*, 2008). The enhanced lipid peroxidation in hypertension with diabetes, shown in the present study, can be explained, in part, through the mechanisms mentioned above. Considering the atherogenic effect of oxidative alterations in the atherosclerotic process, our results provide a possible mechanism which links MetS in hypertension to increased cardiovascular risks.

Since the male and female controls in the present study were of approximately the same age as the patients who had experienced hypertension and/or T2DM, we did not have to be concerned that our conclusions regarding lipid profiles levels in the patient and control groups may have been confounded by age considerations. Furthermore, the possible confounding variable of age appears not to have been a factor in our study because when we tested for possible correlations between LDL-cholesterol, total cholesterol, HDL-cholesterol or triacylglycerols versus age (table not shown) in both female and male pairs, none was found.

However, sex was found to be a possible determinant of the pattern of lipid profile levels in the patients.

There was significant difference in gender FFAs concentration. In both controls and patients, FFAs in plasma are significantly (p < 0.05) higher in male when compared with their female counterparts. In this report, we noted that elevated plasma FFAs were found to be significantly higher in males than in females. Cook *et al.* (2000) in their report on gender differences in pattern of dyslipidaemia noted that elevated LDL-C and reduced HDL-C were more commonly documented in females than males. Bowden (2010) found gender differences in the HDL-C, LDL-C and TAG components of the lipid profile in non-diabetic individuals. From the foregoing it is evident that gender differences are consistently noted in other lipids apart from FFAs (which was shown in our study) in apparent healthy individuals and patient with hypertension and/or T2DM.

CONCLUSION

This research revealed biochemical variations in hypertension and/or T2DM characterised by gender-related elevation in FFAs and oxidative stress. Up-regulation of plasma FFAs and oxidative stress marker (malondialdehyde in plasma, erythrocytes and lipoproteins) in hypertension and/or T2DM were more pronounced in male than their female counterparts.

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