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Assessing cardiovascular status using biomarkers and anthropometry among patients with Type-2 Diabetes in a resource limited setting

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ABSTRACT

Background: Diabetes places extra-burden on those affected with the condition particularly in resource constraint settings. Inaccessibility to affordable diagnostic procedures poses a major challenge to the assessment of cardiovascular status in patients with type-2 diabetes in resource limited settings. The study was aimed at evaluating some easily accessible biochemical markers and anthropometric indices implicated in cardiovascular disease amongst T2DM patients.

Methods: One hundred and sixty (160) type-2 diabetic patients grouped into type-2 diabetes only as group 1, type-2 diabetic patients diagnosed with hypertension as group 2, and eighty (80) age and sex-matched controls as group 3, were enrolled in a cross-sectional pattern. Biochemical parameters were assayed using standard laboratory methods. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20.0 with statistical significance considered at $p \leq 0.05$.

Results: The values obtained for diabetic groups were: Glycated Hemoglobin (HbA1c) 9.07±1.99, 10.15±4.98, Total Homocysteine (tHcy) 14.85±52.10, 28.35±100.35, high sensitivity C-reactive protein (hs-CRP) 6.72±6.78, 10.00±11.15, Waist Circumference, 92.58±1.55, 93.65±18.91, Hip Circumference, 96.87±9.01, 98.96±20.33, Systolic Blood Pressure, 113.50±12.94, 135.50±22.72, Diastolic Blood Pressure, 70.75±8.57, 75.38±12.62, Body Mass Index, 25.40±4.70, 26.93±6.50 (among patients) and HbA1c 5.81±0.86, tHcy 0.75±1.44, hs-CRP 5.30±6.19, Waist Circumference 83.15±10.69, Hip Circumference 93.50±22.05, Systolic Blood Pressure, 113.50±10.20, Diastolic Blood Pressure, 77.00±7.19, Body Mass Index, 24.84±4.93 (among controls).

Conclusion: The assessment of some cardio metabolic markers and anthropometric indices may provide easy and accessible tools for prediction and assessment of cardiovascular disease in patients with T2DM especially in resource poor settings.

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Keywords: non-communicable, anthropometry, Diabetes, heart disease

INTRODUCTION

Despite decrease in the incidences of diabetes mellitus-associated complications in the past two decades (Gregg *et al.*, 2014), its substantial effects

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on individuals, families, healthcare systems and socioeconomic growth cannot be disregarded (WHO, 2017). Cardiovascular disease (CVD) is 2-4 folds more prevalent and the leading cause of early deaths among diabetic patients (Tarkun *et al.*, 2003; Rahman *et al.*, 2009). Type 2 diabetes mellitus (T2DM) has been linked with increased risks of hypertension, myocardial infarction, intermittent claudication and stroke (Giorda *et al.*, 2007; Rahman *et al.*, 2009; Chiha *et al.*, 2012; Martín-Timón *et al.*, 2014). Diabetic patients have been reported to have an increased diagnosis of new heart failure (HF) even in the absence of a baseline heart failure, frequent hospitalization and/or death from HF compared to those without T2DM (Rosano *et al.*, 2017; Kenny and Abel, 2019; Wilkinson *et al.*, 2019). The risk for HF increases 5-fold in women and 2.4-fold in men with diabetes in some climes (Wang *et al.*, 2016).

Type-2 diabetes is characterized by metabolic changes which link hyperglycemia to other risk factors (Lima *et al.*, 2007) including hypercoagulability, dysglycemia, dyslipidemia, hypertension (Rahman *et al.*, 2009), obesity, overweight (Cheung and Li, 2012), inflammation (Rahman *et al.*, 2017), insulin resistance (Lopez-Candales *et al.*, 2017) and/or elevations in homocysteine concentrations (Malaguarnera *et al.*, 2014; El-Maghraby *et al.*, 2016). Life-style and dietary changes that trigger obesity and overweight have been linked with the T2DM epidemic (Gillies *et al.*, 2007). Improvements of traditional risk factors such as blood pressure, body mass index, total cholesterol and dietary modification have shown to evidently reduce the risk of hypertension in patients with type-2 diabetes (Abdul-Ghani *et al.*, 2017).

Insulin resistance syndrome (IRS) is a key component responsible for increased risk of CVD in T2DM but molecular mechanisms involved directly in the pathogenesis of IR are independent of accompanying metabolic abnormalities linked to T2DM (DeFronzo, 2009). As a result obese non-diabetic individuals with IRS present with increased risk of CVD, impaired glucose tolerance, dyslipidemia and hypertension compared with obese diabetic patients (Eckel *et al.*, 2005; Eddy *et al.*, 2009).

Data from epidemiological studies (Khaw *et al.*, 2004; Gerstein *et al.*, 2005; Elley *et al.*, 2008; Eeg-Olofsson *et al.*, 2010) support the link between cardiovascular disease risk and hyperglycemia. Improved glycemic control associated cardiovascular benefits among diabetic patients (Holman *et al.*, 2008; Hayward *et al.*, 2015) and increased risk of atherosclerotic cardiovascular disease (Selvin *et al.*, 2004) in the presence of coexistent dysglycaemia have also been reported. Contrarily, some studies (Patel *et al.*, 2008; Gerstein *et al.*, 2010) have reliably established that HbA1c reduction in type-2 diabetic patients does not have or have unassertive influence on cardiovascular disease risk worsening (Marso *et al.*, 2016).

Although, there are controversies regarding plasma tHcy levels in T2DM. Prospective studies (Avramoglu *et al.*, 2006; Lorenzo *et al.*, 2013) have shown an independent association between elevated plasma tHcy level, prediction of early cardiovascular events and all-cause mortality amongst diabetics. Plasma tHcy levels in type 2 diabetic patients are reported to be similar to or higher than those in healthy subjects (Drzewoski *et al.*, 1999; El-Maghraby *et al.*, 2016). On the contrary, studies by Bansal *et al.* (2016) and Smulders *et al.* (1999) found no significant differences in fasting plasma tHcy levels between type 2 diabetic patients and healthy subjects.

High-sensitivity C-reactive protein (hs-CRP) is considered a stable inflammatory biomarker of arterial wall inflammation, preclinical atherosclerosis and systemic endothelial dysfunction (Tabas *et al.*, 2015) that adds cardiovascular prognostic information beyond traditional risk factors among T2DM patients (Kiran *et al.*, 2017). Although in the past, atherosclerosis was considered a bland lipid storage disease, recent studies have showed that inflammation, underlying cellular, molecular mechanisms and pathophysiologic factors are contributors of atherogenesis (Schillinger *et al.*,

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2003; Hopkins, 2013).

The study is aimed at evaluating some easily accessible biochemical markers and anthropometric indices implicated in cardiovascular disease amongst T2DM patients.

MATERIALS AND METHODS

Study Area and Population

The study was carried out in Dutse, Jigawa State, North-western Nigeria. A total of two hundred and forty (240) participants, one hundred and sixty (160) type 2 diabetic patients aged 29-60 years; eighty (80) type 2 diabetic patients diagnosed without hypertension (Group 1), eighty (80) type 2 diabetes diagnosed with hypertension (Group 2) and eighty (80) control subjects (Group 3) were recruited into the study through convenience sampling in a cross-sectional pattern. Patients with a history of liver diseases, renal impairment, pregnant women and those who did not consent to participate in the study were excluded. The controls were afebrile, apparently healthy volunteers, matched for gender and age after a complete clinical examination by the physician, with or without a self-reported family history of diabetes or hypertension. Anthropometric indices including weight, height, body mass index, waist circumference, hip circumference, systolic and diastolic blood pressure were measured and documented. Relevant data was obtained using the clinical records and a detailed interviewer-based administered questionnaire. Participants provided informed consent in written form before being enrolled into the study.

Ethical Consideration

Ethical approval was sought and granted by the research ethical committee of Rasheed Shekoni Specialist Hospital Dutse, Jigawa State. Ref: RSSH/GEN/226/V.1/36.

Sample Collection and Laboratory Methods

Five milliliters (5ml) of blood was collected via venipuncture from all participants after a 10-hour overnight fast and transferred into EDTA and plain tubes respectively. Plasma total homocysteine (tHcy) and serum high sensitivity C-reactive protein (hs-CRP) were assayed using Enzyme Linked Immunosorbent Assay (ELISA) (Cusabio, China and Monobind Inc, USA), Glycated haemoglobin (HbA1c) was assayed using Immunoturbidimetric assay (Centronic GmbH, Germany). Enzymatic colorimetric methods were used for the assay of lipid profile and fasting plasma glucose using test kits (Agappe diagnostics Switzerland GmbH).

Cut-off for Biochemical Parameters and Anthropometric Indices

Blood pressure Measurement

Normal: Systolic Blood Pressure ≤120 mmHg, Diastolic Blood Pressure ≤80 mmHg.

Prehypertension: Systolic Blood Pressure 120-140 mmHg, Diastolic Blood Pressure 80-90 mmHg.

Hypertension: Systolic Blood Pressure ≥140 mmHg, Diastolic Blood Pressure ≥90 mmHg.

Waist circumference range: Male: 83-98 cm, Female: 78-91 cm.

Hip circumference range: Male: 94-107cm, Female: 97-108 cm.

Body Mass Index Stratification: Underweight: ≤18.5, Normal: 18.5-24.9, Over weight: 25.0-29.9, Obese: ≥30.0.

Total homocysteine (tHcy): Low risk ≤0.78 nmol/l, Normal: 0.78-50.0 nmol/l, High risk: ≥50 nmol/l.

High sensitivity C-reactive protein (hs-CRP): Low risk ≤1.0 μg/ml, Normal: 1-3 μg/ml, High risk: ≥3.0 μg/ml.

Glycated hemoglobin (HbA1C): Low risk ≤6.0%, Normal: 6-9%, High risk: ≥9.0%.

Fasting Plasma Glucose was assessed using the American Diabetes Association Criteria 2010.

The cut-off for total cholesterol, high-density lipoprotein cholesterol, triglycerides and low-density lipoprotein cholesterol were based on local reference ranges.

Statistical Analysis

Statistical Package for Social Sciences version 20.0 (SPSS Inc., Chicago, Illinois, USA) software was used for the statistical analysis of data obtained.

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Statistical significance was considered as p≤0.05 and presented as frequency, percentages, mean ± SD, Unpaired Student's t-test and One-way ANOVA.

RESULTS AND DISCUSSION

Individuals at increased risk of cardiovascular disease (CVD) may exhibit overweight, obesity, hyperglycemia, hyperlipidemia and hypertension (Rahman *et al.*, 2017). Comparable to previous reports (Giorda *et al.*, 2007; Rahman *et al.*, 2011; Petrie *et al.*, 2018; Kenny and Abel, 2019) of increased body mass index (BMI) among type 2 diabetic patients. Our study observed a similar trend among type 2 diabetes (T2D) patients with a marked difference between healthy individuals and T2DM patients diagnosed with hypertension (HTN). Contrary to our report, Gillies *et al.* (2007) reported increased BMI among type 2 diabetic patients not diagnosed with hypertension. Whether BMI imparts HTN in T2DM or vice versa was not detailed in our study. Our study also verified that increased waist and hip circumference is commoner in type 2 diabetic patients compared to apparently healthy individuals and our finding is similar to (Lima *et al.*, 2007). We suggest that waist circumference may be a more promising anthropometric measure in comparison to hip circumference in predicting cardiovascular disease.

Our findings of elevated systolic blood pressure (SBP) among diabetic patients diagnosed with hypertension compared to healthy individuals may provide insights into the independent consideration of SBP as a more specific measure for diagnosis of hypertension and may serve as an inexpensive screening tool for assessing prehypertension among healthy individuals. The variation of diastolic blood pressure (DBP) across the groups suggests that DBP is a sensitive not specific marker for hypertension. The reported incidences of prehypertension in the control group may be attributable to the increased prevalence of the family history of hypertension in the group. Our findings is in concordance with the studies of

Table 1: Socio-demographic Characteristics of the Study Participants

Variables	Group 1, n = 80(%)	Group 2, n = 80(%)	Group 3, n = 80(%)
Age group (years)			
≤ 29	6 (7.5)	0 (0)	40 (50.0)
30 – 50	36 (45.0)	30 (37.5)	40 (50.0)
51 and above	38 (47.5)	50 (62.5)	0 (0.0)
	Mean ± SD	**Mean ± SD**	**Mean ± SD**
Mean age	49.3 ± 13.4 years	55.3 ± 9.4 years	30.2 ±6.1 years
Gender			
Male	32 (40.0)	58 (72.5)	36 (45.0)
Female	48 (60.0)	22 (27.5)	44 (55.0)
Family history of DM			
Present	23 (28.8)	40 (50.0)	28 (35.0)
Absent	57 (71.3)	40 (50.0)	52 (65.0)
Family history of hypertension			
Present	28 (35.0)	45 (56.2)	44 (55.0)
Absent	52 (65.0)	35 (43.8)	36 (45.0)
Family history of obesity			
Present	35 (43.8)	54 (67.5)	8 (10.0)
Absent	45 (56.2)	26 (32.5)	72 (90.0
Duration of DM (years)			
1 – 5	46 (57.5)	51 (63.8)	-
6 and above	34 (42.5)	29 (36.2)	-
	Mean ± SD	**Mean ± SD**	
Mean duration	5.7 ± 4.7 (mmol/l)*	4.8 ± 4.1 (mmol/l)*	

Data presented as frequency (percent); DM = type2 Diabetes Mellitus, SD = Standard Deviation

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Table 2: Categorization of Anthropometric Indices and Biochemical Parameters of the Participants

Variables	Group 1, n = 80(%)	Group 2, n = 80(%)	Group 3, n = 80(%)
Waist circumference (cm)			
Normal	48 (60.0)	53 (66.2)	67 (83.8)
Abnormal	32 (40.0)	27 (33.8)	13 (16.2)
Mean±SD	92.58±11.55	93.65±18.91	83.15±10.69
Hip circumference (cm)			
Normal	51 (63.8)	50 (62.5)	72 (90.0)
Abnormal	29 (36.2)	30 (37.5)	8 (10.0)
Mean±SD	96.82±9.01	98.96±20.33	93.50±22.05
SBP (mmHg)			
Normal	40 (50.0)	17 (21.3)	44 (55.0)
Pre-hypertension	40 (50.0)	20 (25.0)	36 (45.0)
Hypertension	0 (0.0)	43 (53.8)	0 (0.0)
Mean±SD	113.50±12.94	135.50±22.72	113.50±10.20
DBP (mmHg)			
Normal	58 (72.5)	45 (56.2)	20 (25.0)
Pre-hypertension	22 (27.5)	15 (18.8)	60 (75.0)
Hypertension	0 (0.0)	20 (25.0)	0 (0.0)
Mean±SD	70.75±8.57	75.38±12.62	77.00±7.19
Combined (SBP &DBP) status			
Absent	80 (100.0)	74 (92.5)	80 (100.0)
Present	0 (0.0)	6 (7.5)	0 (0.0)
BMI (kg/m²)			
Under weight	14 (17.5)	2 (2.5)	8 (10.0)
Normal	21 (26.3)	36 (45.0)	40 (50.0)
Over weight	30 (37.5)	20 (25.0)	24 (30.0)
Obese	15 (18.8)	22 (27.5)	8 (10.0)
Mean ± SD	25.40 ± 4.70	26.93 ± 6.50	24.84 ± 4.93
Glycated haemoglobin (%)			
Low risk	13 (16.3)	3 (3.8)	44 (55.0)
Normal	37 (46.3)	38 (47.5)	36 (45.0)
High risk	30 (37.5)	39 (48.7)	0 (0.0)
Fasting plasma glucose(mmol/l)			
Normal	42 (52.5)	30 (37.5)	80 (100.0)
Abnormal	38 (47.5)	59 (62.5)	0 (0.0)
Total homocysteine (nmmol/l)			
Low risk	62 (77.5)	56 (70.0)	72 (90.0)
Normal	10 (12.5)	18 (22.5)	8 (10.0)
High risk	8 (10.0)	6 (7.5)	0 (0.0)
hs C-reactive Protein (µg/ml)			
Low risk	3 (3.8)	7 (8.8)	4 (5.0)
Normal	20 (25.0)	13 (16.3)	36 (45.0)
High risk	57 (71.2)	60 (75.0)	40 (50.0)
Total cholesterol (mmol/l)			
Normal	77 (96.2)	64 (80.0)	80 (100.0)
Abnormal	3 (3.8)	16 (20.0)	0 (0.0)
HDL-cholesterol (mmol/l)			
Normal	77 (96.2)	70 (87.5)	72 (90.0)
Abnormal	3 (3.8)	10 (12.5)	8 (10.0)
Triglycerides(mmol/l)			
Normal	54 (67.5)	64 (80.0)	56 (70.0)
Abnormal	26 (32.5)	16 (20.0)	24 (30.0)
LDL-cholesterol (mmol/l)			
Normal	77 (96.2)	68 (85.0)	80 (100.0)
Abnormal	3 (3.8)	12 (15.0)	0 (0.0)

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Table 3: Mean and Median of Biochemical parameters in the three groups

Parameters	Groups, n = 80	Mean ± SD	Median (IQR)
Glycated haemoglobin (%)	1	10.15 ± 4.98*	8.35 (7.60 – 10.95)
	2	9.07 ± 1.99	8.70 (8.00 – 10.50)
	3	5.81 ± 0.86	5.65 (5.00 – 6.73)
FBG (mmol/L)	1	7.83 ± 3.83*	6.40 (4.80 – 10.80)
	2	7.74 ± 3.67*	7.30 (5.10 – 8.10)
	3	4.89 ± 0.99	5.00 (4.20 – 5.65)
Total homocysteine (nmmol/L)	1	28.35 ± 100.82*	0.51 (0.23 – 0.70)
	2	14.85 ± 52.10*	0.65 (0.45 – 1.06)
	3	0.75 ± 1.44*	0.42 (0.26 – 0.55)
hs C-reactive Protein (µg/mL)	1	10.00 ± 11.15*	6.15 (2.88 – 10.82)
	2	6.72 ± 6.78	5.20 (3.04 – 7.68)
	3	5.30 ± 6.19	2.98 (1.59 – 6.34)
Total cholesterol (mmol/L)	1	3.30 ± 0.70	3.25 (2.80 – 3.70)
	2	3.40 ± 0.94	3.50 (2.93 – 4.00)
	3	3.63 ± 0.55	3.60 (3.01 – 4.10)
HDL-cholesterol (mmol/L)	1	1.12 ± 0.30	1.10 (1.90 – 1.40)
	2	1.24 ± 0.50*	1.10 (1.90 – 1.40)
	3	1.26 ± 0.35	1.30 (1.00 – 1.58)
Triglycerides(mmol/L)	1	0.79 ± 0.43*	0.60 (0.40 – 1.10)
	2	0.84 ± 0.56*	0.70 (0.50 – 1.00)
	3	0.75 ± 0.48*	0.60 (0.40 – 0.85)
LDL-cholesterol (mmol/l)	1	1.88 ± 0.67*	1.85 (1.40 – 2.40)
	2	1.81 ± 0.83*	1.90 (1.20 – 2.20)
	3	2.03 ± 0.55	2.00 (1.63 – 2.40)

Table 4: Variation in Biochemical Parameters and Anthropometric Indices between groups 1 and 3

Parameters	n = 80	Mean ± SD	t-value	p-value	Mean diff	95% CI
Glycated haemoglobin (%)	1	10.15 ± 4.98*	7.691	< 0.001	4.349	3.2319 – 5.466
	3	5.81 ± 0.86				
FBG (mmol/l)	1	7.83 ± 3.83*	6.679	< 0.001	2.948	2.0759 - 3.819
	3	4.89 ± 0.99				
Total homocysteine (nmmol/l)	1	28.35 ± 100.82*	2.448	0.015	27.598	5.3316 - 49.86
	3	0.75 ± 1.44*				
hs C-reactive Protein (µg/ml)	1	10.00 ± 11.15*	3.296	0.001	4.7	1.8837 – 7.517
	3	5.30 ± 6.19				
Total cholesterol (mmol/l)	1	3.30 ± 0.70	-3.331	0.001	-0.33	-0.5300 - 0.135
	3	3.63 ± 0.55				
HDL-cholesterol (mmol/l)	1	1.12 ± 0.30	-2.739	0.007	-0.141	-0.2431 - 0.039
	3	1.26 ± 0.35				
Triglycerides(mmol/l)	1	0.79 ± 0.43*	0.485	0.628	0.4	-0.1075 - 0.178
	3	0.75 ± 0.48*				
LDL-cholesterol (mmol/l)	1	1.88 ± 0.67*	-1.469	0.144	-1.469	-0.0486 - 0.144
	3	2.03 ± 0.55				
Waist circumference (cm)	1	92.58 ± 11.55	5.359	< 0.001	9.43	5.9560 - 12.907
	3	83.15 ± 10.69				
Hip circumference (cm)	1	96.82 ± 9.01	1.247	0.214	3.32	-1.9400 - 8.580
	3	93.50 ± 22.05				
SBG (mmHg)	1	113.50 ± 12.94	0	1	0	-3.6380 - 3.638
	3	113.50 ± 10.20				
DBG (mmHg)	1	70.75 ± 8.57	-5.01	< 0.001	-6.25	-8.7140 - 3.786
	3	77.00 ± 7.19				
BMI (kg/m2)	1	25.40 ± 5.34	0.691	0.491	0.56	-1.0429-2.1654
	3	24.84 ± 4.93				
Age (years)	1	49.30 ± 13.40	11.621	< 0.001	19.15	15.895 – 22.405
	3	30.15 ± 6.13				

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Table 5: Variation in Biochemical Parameters and Anthropometric Indices across the groups

Parameters	n=80	Mean ± SD	f –value	p-value
Glycated haemoglobin (%)	1	10.15 ± 4.98*	41.375	< 0.001
	2	9.07 ± 1.99		
	3	5.81 ± 0.86		
Fasting plasma glucose(mmol/l)	1	7.83 ± 3.83*	23.167	< 0.001
	2	7.74 ± 3.67*		
	3	4.89 ± 0.99		
Total homocysteine (nmmol/l)	1	28.35 ± 100.82*	3.458	0.030
	2	14.85 ± 52.10*		
	3	0.75 ± 1.44*		
hs C-reactive Protein (µg/ml)	1	10.00 ± 11.15*	6.687	< 0.001
	2	6.72 ± 6.78		
	3	5.30 ± 6.19		
Total cholesterol (mmol/l)	1	3.30 ± 0.70	4.187	0.016
	2	3.40 ± 0.94		
	3	3.63 ± 0.55		
HDL-cholesterol (mmol/l)	1	1.12 ± 0.30	3.020	0.051
	2	1.24 ± 0.50*		
	3	1.26 ± 0.35		
Triglycerides(mmol/l)	1	0.79 ± 0.43*	0.785	0.457
	2	0.84 ± 0.56*		
	3	0.75 ± 0.48*		
LDL-cholesterol (mmol/l)	1	1.88 ± 0.67*	1.998	0.138
	2	1.81 ± 0.83*		
	3	2.03 ± 0.55		
Waist circumference (cm)	1	92.58 ± 11.55	13.238	< 0.001
	2	93.65 ± 18.91		
	3	83.15 ± 10.69		
Hip circumference (cm)	1	96.82 ± 9.01	1.849	0.160
	2	98.96 ± 20.33		
	3	93.50 ± 22.05		
Systolic blood pressure (mmHg)	1	113.50 ± 12.94	49.162	< 0.001
	2	135.50 ± 22.72		
	3	113.50 ± 10.20		
Diastolic blood pressure(mmHg)	1	70.75 ± 8.57	8.891	< 0.001
	2	75.38 ± 12.62		
	3	77.00 ± 7.19		
BMI (kg/m2)	1	25.40 ± 5.34	2.959	0.054
	2	26.93 ± 6.50		
	3	24.84 ± 4.93		
Age (years)	1	49.30 ± 13.40	135.662	< 0.001
	2	55.33 ± 9.41		
	3	30.15 ± 6.13		

*skewed, SD = Standard Deviation, BMI =Body Mass Index

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Table 6: Variation in Biochemical Parameters and Anthropometric Indices between groups 2 and 3

Parameters	n=80	Mean ± SD	t-value	p-value	Mean diff	95% CI
Glycated haemoglobin (%)	2	9.07 ± 1.99	13.451	<0.001	3.268	2.7881-3.7480
	3	5.81 ± 0.86				
FBG (mmol/L)	2	7.74 ± 3.67*	6.711	<0.001	2.854	2.0142-3.6943
	3	4.89 ± 0.99				
Total homocysteine (mmol/L)	2	14.85 ± 52.10*	2.418	0.017	14.2	2.57935-25.599
	3	0.75 ± 1.44*				
hs C-reactive Protein (µg/mL)	2	6.72 ± 6.78	1.383	0.169	1.419	-0.6083-3.4470
	3	5.30 ± 6.19				
Total cholesterol (mmol/L)	2	3.40 ± 0.94	-1.935	0.055	-0.230	-0.4750-0.0050
	3	3.63 ± 0.55				
HDL-cholesterol (mmol/L)	2	1.24 ± 0.50*	-0.333	0.74	-0.020	-0.1561-0.1111
	3	1.26 ± 0.35				
Triglycerides(mmol/L)	2	0.84 ± 0.56*	1.174	0.242	0.090	-0.6560-0.2581
	3	0.75 ± 0.48				
LDL-cholesterol (mmol/L)	2	1.81 ± 0.83*	-1.935	0.055	-0.220	-0.4320-0.0045
	3	2.03 ± 0.55				
Waist circumference (cm)	2	93.65 ± 18.91	4.323	<0.001	10.50	5.7030-15.2970
	3	83.15 ± 10.69				
Hip circumference (cm)	2	98.96 ± 20.33	1.627	0.106	5.460	-1.1680-12.078
	3	93.50 ± 22.05				
SBP (mmHg)	2	135.50 ± 22.72	7.901	<0.001	22.00	16.500-27.5000
	3	113.50 ± 10.20				
DBP (mmHg)	2	75.38 ± 12.62	-1.001	0.319	-1.620	-4.8330-1.5830
	3	77.00 ± 7.19				
BMI (kg/m2)	2	26.93 ± 6.50	2.293	0.023	2.090	0.2899-3.89260
	3	24.84 ± 4.93				
Age (years)	2	55.33 ± 9.41	20.056	<0.001	25.18	22.6960-27.654
	3	30.15 ± 6.13				

**Skewed, SD = Standard Deviation, BMI =Body Mass Index*

(Rahman *et al.*, 2009; Petrie *et al.*, 2018) but contrary to the report of (Giorda *et al.*, 2007). Our report brings to fore the possible constellation of anthropometric indices as early predictors of cardiovascular risk in patients with T2DM and the general population.

Our study demonstrated the independent relationship between hyperglycemia, HbA1c levels, diabetes and hypertension. Evidently, glycemic status among healthy non-obese individuals may not serve as an independent early predictor for T2DM and hypertension especially in the presence of a family history of diabetes. Conversely, non-traditional risk factors linked to insulin resistant states may predict CVD outcomes independent of hyperglycemia in healthy individuals. Nonetheless, hyperglycemia may be an independent risk factor for overt cardiovascular disease in the presence of other metabolic, biochemical and physiological changes that may trigger macro or microvascular complications regardless of glycemia. The outcome of our study is in agreement to that of Abdul-Ghani *et al.* (2017) and Gillies *et al.* (2007).

Hyperhomocysteinemia is a known risk factor for atherogenesis, CVD and incident T2DM. Majority of our study participants regardless of the group belonged to the tHcy low risk strata. This may be credited to the hypothesis that low homocysteine level serves as an indication of early loss of pancreatic beta cell function independent of glycemia, traditional and non-traditional risk factors for cardiovascular disease. We observed that minority of the participants had abnormal plasma tHcy values particularly type 2 diabetic patients not diagnosed

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with hypertension.

The discovery may imply that T2DM may be considered a CVD equivalent since hyperhomocysteinemia is influenced by insulin resistance and intact pancreatic beta cell function. Our study found elevations in plasma tHcy levels among patients diagnosed with T2DM as reported by (Gillies *et al.*, 2007; Lima *et al.*, 2007; Rahman *et al.*, 2009; Abdul-Ghani *et al.*, 2017). Conversely Gillies *et al.* (2007) reported higher incidences of hyperhomocysteinemia among type 2 diabetic patients diagnosed with hypertension. Screening for tHcy in asymptomatic diabetic patients and healthy individuals may be considered in clinical practice to assess pancreatic function and serve as an early predictor of T2DM or CVD risk in resource constraint settings.

The relationship between increased hs-CRP concentrations and risk of incident type 2 diabetes is well established (Chiha *et al.*, 2012; Dongway *et al.*, 2015) although Kenny and Abel (2019) reported a contrary finding. Patients with elevated hs-CRP often times present with increased risk of coronary heart disease (Petrie *et al.*, 2018) and are likely to benefit from specific lifestyle interventions (Chiha *et al.*, 2012). Our study reported about two-third of type 2 diabetic patients and 50% of healthy individuals were within the high-risk strata for hs-CRP which is similar to the reports of (Rahman *et al.*, 2011; Petrie *et al.*, 2018; Wilkinson *et al.*, 2019). The cofounder in our study may be increased age of the type 2 diabetic patients since hs-CRP has been reported to increase with age (Wilkinson *et al.*, 2019). Whether the family history of diabetes, hypertension and/or obesity among healthy individuals imparts hs-CRP concentrations remains vague in our study. We suggest that larger epidemiological studies consider the family history of participants prior to hs-CRP baseline assay.

The pattern of diabetic dyslipidemia we observed in our study was characterized by hypertriglyceridemia, decreased levels of total cholesterol (TC), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein-cholesterol (HDL-C). Our finding suggests the significant role hypertriglyceridemia plays in diabetic dyslipidemia. Our finding validates the indispensable roles of hypertriglyceridemia, inflammation, obesity and hyperglycemia in the pathogenesis of atherosclerotic CVD among type 2 diabetic patients and healthy individuals. We suggest the measurement of these conventional biochemical parameters in conjunction with the assessment of anthropometric indices as early predictors for future cardiovascular disease in apparently healthy patients with a family history of hypertension, diabetes or obesity in resource limited settings. The finding of our study is in agreement with Petrie *et al.* (2018) but dissimilar to Gillies *et al.* (2007), Giorda *et al.* (2007) and Rahman *et al.*, (2011) although Lima *et al.*, (2007) showed higher TC levels and higher HDL-C levels among controls than diabetic patients.

Our study also noted the absence of abnormal LDL-C levels in the control group suggesting that LDL-C may not be the best gauge for primary dyslipidemia in healthy patients and may not predict future cardiovascular disease risk in apparently healthy patients with family history of hypertension, diabetes and obesity. Our report is similar to Lima *et al.* (2007) and Wang *et al.* (2016) but dissimilar to Abdul-Ghani *et al.*, (2017).

The interplay between traditional and non-traditional risk factors for T2DM and hypertension including dyslipidemia, obesity, hyperglycemia, hyperhomocysteinemia and low grade inflammation observed in our study are known contributors of CVD risk. Our study did not capture the presence or absence of macrovascular and microvascular complications, genetic predisposition or insulin resistance among the participants. As a result, we cannot completely rule out the effect of the unmeasured variables and duration of diabetes on the biochemical markers and anthropometric indices of the participants.

Some of the limitations of our study include its cross-sectional design and small sample size due to insufficient resources. As a result, our findings on the association between type 2 diabetes and

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cardiovascular outcomes cannot be fully established due to limited diagnostic procedures and absence of genetic evaluations. The inability of our study participants to undergo electrocardiography and some radiological procedures may also result in bias of some reported findings.

The strengths of our study include its ability to assay dependent and independent variables for cardio metabolic risk among the participants and ensuring the sanctity of collected data through the use of trained clinical assistants and interviewers.

CONCLUSION

The assessment of some accessible cardio metabolic markers and anthropometric indices may provide easy tools for prediction and assessment of cardiovascular disease in patients with T2DM especially in resource poor settings

COMPETING INTEREST

Authors declare that they have no competing interests.

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