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Preliminary Assessment of Triglyceride/High-Density Lipoprotein Cholesterol (tg/hdl-c) Ratio among Nigerian Adolescents with Self-Reported Symptoms of Cardiovascular Illness

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ABSTRACT

Summary: The need to identify high risk features of atherosclerotic cardiovascular disease (ASCVD) in indigenous Black African adolescents is urgent now more than ever. In ASCVD, an immunoinflammatory pathology, plaques of lipid origin progressively gather in wall of human blood vessels and partially or completely obscure the lumen.

Objective: To determine the association of TG/HDL-c ratio with hypertension and dysglycaemia among apparently healthy Nigerian adolescents.

Materials and Method: A nutritional survey was conducted from October 2019 to March 2010 among secondary school students in Lagos, Nigeria. Statistical analysis was restricted to 613 study subjects whose anthropometric and clinical data were complete. Subjects were categorized into early, mid and late adolescents. A semi-structured questionnaire instrument was used to gather socio-demographic data and information on current health status of the study subjects. Fasting blood was collected for the analyses of plasma glucose (FPG), triglyceride (TG), total cholesterol (T-Chol), high density lipoprotein-cholesterol and low-density lipoprotein cholesterol. Anthropometric data were also collected. Systolic and diastolic blood pressures were measured.

Results: In all, 613 (boys=236, or 38.5%, girls=377, or 61.5%: early adolescents=297 or 48.5%, mid adolescents=205 or 33.4%, late adolescents=111 or 18.1%) secondary school students, aged 10-19 years, were studied. TG/HDL-c was significantly higher (P-value=0.02) in study subjects with systolic hypertension (median=4.7 vs 3.2) compared with subjects with normal BP; notably higher (P-value=0.008) in those with high than low LDL-c (3.3 vs 1.8); significantly higher (P-value=0.02) among early adolescent girls than boys who “get tired easily” (3.2 vs 2.3); and also significantly variable (P-value=0.03) among late adolescent girls than boys who ever smoked (4.5 vs 2.0). There was a fairly strong and significant correlation (r=0.75, P-value=0.01) between TG/HDL-c and DBP among late adolescent boys who had, or a close relative had, heart disease. There was also a weak but significant correlation (r=0.54, P-value=0.2) between TG/HDL-c ratio and SBP among early adolescent boys who have parent or close relative receiving treatment for heart disease.

Conclusion: The current study indicates that a higher TG/HDL-c ratio is associated with high BP and high LDL-c among Nigerian adolescents, suggesting probable association of TG/HDL-c ratio with a risk of cardiovascular consequences among adolescents in Nigeria. There is an urgent need for further well-designed studies to verify the present findings.

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Introduction

The pathophysiology of cardiovascular diseases (CVD) is contingent mainly on lipid transportation and with inflammation which is linked with both the initiation and progression of atherosclerosis [1]. High triglyceride (TG) and low high-density lipoprotein cholesterol (HDL-C) impart risk for heart disease [2]. Abnormal lipid levels in adolescence are linked to early atherosclerosis [3]. Risk stratification may be improved by using triglyceride to high-density lipoprotein cholesterol ratio (TG/HDL-C), which relates to arterial stiffness in adults but not yet well-documented in adolescents. Over the years, the world has witnessed developments in the management of cardiovascular diseases (CVD) from a technological perspective [4]. Certain risk factors for adverse consequences, including advanced age, obesity and dysglycaemia are well-known. Recently, however, novel risk factors such as endothelial dysfunction, oxidative stress, insulin resistance and inflammation are equally important players associated with cardiovascular disorders [5]. For better risk stratification regarding cardiovascular outcomes, a simple, accurate, reproducible, and easily measurable marker is needed. Studied have suggested that the ratio of triglyceride to high-density lipoprotein-c (TG/HDL-c) is a reliable instrument to verify apparently healthy individuals with high cardiometabolic risk and insulin resistance [6-10]. Bittner et al are of the opinion that the combination of high TG and low HDL-C, linked with high apolipoprotein B and trivial dense low-density lipoprotein (LDL) particles strongly foretells coronary heart disease (CHD). Gaziano et al., originally documented a case control study that TG/HDL-c ratio convincingly forecasts the probability of myocardial infarction [11,12] .There are other studies that had also associated an elevated TG/HDL-c ratio with fatal conditions such as coronary atherosclerosis, CHD incidence as well as CHD and cardiovascular and all-cause death [13-15]. None of these studies was conducted in continental Africa and it is uncertain if such studies are available in this part of the world. Thus, data on TG/HDL-c ratio among indigenous Black Africans is sub-Sahara is very rare. This study attempted to fill the hiatus created by lack of information on TG/HDL-c in this population, especially among the adolescents. Furthermore, this study hopes to provide more data to utilize TG/HDL-c ratio as a prognostic marker, in support of the proposition. Therefore, the objective of this study was to investigate possible association of TG/HDL-c ratio, first with hypertension, dysglycemia and LDL-c and secondly with any of the self-reported symptoms of cardiovascular illness among indigenous Nigerian adolescents. This is to verify, to an extent, whether or not, TG/HDL-c has a role in distinguishing harmful cardiovascular consequences among the African adolescents.

Materials and Methods

The materials and methods for this study have been openly documented in a previous report [16]. Briefly, the study was epidemiological and descriptive. Initially 650 adolescents from selected primary schools were recruited, but 26 (4.0%) were dropped. Of the remaining 624, 11 (1.8%) did not complete the questionnaire part of the study and were excluded, remaining 613, aged 10-19 years, whose primary data were processed and analyzed. Ethical approval for the study, conducted between October 2019 and March 2020, was obtained from the Nigerian Institute of Medical Research (IRB/18/062 of February 4, 2019) after which documented informed consents were obtained from parents before the participants gave verbal agreement. The study was carried out according to the Helsinki Declaration (2000).

Study Site

Lagos State, in Southwest Nigeria, situates on the Atlantic Ocean coastline and has a population of approximately 20 million heterogenous people from Nigeria, Africa and other parts of the world. It is a city-state and the economic hub of the nation with social amenities and acceptable sewage disposal system.

Sample Size, Sampling Technique and Procedure

The sample size was designed for a single population with 95% confidence interval, 54 % proportion, a margin of error 5%, and allowing for 12% non-response. The study arrived at a sample of 650 secondary school students to cater for attrition and missing data. Study participants were from 3 Senatorial Districts – Lagos East, Lagos West and Lagos Central – with 5, 10 and 5 Local Government Areas respectively. Participants were recruited using simple random sampling, probability proportional to size and systematic sampling technique.

Inclusion Criteria

These were (i) a student's age must be between 10 and 19 years (ii) participant must be a registered and regular student in the school of study (iii), must be Nigerian resident in the community of study for a minimum of 5 years.

Exclusion Criteria

These included (i) students who were on therapeutic diet or drugs (ii) admissions to a health facility in previous 6 months (iii) pregnancy (iv) suspected pregnancy (v) breastfeeding (vi use of oral contraceptive (vi) known diabetics (vii) history of vascular/liver/renal or other chronic illness (viii) those taking lipid-lowering medications.

Questionnaire

A semi-structured questionnaire was administered to document, in part, responses to cardio-respiratory symptoms such as (i) gets tired easily (ii) chest pain (iii) finds it difficult to breath and (iv) has or a close relative has heart disease are relevant to this paper.

Measurements

Trained field workers took anthropometric measurements including body weight (to the nearest 0.1 kg, with minimal clothing and no shoes), height and waist circumferences (to the nearest millimeter). Electronic scale (FBS machine Model HBF-514C and DP scale HN-283) was used to measure weight; portable stature meter (SURGILAC) was used to measure height (no shoes), cloth tape was used to measure waist circumference (to the nearest millimeter) midway between the lowest rib and the iliac crest. AnthroPlus V1.0.4 (WHO, Geneva, Switzerland) was used to calculate BMI-for-age and height-for-age percentiles for boys and girls separately [17]. Sex-specific categorization was used for BMI. Cut-offs available for Nigerian or African for waist circumference was 0.94 m for boys and 0.80 m for girls. Systolic and diastolic blood pressure (SBP, DBP) (upper arm) and pulse rate were measured after 30 min of resting, using automatic blood pressure monitor for {Medical Instrument WUXI, Ltd, EN-BL-8030 [China]}. The average of three measurements was used. After overnight fasting, 5 ml of venous blood was taken, processed, separated into appropriate tubes for the analyses of fasting plasma glucose (FPG), total cholesterol, triglyceride, high-density lipoprotein (HDL) and low-density lipoprotein (LDL). Randox Glucose-PAP (Randox Laboratories, UK) reagent was used for analyzing FPG and lipid profile, using a photo spectrometric analyzer (BioSystems EN ISO 13485 and EN ISO 9001 standards (Barcelona, Spain).

Statistical Analysis

In this report, participants were segregated by sex (boys and girls) and by stage of adolescence (early or 10-13 years of age, mid or 14-17 years of age and late or 18-19 years of age). The data was subjected to descriptive statistics, Analysis of variance, Chi-square with odds ratios and Spearman's correlation using NCSS version 22 (Kaysville, Utah, USA). Values were reported as mean (±), standard deviation (SD) and 95% CI for the continuous variables. Shapiro-Wilk's Normality test for normality of data distribution for continuous measures was conducted and when the test failed (i.e hen p-value (asymp. sig.) was <0.05, the normality of data distribution was rejected and Mann-Whitney U-test one-way ANOVA was used to determine differences between 2 medians. Independent Student's t-tests were used to identify differences in anthropometric measurements. An unadjusted p-value <0.05 was considered statistically significant. Data were illustrated as tables, graphs, charts, and figures.

Definitions

Abnormal lipid levels were classified as (i) total cholesterol ≥200 mg/dL (ii) low-density lipoprotein-cholesterol (LDL-C) ≥ 130 mg/dL (iii) triglycerides (TG) ≥130 mg/dL (hypertriglyceridemia), (iv) high-density lipoprotein cholesterol (HDL-C) < 40 mg/dL [18]. (v) glucose ≥100mg/dL; (vi) stage 1 hypertension, BP 130-139/80-89, and stage 2 ≥140/90 mmHg [19]. Fasting plasma glucose (FPG) of ≥126mg/dL was taken as diabetic [20].Triglyceride/High-density lipoprotein-c (TG/HDL-c) is the ratio of triglyceride divided by high-density lipoprotein-c of each study participant.

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Table 1: Frequency and Means Distribution of Anthropometric and Clinical Variables of Study Subjects by Sex and Stages of Adolescence

Variable	Total (Freq, (%)			Early adolescents				Mid adolescents				Late adolescents			
	All (n=613)	Boys 236, (38.5)	Girls 377, (61.5)	All 297 (48)	Boys 109 (36.7)	Girls 188, (63.3)	T-test (P-value)	All 205 (33.4)	Boys 84 (41.0)	Girls 121, (59.0)	T-test (P-value)	All 111 (18.1)	Boys 43, (38.7)	Girls 68, (61.3)	T-test (P-value)
Anthropometric and Blood pressure characteristics (Mean ± sd) Shapiro-Wilk's statistic=0.034 (P-value<0.0001). Data considered to be normally distributed															
Age (yrs)	14.7 (2.1)	14.8 (2.2)	14.6 (2.1)	12.9 (1.3)	12.8 (1.3)	13.0 (1.3)	-1.28 (0.20)	15.6 (0.5)	15.7 (0.6)	15.6 (0.5)	1.25 (0.21)	17.8 (0.7)	18.0 (0.8)	17.6 (0.6)	2.83 (0.006)
Weight (Kg)	47.4 (11.6)	46.5 (12.4)	47.9 (11.1)	45.3 (11.6)	42.9 (10.8)	46.7 (11.8)	-2.82 (0.005)	48.3 (11.0)	48.3 (12.0)	48.3 (10.3)	0.00 (1.00)	51.2 (11.9)	52.1 (14.6)	50.7 (9.9)	0.56 (0.58)
Height (cm)	156.7 (12.3)	157.7 (12.9)	156.0 (11.9)	154.3 (13.4)	154.2 (11.5)	154.4 (14.4)	-0.13 (0.90)	158.2 (10.5)	159.8 (12.7)	157.2 (8.5)	1.64 (0.10)	160.0 (11.4)	162.4 (14.6)	158.5 (8.6)	1.59 (0.12)
WC (cm)	65.4 (6.7)	65.0 (6.7)	65.7 (6.7)	64.7 (7.2)	63.7 (6.8)	65.3 (7.3)	-1.90 (0.06)	65.5 (6.0)	65.3 (5.8)	65.7 (6.1)	-0.48 (0.63)	67.0 (6.6)	67.2 (7.3)	66.8 (6.1)	0.30 (0.76)
WHR	0.79 (0.06)	0.81 (0.06)	0.77 (0.06)	0.79 (0.06)	0.81 (0.07)	0.78 (0.05)	3.93 (0.0001)	0.78 (0.06)	0.80 (0.06)	0.77 (0.06)	3.52 0.0005)	0.78 (0.06)	0.81 (0.04)	0.77 (0.06)	4.25 (0.00005)
WHtR	0.42 (0.04)	0.41 (0.04)	0.42 (004)	0.42 (0.04)	0.42 (0.04	0.42 (0.04)	0.00 (1.00)	0.42 (0.04)	0.41 (0.03)	0.42 (0.04)	-2.04 (0.04)	0.42 (0.04)	0.41 (0.04)	0.42 (0.03)	-1.46 (0.15)
HAZ	-0.60 (1.68)	-0.89 (1.92)	-0.43 (1.48)	-0.10 (1.66)	-0.22 (1.86)	-0.02 1.54)	-0.95 (0.34)	-1.01 (1.45)	-1.38 (1.61)	-0.76 (1.27)	-2.95 (0.004)	-1.21 (1.71)	-1.62 (2.09)	-0.96 (1.38)	-1.84 (0.07)
BMI-for-age	-0.47 (1.31)	-0.67 (1.32)	-0.35 (1.28)	-0.20 (1.3)	-0.35 (1.33)	-0.11 1.32)	-1.50 (0.13)	-0.75 (1.23)	-0.93 (1.19)	-0.63 (1.24)	-1.74 (0.08)	-0.68 (1.28)	-0.95 (1.43)	-0.51 (1.15)	-1.71 (0.09)
Systolic BP	108.2 (12.4)	108.5 (13.9)	108.1 (11.4)	106.7 (12.4)	106.4 (13.1)	106.9 (12.0)	-0.33 (0.74)	109.5 (12.7)	110.0 (14.8)	109.2 (11.1)	0.42 (0.67)	109.8 (11.6)	110.7 (13.8)	109.3 (10.0)	0.58 (0.57)
Diastolic BP	66.2 (9.6)	65.0 (10.4)	66.9 (9.1)	65.5 (9.4)	64.3 (10.1)	66.2 (9.0)	-1.63 (0.11)	66.9 (10.2)	65.7 (10.7)	67.8 (9.8)	-1.43 (0.15)	66.5 (8.5)	65.6 (10.4)	67.1 (7.8)	-0.81 (0.42)
Fasting Plasma Glucose and Lipids characteristics (Median values; Mann-Whitney (P-value) instead of t-test) Shapiro-Wilk's statistics=0.91 (FPG), 0.95 (TG) and 0.85 (HDL-c) (P-value<0.0001). Decision: reject normality															
FPG	87.3	89.3	86.1	87.6	87.2	89.0	-0.26 (0.79)	86.9	89.9	84.1	0.66 (0.51)	87.2	89.8	83.8	1.07 (0.28)
TG	199.3	204.1	197.9	207.1	203.5	207.3	-0.73 (0.46)	198.1	214.1	181.7	2.37 (0.02)	191.8	191.8	191.7	-0.02 (0.99)
HDL-c	55.7	54.0	56.4	56.5	53.6	58.1	-0.87 (0.38)	55.0	53.3	55.2	-0.37 (0.71)	55.4	54.5	55.6	0.47 (0.64)
LDL-c	291.1	267.7	295.7	295.2	280.3	310.4	-2.86 (0.004)	284.6	280.1	291.6	-0.98 (0.33)	273.1	248.7	275.6	-1.20 (0.23)

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Table 2: Median Values of TG/HDL-c Among Boys and Girls with Systolic and Diastolic Hypertension, Dysglycemia and High Low-Density Lipoprotein

		Systolic Hypertension				**Diastolic Hypertension**			
		Yes		**No**		**Yes**		**No**	
		Freq. (%)	**Median TG/HDL-c**	**Freq. (%)**	**Median TG/HDL-c**	**Freq. (%)**	**Median TG/HDL-c**	**Freq. (%)**	**Median TG/HDL-c**
All (n=613)		26 (4.2)	4.7	587 (95.8)	3.2	8 (1.3)	3.1	605 (98.7)	3.2
Mann-Whitney (P-value)		2.32 (0.02)				-0.22 (0.83)			
Early adolescents	All (n=297, 48.5%)	10 (38.5)	4.5!	287 (48.9)	2.9!	4 (50.0)	1.3	293 (48.4)	3.0
	Boys	5 (50.0)	5.7	104	2.9	2 (50.0)	4.8	107 (36.5)	3.0
	Girls	5(50.0)	3.7	183	3.0	2 (50.0)	1.3	186 (63.5)	3.0
Mann-Whitney (P-value)		0.73 (0.46)		0.38 (0.70)		0.00 (1.00)		0.47 (0.64)	
Mid adolescents	All (n=205, 33.4%)	11 (42.3)	3.9	194 (33.0)	3.7	2 (25.0)	3.3	203 (33.6)	3.8
	Boys	8 (72.7)	5.9	76 (39.2)	4.0	2 (100.0)	3.3	82 (40.4)	4.2
	Girls	3 (27.3)	2.4	118 (60.8)	3.6	0 (0.0)	0.0	121 (59.6)	3.6
Mann-Whitney (P-value)		-0.41 (0.68)		0.84 (0.40)		-		1.06 (0.29)	
Late adolescents	All (n=111, 18.1%)	5 (19.2)	9.5*	106 (18.1)	3.3*	2 (25.0)	6.1	109 (18.0)	3.3
	Boys	4 (80.0)	7.4**	39 (36.8)	2.7**	1 (50.0)	8.9	42 (38.5)	2.8
	Girls	1 (20.0)	21.7	67 (63.2)	3.5	1 (50.0)	3.3	67 (61.5)	3.5
Mann-Whitney (P-value)		0.71 (0.48)		-1.69 (0.09)		1.00 (0.32)		-1.54 (0.12)	
		Dysglycemia				High low-density lipoprotein-c			
		Yes		No		Yes		No	
		Freq. (%)	Median TG/HDL-c	Freq. (%)	Median TG/HDL-c	Freq. (%)	Median TG/HDL-c	Freq. (%)	Median TG/HDL-c
All (n=613)		71 (11.6)	3.1	542 (88.4)	3.3	525 (85.6)	3.3	88 (14.4)	1.8
Mann-Whitney (P-value)		-1.28 (0.20)				-2.65 (0.008)			
Early adolescents	All (n=297, 48.5%)	44 (62.0)	3.0	253 (46.7)	3.0	257 (49.0)	3.1#	40 (45.5)	1.8#
	Boys	15 (34.1)	2.5	94 (37.2)	3.1	90 (35.0)	3.2##	19 (47.5)	1.4##
	Girls	29 (65.9)	3.1	159 (62.8)	3.0	167 (65.0)	3.1###	21 (52.5)	1.8###
Mann-Whitney (P-value)		-0.71 (0.48)		0.90 (0.37)		0.89 (0.37)		-0.34 (0.73)	
Mid adolescents	All (n=205, 33.4%)	16 (22.5)	3.5	189 (34.9)	3.7	174 (33.1)	3.8	31 (35.2)	2.7
	Boys	7 (43.7)	1.3	77 (40.7)	4.2	72 (41.4)	4.2	12 (38.7)	2.5
	Girls	9 (56.3)	4.2	112 (59.3)	3.4	102 (58.6)	3.6	19 (61.3)	2.7
Mann-Whitney (P-value)		-1.11 (0.27)		1.42 (0.15)		1.40 (0.16)		-0.20 (0.84)	
Late adolescents	All (n=111, 18.1%)	11 (15.5)	3.1	100 (18.4)	3.4	94 (17.9)	3.4	17 (19.3)	1.8
	Boys	3 (27.3)	1.8	40 (40.0)	3.0	37 (39.4)	3.3	6 (35.3)	1.7
	Girls	8 (72.7)	3.2	60 (60.0)	3.6	57 (60.6)	3.4	11 (64.7)	5.0
Mann-Whitney (P-value)		-0.61 (0.54)		-1.36 (0.17)		-0.58 (0.56)		-1.11 (0.27)	

!Mann-Whitney U-test (P-value)=2.09 (0.04); *Mann-Whitney U-test (P-value)=2.09 (0.04); **Mann-Whitney U-test (P-value)=2.01 (0.04); #Mann-Whitney U-test (P-value)=-3.50 (0.0005); ## Mann-Whitney U-test (P-value)=-2.35 (0.02); ### Mann-Whitney U-test (P-value)=-2.62 (0.009);

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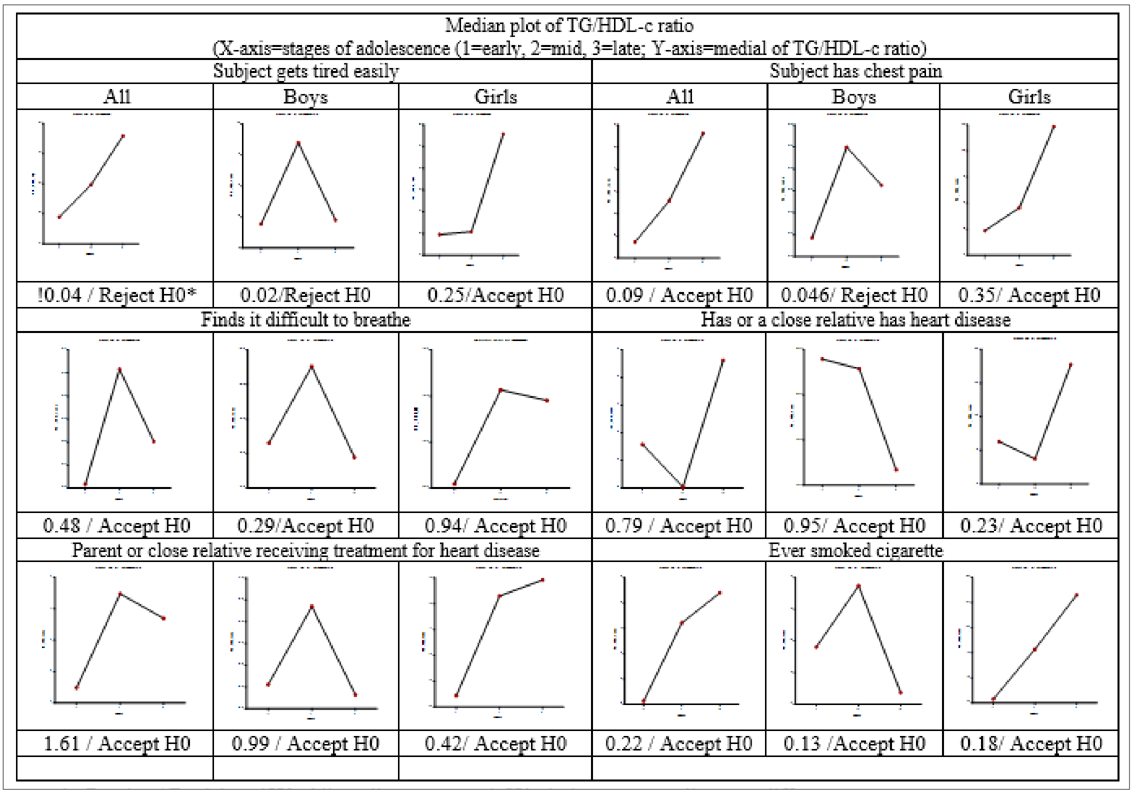
Table 3: Median Values of TG/HDL-c in Self-Reported Health Conditions in Stages of Adolescence

	Early adolescents											
	Gets tired easily				**Has chest pain**				**Finds it difficult to breathe**			
	Yes (n=146)		**No (n=151)**		**Yes (n=129)**		**No (n=168)**		**Yes (n=120)**		**No (n=177)**	
	Freq. (%)	**TG/HDL-c ratio**	**Freq. (%)**	**TG/HDL-c ratio**	**Freq. (%)**	**TG/HDL-c ratio**	**Freq. (%)**	**TG/HDL-c ratio**	**Freq. (%)**	**TG/HDL-c ratio**	**Freq. (%)**	**TG/HDL-c ratio**
Boys	48 (32.9)	2.4	61 (40.3)	3.4	44 (34.1)	2.3	65 (38.7)	3.4	44 (36.7)	2.3	65 (36.7)	3.4
Girls	98 (67.1)	3.1	90 (59.7)	2.9	85 (65.9)	3.2	103 (61.3)	2.6	76 (63.3)	3.2	112 (63.3)	2.6
T (P-value)	-1.27 (0.21)		1.91 (0.06)		-1.56 (0.12)		2.00 (0.04)		-2.34 (0.02)		2.47 (0.01)	
	Has or a close relative has heart disease				Parent or close relative receiving treatment for heart disease				Ever smoked			
	Yes (n=33)		No (n=264		Yes (n=71)		No (n=226		Yes (n=107)		No (n=190)	
Boys	12 (36.4)	2.3	97 (36.7)	3.1	19 (26.8)	3.3	90 (39.8)	2.9	36 (33.6)	2.3	73 (38.4)	3.4
Girls	21 (63.6)	3.2	167 (63.3)	2.9	52 (73.2)	3.1	136 (60.2)	2.9	71 (66.4)	3.2	117 (61.6)	2.8
T (P-value)	-0.34 (0.74)		0.76 (0.45)		0.52 (0.60)		0.42 (0.67)		-1.00 (0.32)		1.38 (0.17)	
	Mid adolescents											
	Gets tired easily				Has chest pain				Finds it difficult to breathe			
	Yes (n=96)		No (n=109)		Yes (n=90)		No; (n-115)		Yes (n=71)		No (n=134)	
Boys	37 (38.5)	5.2	47 (43.1)	3.5	38 (42.2)	4.7	46 (40.0)	3.8	29 (40.8)	3.3	55 (41.0)	4.9
Girls	59 (61.5)	3.7	62 (56.9)	3.2	52 (57.8)	3.4	69 (60.0)	3.7	42 (59.2)	3.4	79 (59.0)	3.7
T (P-value)	1.80 (0.07)		-0.18 (0.86)		0.96 (0.34)		0.47 (0.64)		-0.20 (0.84)		1.34 (0.18)	
	Has or a close relative has heart disease				Parent or close relative receiving treatment for heart disease				Ever smoked			
	Yes (n=33)		No; (n=172)		Yes (n=55)		No (n=150)		Yes (n=88)		No (n=117)	
Boys	18 (54.5)	2.6	66 (38.4)	4.6	23 (41.8)	3.6	61 (40.7)	4.2	37 (42.0)	3.6	47 (40.2)	4.5
Girls	15 (45.5)	3.0	106 (61.6)	3.6	32 (58.2)	3.6	89 (59.3)	3.6	51 (58.0)	3.9	70 (59.8)	3.4
T (P-value)	0.51 (0.61)		1.55 (0.12)		0.20 (0.84)		1.33 (0.18)		-0.47 (0.64)		1.78 (0.08)	
	Late adolescents											
	Gets tired easily				Has chest pain				Finds it difficult to breathe			
	Yes (n=54)		No (n=57)		Yes (n=47)		No (n=64)		Yes (n=36)		No (n=75)	
Boys	23 (42.6)	3.1	20 (35.1)	2.8	21 (44.7)	3.0	22 (34.4)	2.8	15 (41.7)	2.2	28 (37.3)	3.7
Girls	31 (57.4)	3.5	37 (64.9)	3.5	26 (55.3)	4.3	42 (65.6)	3.4	21 (58.3)	3.1	47 (62.7)	3.6
T (P-value)	-1.06 (0.29)		-0.90 (0.37)		-1.26 (0.21)		-0.69 (0.49)		-1.24 (0.22)		-0.87 (0.39)	
	Has or a close relative has heart disease				Parent or close relative receiving treatment for heart disease				Ever smoked			
	Yes (n=16)		No (n=95)		Yes (n=29)		No (n=82)		Yes (n=39)		No (n=72)	
Boys	10 (62.5)	2.2	33 (34.7)	3.0	14 (48.3)	3.7	29 (35.4)	2.7	16 (41.0)	2.0	27 (37.5)	3.5

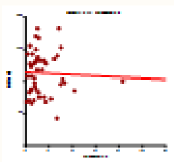
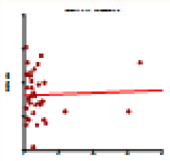
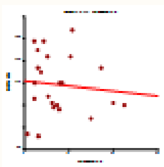
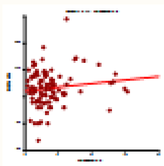
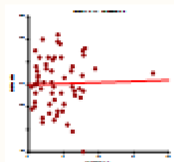
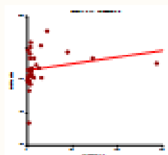
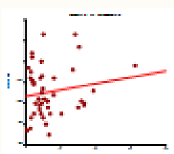
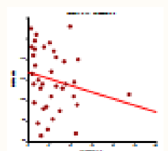
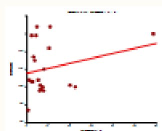
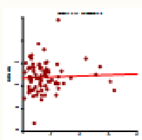
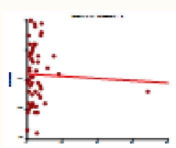
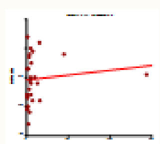
Girls	6 (37.5)	7.2	62 (65.3)	3.4	15 (51.7)	4.5	53 (64.6)	3.4	23 (59.0)	4.5	45 (62.5)	3.4
T (P-value)	1.52 (0.13)		-0.85 (0.40)		-0.31 (0.76)		1.54 (0.12)		-2.18 (0.03)		0.06 (0.95)	

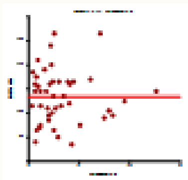
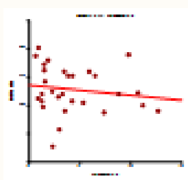
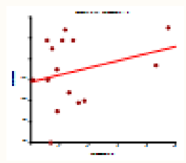
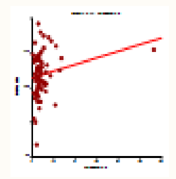
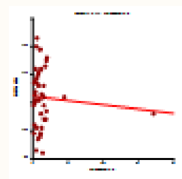
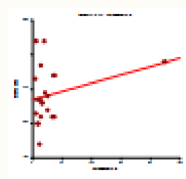
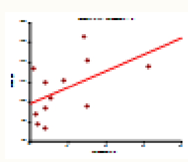
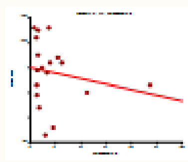
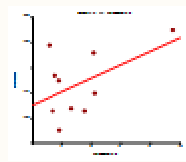
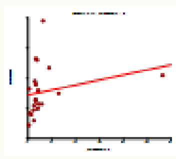
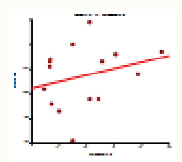
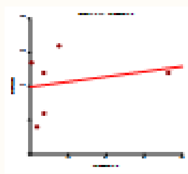
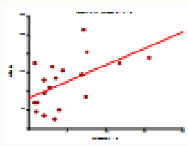
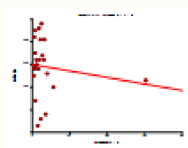
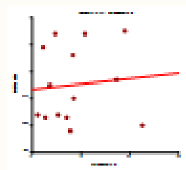
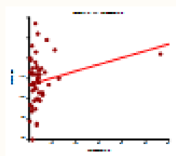
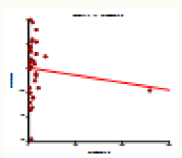
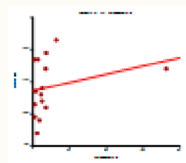
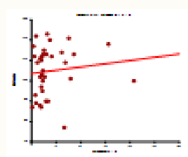
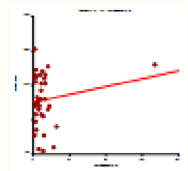
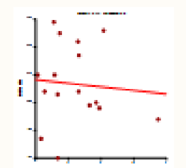
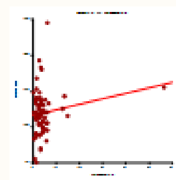
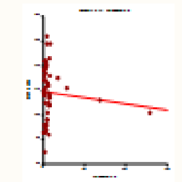
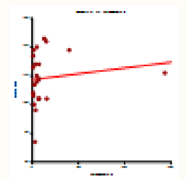
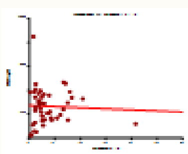
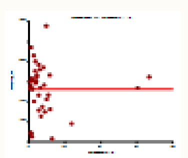
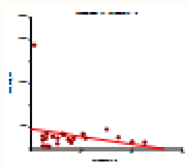
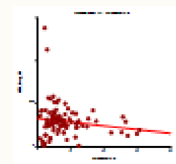
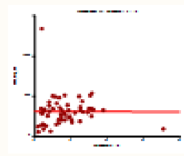
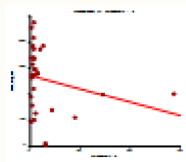
Shapiro-Wilk normality test for TG/HDL-c=0.34; Decision (5%)=reject normality



!= P-value / Decision; *H0: All medians are equal; H1: At least two medians are different

Figure 1: Kruskal-Wallis' Analysis of Variance and Its Significance Level Comparing Medians of TG/HDL-c for Each Health Condition of Study Subjects Relative to Gender

	Boys			Girls		
	Early adolescents	Mid adolescents	Late adolescents	Early adolescents	Mid adolescents	Late adolescents
SBP (mm Hg) vs TG/HDL-c ratio						
Correlation (95% CL)	-0.04 (-0.32, 0.25)	0.04 (-0.29, 0.36)	-0.10 (-0.49, 0.33)	0.13 (-0.07, 0.32)	0.03 (-0.23, 0.28)	0.21 (-0.15, 0.53)
T (P-value)	-0.26 (0.79)	0.24 (0.81)	-0.46 (0.65)	1.29 (0.20)	0.21 (0.83)	1.18 (0.25)
Has chest pain						
SBP (mm Hg) vs TG/HDL-c ratio						
Correlation (95% CL)	0.16 (-0.14, 0.44)	-0.20 (-0.49, 0.12)	0.25 (-0.20, 0.62)	0.05 (-0.17, 0.26)	-0.04 (-0.31, 0.24)	0.12 (-0.28, 0.48)
T (P-value)	1.04 (0.30)	-1.25 (0.22)	1.14 (0.27)	0.43 (0.67)	-0.26 (0.79)	0.58 (0.57)

Finds it difficult to breathe						
SBP (mm Hg) vs TG/HDL-c ratio						
Correlation (95% CL)	-0.001 (-0.30, 0.30)	-0.15 (-0.49, 0.23)	0.28 (-0.28, 0.69)	0.20 (-0.02, 0.41)	-0.08 (-0.37, 0.23)	0.28 (-0.17, 0.63)
T (P-value)	-0.007 (0.99)	-0.80 (0.43)	1.03 (0.32)	1.79 (0.08)	-0.50 (0.62)	1.23 (0.22)
Has or a close relative has heart disease						
SBP (mm Hg) vs TG/HDL-c ratio						
Correlation (95% CL)	0.51 (-0.08, 0.84)	-0.19 (-0.60, 0.30)	0.51 (-0.18, 0.86)	0.24 (-0.21, 0.61)	0.27 (-0.28,0.69)	0.22 (-0.72, 0.88)
T (P-value)	1.90 (0.09)	-0.78 (0.45)	1.67 (0.13)	1.08 (0.29)	1.00 (0.33)	0.46 (0.67)
Parent or close relative receiving treatment for heart disease						
SBP (mm Hg) vs TG/HDL-c ratio						
Correlation (95% CL)	0.54 (0.11, 0.80)	-0.14 (-0.52, 0.29)	0.10 (-0.46, 0.60)	0.22 (-0.05, 0.47)	-0.12 (-0.45, 0.24)	0.27 (-0.28, 0.69)
T (P-value)	2.63 (0.02)	-0.64 (0.53)	0.33 (0.74)	1.60 (0.11)	-0.66 (0.51)	1.01 (0.33)
Ever smoked cigarette						
SBP (mm Hg) vs TG/HDL-c ratio						
Correlation (95% CL)	0.11 (-0.22, 0.43)	0.16 (-0.17, 0.46)	-0.09 (-0.56, 0.43)	0.17 (-0.07, 0.390	-0.09 (-0.36, 0.19)	0.14 (-0.29, 0.52)
T (P-value)	0.67 (0.51)	0.98 (0.33)	-0.32 (0.75)	1.43 (0.16)	-0.65 (0.52)	0.63 (0.54)
	Boys			Girls		
	Stage of adolescence			Stage of adolescence		
	Early	Mid	Late	Early	Mid	Late
LDL-c (mg/dL) vs TG/HDL-c ratio						
Correlation (95% CL)	-0.04 (-0.32, 0.24)	-0.002 (-0.33,0.32)	-0.22 (-0.58, 0.21)	-0.15 (-0.34, 0.05)	-0.10 (-0.26, 0.25)	-0.23 (-0.54, 0.13)
T (P-value)	0.30 (0.77)	0.009 (0.99)	1.05 (0.31)	1.51 (0.13)	0.04 (0.96)	1.30 (0.21)
Has chest pain						

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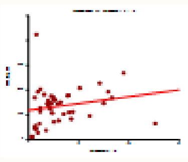
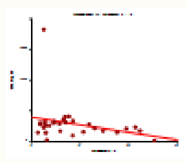
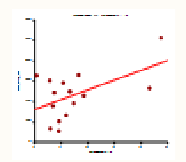
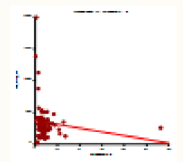
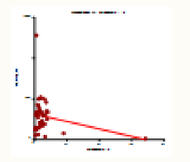
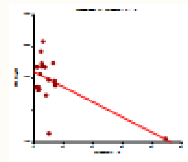
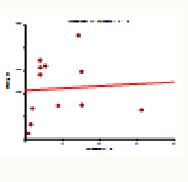
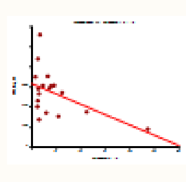
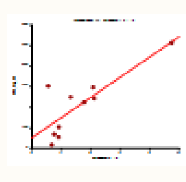
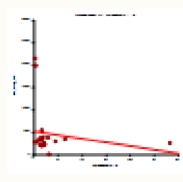
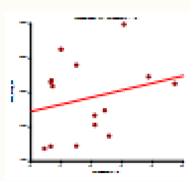
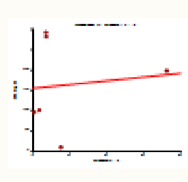
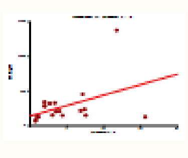
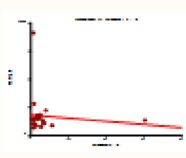
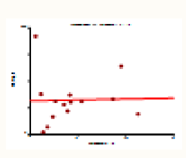
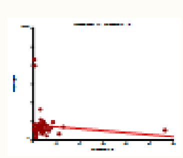
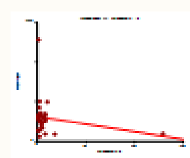
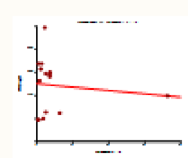
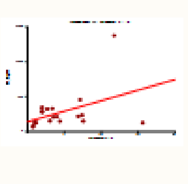
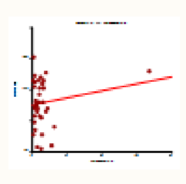
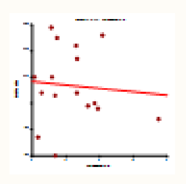
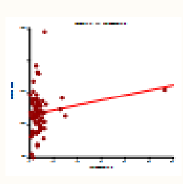
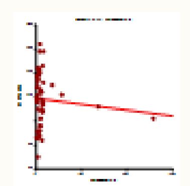
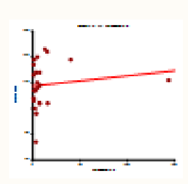
LDL-c (mg/dL) vs TG/HDL-c ratio						
Correlation (95% CL)	0.20 (-0.10, 0.47)	-0.27 (-0.58, 0.11)	0.54 (0.03, 0.82)	-0.14 (-0.35, 0.09)	-0.23 (-0.50, 0.08)	-0.60 (-0.82, -0.23)
T (P-value)	1.33 (0.19)	1.46 (0.16)	2.29 (0.04)	1.20 (0.23)	1.51 (0.14)	3.31 (0.004)
Has or a close relative has heart disease						
LDL-c (mg/dL) vs TG/HDL-c ratio						
Correlation (95% CL)	0.06 (-0.53, 0.61)	-0.49 (-0.78, -0.04)	0.82 (0.39, 0.96)	-0.18 (-0.57, 0.27)	0.25 (-0.31,0.67)	0.11 (-0.77, 0.85)
T (P-value)	0.19 (0.85)	2.78 (0.04)	4.01 (0.004)	0.80 (0.44)	0.91 (0.38)	0.23 (0.83)
Parent or close relative receiving treatment for heart disease						
LDL-c (mg/dL) vs TG/HDL-c ratio						
Correlation (95% CL)	0.42 (-0.04, 0.74)	-0.10 (-0.49, 0.32)	0.03 (-0.51, 0.55)	-0.11 (-0.38, 0.16)	-0.20 (-0.51, 0.16)	-0.11 (0.59, 0.43)
T (P-value)	1.92 (0.07)	0.47 (0.65)	0.09 (0.93)	0.82 (0.42)	1.13 (0.27)	0.40 (0.69)
Ever smoked cigarette						
LDL-c (mg/dL) vs TG/HDL-c ratio						
Correlation (95% CL)	0.11 (-0.22, 0.43)	0.16 (-0.17, 0.46)	-0.09 (-0.56, 0.43)	0.17 (-0.07, 0.390	-0.09 (-0.36, 0.19)	0.14 (-0.29, 0.52)
T (P-value)	0.67 (0.51)	0.98 (0.33)	-0.32 (0.75)	1.43 (0.16)	-0.65 (0.52)	0.63 (0.54)

Figure 2 (a-b). Scatterplot and Pearson's correlation coefficient of TG/HDL-C with SBP and LDL-c among early, mid and late adolescents with varying health conditions relative to gender.

Results

In all, 613 adolescents (mean age 14.7±2.1 years, 38.5% boys, 61.5% girls), students at various secondary schools in Lagos State, Nigeria, with complete analyzable data, were included in the study. Table 1 presents the anthropometric and clinical characteristics – age, sex, weight (kg), height (cm), body mass index SBP, DBP and fasting plasma glucose (FPG) and the lipids – of all the study subjects in their adolescence stages – early (n=297, 48.5%), mid (205, 33.4%) and late (111, 18.1%). In early adolescence, girls (mean weight: 46.7±11.8 kg), were significantly heavier (t-test=2.82, P-value=0.005) than boys (Mean weight: 42.9±10.8 kg), probably due to hormonal transition. Mean of Waist/hip ratio (WHR) was notably higher among boys than girls in early (0.81±0.07 vs 0.78±0.05; t-test=3.93, P-value=0.0001), mid (0.80±0.06 vs 0.77±0.06; t-test=3.52, P-value=0.0005) and late (0.81±0.04 vs 0.77±0.06; t-test=4.25, P-value=0.00005) adolescents. In mid-adolescence, boys were significantly more stunted than girls (HAZ: -1.38±1.61 vs -0.76±1.27; T-test=-2.95, P-value=0.004): Fasting plasma glucose (FPG) and lipid profiles were evenly spread among the study participants. Table 2 shows that, overall, TG/HDL-c was significantly elevated among adolescents with systolic hypertension than among those with normal blood pressure (4.7 vs 3.2; P-value=0.02), especially in early adolescence (4.5 vs 2.9; P-value=0.04) and late adolescence (9.5 vs 3.3; P-value=0.04), especially among boys (7.4 vs 2.7; P-value=0.04). Surprisingly, TG/HDL-c was significantly pronounced among those with high level of LDL-c than among those with normal level of LDL-c (3.3 vs 1.8; P-value=0.008), especially in early adolescence (3.1 vs 1.8; P-value=0.0005). The focus then shifted to self-reported health conditions among the study subjects (Table 3). The only significant variation in TG/HDL-c ratio was observed among late adolescents who had ever smoked cigarette, in which the ration was notably higher in girls (4.5 vs 2.0; P-value=0.03). Kruskal-Wallis' analysis of variance indicates that the median values of TG/HDL-c were significantly different (P-value=0.04) in study subjects who "get tired easily", mainly among boys (P-value=0.02) and also among boys who had chest pain (P-value=0.046), otherwise, the median values of TG/HDL-c were evenly distributed among the study subjects (Figure 1). The next step was to run a scatterplot and Pearson's correlation coefficient of TG/HDL-c with SBP and LDL-c relative to study subjects' gender, different stages of adolescence and in self-reported health conditions (Figures 2 (a-b). There was a moderately strong, positive and significant correlation (r=+0.54, 95% CL=0.11, 0.80, t-test=2.63, P-value=0.02) between SBP and TG/HDL-c among boys in early adolescents whose parent or close relative was receiving treatment for heart disease. On the other hand, there were a moderately strong, positive and significant correlations and a moderately strong, negative and significant correlations, respectively, between LDL-c and TG/HDL-c ratio among late adolescent boys (r=+0.54, 95% CL=0.03, 0.82, t-test=2.29, P-value=0.04) and girls (r=-0.60, 95% CL=-0.8, -0.23, t-test=3.31, P-value=0.004) who found it difficult to breath (dyspnea). There was a negatively weak and significant correlation between LDL-c and the TG/HDL-c ratio among boys in mid (r=-0.49, 95% CL=-0.78, -0.04, t-test=2.78, P-value=0.04) and a strongly positive correlation and boys in late (r=+0.82, 95% CL=0.39, 0.96, t-test=4.01, P-value=0.004) adolescence who "has, or a close relative has heart disease".

Discussion

This study was undertaken to investigate the relationship between TG/HDL-c and systolic hypertension, high LDL-c and diabetes in a small cohort sub-Saharan population – Nigerian adolescents. Most studies have revealed triglyceride to high-density lipoprotein cholesterol ratio as a novel surrogate indicator of insulin resistance, an atherogenic index of plasma and a simple method to identify unfavorable cardiovascular outcomes in the general population, though such studies are limited, especially among Black Africans, particularly adolescents [21-23]. This current study was a preliminary exploration of TG/HDL-c ratio and its association first with systolic hypertension, diabetes mellitus and LDL-c and secondly among those that have symptoms of cardiovascular disease. Available data on TG/HDL-c ratio are mainly on adult population and as such, reports presented in this paper may be novel and are compared and contrasted with what have been recounted on adult population. There are some key findings in this evaluation indication that high TG/HDL-c ratio is associated with both cardiovascular and atherosclerotic morbidity.

It has been ascertained that disorders of lipid metabolism are accountable for atherogenesis and a consequent increased occurrence of ASCVD, such as coronary artery disease (CAD), peripheral artery disease (PAD) and cerebrovascular disease (CVD) [24]. In the first instance, majority (85.6%) of the study subjects, especially those in early adolescence (49.0%), presented with high LDL-c. The median level of 280.3 mg/dL of LDL-c observed in this study (approximately 15.6 mmol/L) is far higher than the 2.06±0.54 mmol/L reported by Zhao et al in China which reported that high LDL-c levels in childhood is the strongest predictive risk factor for CAD in adulthood [25].The authors of the Chinese study admits that emphasis is now placed on lipid ratios as powerful and independent markers of various clinical diseases giving an example of TC/HDL-c ratio as a well-characterized marker of atherogenic particle burden [26]. Studies have indicated that lipid ratios are useful markers for various diseases such as hypertension, CVD and diabetes [27-29]. The TG/HDL-c ratios were significantly higher among adolescent study subjects, particularly girls, with self-reported cardiovascular disease symptoms such as dyspnea and those who ever smoked cigarettes, Abundant scientific proof exists to indicate a strong relationship between high LDL-c and poor cardiovascular outcomes [30]. Further, this study established a correlation between LDL-c and TG/HDL-c ratio among late adolescent boys and girls with dyspnea. To buttress these findings, this study shows that TG/HDL-c ratio was significantly higher among adolescents with systolic hypertension (P-value=0.02) than among normotensive adolescents. This is in consonance with the findings of Onat et al., that atherogenic index of plasma as determined by "log10 triglyceride/high-density lipoprotein cholesterol" predicts diabetes and high blood pressure in adults [31]. Further, Salazar et al., demonstrated the predictive influence of TG/HDL ratio with regard to cardiovascular disease in hypertensive patients by showing that TG/HDL-c ratio was higher in adults with hypertension as compared with the normotensive group [32]. In fact, the current study observed a moderately strong, positive and significant correlation (r=0.54, P-value=0.02) between SBP and TG/HDL-c ratio among adolescent subjects whose parent or close relative were receiving treatment for heart disease. This suggests a relationship between TG/HDL-c and CVD even among sub-Saharan Black African adolescents. Finally, it was observed that TG/HDL-c was insignificantly lower in study subjects with high fasting blood sugar, especially in mid- (3.5 vs 3.7) and late- (3.1 vs 3.4) adolescents. One study has shown TG/HDL-c to be positively associated with diabetes risk and positively related to episode of diabetes when TG/HDL-C is less than 1.186 [33].

There are certain limitations in this study which need consideration. First of all, the study was cross-sectional in design thus disallowing the determination of causality. Secondly there was bias in gender as girls were in higher proportion than boys. There could have been bias also in sample size as some overweight and obese adolescents may have been neglected while more lean students may have been selected. Thirdly, there has not been a follow-up study to verify if those with high TG/HDL-c actually developed any CVD or atherosclerotic disease later in life or if there was any mortality. Furthermore, the importance of this health condition necessitates additional studies, preferably on national scale with a more robust sample size to fully grasp the association of TG/HDL-c with cardiovascular and atherosclerotic incidences among adolescents in sub-Saharan Black Africa.

Conclusion

TG/HDL-c ratio is associated with high BP and high LDL-c among Nigerian adolescents, suggesting probable association of with a risk of cardiovascular consequences among adolescents in Nigeria. This parameter is simple and reproducible and can easily be estimated in clinical practice. This study increases the body of current facts implying that this parameter has significant prognostic value. There is an urgent need for further well-designed studies to verify the present findings.

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Contributions

All authors were responsible for drafting the manuscript and revising it critically for constructive intellectual content. All authors approved the version to be published.

Ethics Approval and Consent to Participate
The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Nigerian Institute of Medical Research (IRB/18/062 of February 4, 2019). Informed written consent was obtained from all patients before their enrollment in this study.

Competing Interests
The authors declare that they have no conflict of interest.

References

1. Christodoulidis G, Vittorio TJ, Fudim M, Lerakis S, Kosmas C (2014) Inflammation in Coronary Artery Disease. Cardiology in Review 22: 279-288.
2. Vega GL, Barlow CE, Grundy SM, Leonard D, DeFina LF (2014) Triglyceride–to–High-Density-Lipoprotein-Cholesterol Ratio is an Index of Heart Disease Mortality and of Incidence of Type 2 Diabetes Mellitus in Men. Journal of Investigative Medicine 62: 345-349.
3. Urbina EM, Khoury PR, McCoy EM, Dolan LM, Daniels SR, et al. (2013) Triglyceride to HDL-C Ratio and Increased Arterial Stiffness in Children, Adolescents, and Young Adults. Pediatrics 131: e1082-e1090.
4. Sun ZJ, Zhang ZE (2005) Historic perspectives and recent advances in major animal models of hypertension. Acta Pharmacol Sin 26: 295-301.
5. Sonmez A, Yilmaz MI, Saglam M, Unal HU, Gok M, et al. (2015) The role of plasma triglyceride/high-density lipoprotein cholesterol ratio to predict cardiovascular outcomes in chronic kidney disease. Lipids Health Dis 14: 29.
6. Murguía-Romero M, Jiménez-Flores JR, Sigrist-Flores SC, Espinoza-Camacho MA, Jiménez-Morales M, et al. (2013) Plasma triglyceride/HDL-cholesterol ratio, insulin resistance, and cardiometabolic risk in young adults. J Lipid Res 54: 2795-2799.
7. McLaughlin T, Reaven G, Abbasi F, Lamendola C, Saad M, et al. (2005) Is there a simple way to identify insulin-resistant individuals at increased risk of cardiovascular disease? Am J Cardiol 96: 399-404.
8. Hanak V, Munoz J, Teague J, Stanley A Jr, Bittner V (2004) Accuracy of the triglyceride to high-density lipoprotein cholesterol ratio for prediction of the low-density lipoprotein phenotype B. Am J Cardiol 94: 219-222.
9. Dobiásová M, Frohlich J (2001) The plasma parameter log (TG/HDL-C) as an atherogenic index: correlation with lipoprotein particle size and esterification rate in apoB-lipoprotein-depleted plasma (FER(HDL)). Clin Biochem 34: 583-588.
10. Jia L, Long S, Fu M, Yan B, Tian Y, et al. (2006) Relationship between total cholesterol/high-density lipoprotein cholesterol ratio, triglyceride/high-density lipoprotein cholesterol ratio, and high-density lipoprotein subclasses. Metabolism 55: 1141-1148.
11. Bittner V, Johnson BD, Zineh I, Rogers WJ, Vido D, et al. (2009) The triglyceride/high-density lipoprotein cholesterol ratio predicts all-cause mortality in women with suspected myocardial ischemia: a report from the Women's Ischemia Syndrome Evaluation (WISE). Am Heart J 157: 548-555.
12. Gaziano JM, Hennekens CH, O'Donnell CJ, Breslow JL, Buring JE (1997) Fasting triglycerides, high-density lipoprotein, and risk of myocardial infarction. Circulation 96: 2520-2525.
13. Frohlich J, Dobiásová M (2003) Fractional esterification rate of cholesterol and ratio of triglycerides to HDL-cholesterol are powerful predictors of positive findings on coronary angiography. Clin Chem 49: 1873-1880.
14. Drexel H, Aczel S, Marte T, Benzer W, Langer P, et al. (2005) Is atherosclerosis in diabetes and impaired fasting glucose driven by elevated LDL cholesterol or by decreased HDL cholesterol?. Diabetes Care 28: 101-107.
15. Jeppesen J, Hein HO, Suadicani P, Gyntelberg F (2001) Low triglycerides-high high-density lipoprotein cholesterol and risk of ischemic heart disease. Arch Intern Med 161: 361-366.
16. Afolabi BM, Holdbrooke SJ, Sanni MT (2024) Cardio-Pulmonary Symptoms Associated With Metabolic Syndrome Among Sub-Sahara Black African Adolescents – Nigerians: A Follow-Up Study. International Academic Journal of Medical and Clinical Practice 9: 1-15.
17. (2022) World Health Organization. AnthroPlus https://www.who.int/tools/growthreference-data-for-5to19-years/application-tools.
18. (1992) National Cholesterol Education Program (NCEP). Expert Panel on Blood Cholesterol Levels in Children and Adolescents: highlight of the reports of the Expert Panel. Pediatrics 89: 495-501.
19. Lande MB, Batisky DL (2019) New American Academy of Pediatrics Hypertension guideline. Hypertension 73: 31-32.
20. (2023) The Global Health Observatory. WHO https://www.who.int/data/gho/indicator-metadata-registry/imr-details/2380.
21. Chen Z, Hu H, Chen M, Luo X, Yao W, et al. (2020) Association of Triglyceride to high-density lipoprotein cholesterol ratio and incident of diabetes mellitus: a secondary retrospective analysis based on a Chinese cohort study. Lipids Health Dis 19: 33.
22. Chen Y, Chang Z, Liu Y, Zhao Y, Fu J, et al. (2022) Triglyceride to high-density lipoprotein cholesterol ratio and cardiovascular events in the general population: A systematic review and meta-analysis of cohort studies. Nutr Metab Cardiovasc Dis 32: 318-329.
23. Turak O, Afşar B, Ozcan F, Öksüz F, Mendi MA, et al. (2016) The Role of Plasma Triglyceride/High-Density Lipoprotein Cholesterol Ratio to Predict New Cardiovascular Events in Essential Hypertensive Patients. J Clin Hypertens 18: 772-777.
24. Kosmas CE, Rodriguez Polanco S, Bousvarou MD, Papakonstantinou EJ, Peña Genao E, et al. (2023) The Triglyceride/High-Density Lipoprotein Cholesterol (TG/HDL-C) Ratio as a Risk Marker for Metabolic Syndrome and Cardiovascular Disease. Diagnostics (Basel) 13: 929.
25. Zhao Q, Jiang Y, Zhang M, Chu Y, Ji B, et al. (2019) Low-density lipoprotein cholesterol levels are associated with insulin-like growth factor-1 in short-stature children and adolescents: a cross-sectional study. Lipids Health Dis 18: 120.
26. Elshazly MB, Quispe R, Michos ED, Sniderman AD, Toth PP, et al. (2015) Patient-Level Discordance in Population Percentiles of the Total Cholesterol to High-Density Lipoprotein Cholesterol Ratio in Comparison With Low-Density Lipoprotein Cholesterol and Non-High-Density Lipoprotein Cholesterol: The Very Large Database of Lipids Study (VLDL-2B). Circulation 8: 667-676.
27. Wang H, Li Z, Guo X, Chen Y, Chen S, et al. (2018) Contribution of non-traditional lipid profiles to reduced glomerular filtration rate in H-type hypertension population of rural China. Ann Med 3: 249-259.
28. Wang H, Li Z, Guo X, Chen Y, Chang Y, et al. (2018) The impact of nontraditional lipid profiles on left ventricular geometric abnormalities in general Chinese population. BMC Cardiovasc Disord 1: 88.

29. Wang H, Guo X, Chen Y, Li Z, Xu J, et al. (2017) Relation of four nontraditional lipid profiles to diabetes in rural Chinese H-type hypertension population. Lipids Health Dis 1: 199.
30. Guijarro C, Cosín-Sales J (2021) LDL cholesterol and atherosclerosis: The evidence. Clin Investig Arterioscler 1: 25-32.
31. Onat A, Can G, Kaya H, Hergenç G (2010) Atherogenic index of plasma (log10 triglyceride/high-density lipoprotein-cholesterol) predicts high blood pressure, diabetes, and vascular events. J Clin Lipidol 4: 89-98.
32. Salazar MR, Carbajal HA, Espeche WG, Aizpurúa M, Leiva Sisnieguez CE, et al. (2014) Use of the plasma triglyceride/high-density lipoprotein cholesterol ratio to identify cardiovascular disease in hypertensive subjects. J Am Soc Hypertens 8: 724-731.
33. Chen Z, Hu H, Chen M, Luo X, Yao W, et al. (2020) Association of Triglyceride to high-density lipoprotein cholesterol ratio and incident of diabetes mellitus: a secondary retrospective analysis based on a Chinese cohort study. Lipids Health Dis 19: 33.