Prevalence and pattern of dyslipidaemia among Nigerian adolescents living in Benin City: A school-based cross-sectional study

***Alphonsus N Onyiriuka[1], Nosakhare J Iduoriyekemwen[2], Wilson E Sadoh[3]**

Sri Lanka Journal of Child Health, 2021; **50**(3): 385-392

Abstract

Background: The increasing prevalence of overweight and obesity in the paediatric population can be associated with an increased rate of dyslipidaemia, a modifiable metabolic risk factor for developing cardiovascular disease.

Objectives: To estimate the prevalence and describe the pattern of dyslipidaemia among overweight/obese and normal-weight students aged 10 to 16 years, living in Benin City, Nigeria.

Method: In this case-control study, a total of 98 students comprising 49 subjects with high BMI (≥ 85th percentile) and 49 controls with normal BMI (5th to <85th percentile), matched for age and gender and from similar socio-economic and ethnic background were investigated. The first public school in a list of alphabetically arranged secondary schools was selected. Thereafter, the students were randomly selected. Serum concentrations of total cholesterol, high-density lipoprotein-cholesterol (HDL-C), triglycerides and low-density lipoprotein-cholesterol were determined, using an automated analyzer with commercially available kits.

Results: Of the 98 students who were investigated, there was at least one "abnormal" lipid concentration in 31 (63.3%; 95% Confidence interval (CI) = 49.8-76.8) adolescents with overweight/obese and the corresponding prevalence of 51% (95% CI = 43.9-58.1) in adolescents with normal BMI; p-value >0.05. Among overweight/obese participants, the prevalence of dyslipidaemia was significantly higher in girls than boys (p <0.05) The frequency of borderline-low HDL-C in overweight/obese and normal-BMI participants was 18.4% and 16.3%, respectively. In both overweight/obese and normal-BMI participants, the most common type of dyslipidaemia was low HDL-C with a prevalence of 62.3% (95% CI= 55.6-69.2) and 51.0% (95% CI=43.9-58.1) in overweight/obese and normal-BMI participants, respectively (p >0.05).

Conclusions: A high proportion of adolescents with either overweight/obesity or normal BMI had dyslipidaemia with the former having a higher proportion. Low HDL-C level was the most common abnormality in dyslipidaemia.

DOI: http://doi.org/10.4038/sljch.v50i3.9685

(Key words: Adolescents, dyslipidaemia, overweight, obesity, Nigeria, students)

Introduction

Dyslipidaemia refers to abnormal concentrations of lipids and/or lipoproteins in the blood and may result from defects in the production, transport and/or degradation of lipoproteins[1]. It may be classified as primary or secondary to other diseases, such as HIV infection, insulin resistance or chronic kidney disease[1]. The reported prevalence of dyslipidaemia in adolescence ranges from 19.7 to 34.3%, depending on the lifestyle and the cut-off values applied in the definition[3-5]. Two separate school-based studies, one in India and the other in Brazil, reported dyslipidaemia prevalence rates as high as 62.3% and 66.7%, respectively[6,7]. The results of several studies indicate that the prevalence of dyslipidaemia in adolescence is increasing in parallel with the dramatic rise in prevalence of adolescent obesity in various countries[8-10]. Some recent studies involving children and adolescents revealed that high body mass index (BMI) is closely associated with dyslipidaemia[11,12]. Dyslipidaemia is a modifiable, metabolic risk factor for development of cardiovascular disease (CVD)[1] and insulin resistance[2]. It is estimated that 40-55% of children with dyslipidaemia will have hyperlipidaemia during adulthood[13]. Elevated levels of serum triglyceride and low-density lipoprotein cholesterol (LDL-C) are linked metabolically and this combination, known as "atherogenic dyslipidaemia", is a strong risk factor for CVD[14,15].

[1]*Endocrinology and Metabolism Unit,* [2]*Nephrology Unit,* [3]*Cardiology Unit, Department of Child Health, University of Benin Teaching Hospital, Benin City, Nigeria*
**Correspondence:* alpndiony@yahoo.com

https://orcid.org/0000-0003-3682-9657
(Received on 05 June 2020: Accepted after revision on 24 July 2020)
The authors declare that there are no conflicts of interest
Personal funding was used for the project.

Increasing triglyceride (TG) levels causes profound changes in both the physical and chemical composition of high-density lipoprotein cholesterol (HDL-C), very low-density lipoprotein (VLDL) and LDL-C particles[16]. The particle core represented by cholesterol esters in HDL-C, is progressively depleted and replaced by TG[16].

VLDL is produced in the liver and is typically composed of Apo B 100, Apo E, and Apo CI, Apo C II, and Apo C III[17]. It is the major transporter of endogenously newly synthesized triglyceride from the liver to the cells. The plasma concentration of triglyceride is dependent on the circulating VLDL level. Hypertriglyceridaemia develops either when VLDL production is increased or its clearance is impaired. There is no easy way to measure VLDL but it is usually estimated from the individual's plasma TG level. It has been suggested that dysfunctional VLDL synthesis and release is a key factor in progression to nonalcoholic steatohepatitis[18]. Increased secretion of VLDL leads to increase in small density LDL production and decrease in HDL, substantially influencing the development of atherosclerosis[19].

In African countries, including Nigeria, epidemiological data regarding the prevalence and pattern of dyslipidaemia in the paediatric age group are very scarce. The same is true of the prevalence of elevated serum levels of VLDL-C.

Objectives

The present study aimed at estimating the prevalence and describing the pattern of dyslipidaemia among overweight/obese and normal-weight students aged 10 to 16 years, living in Benin City, Nigeria.

Method

This was a case-control school-based cross-sectional study involving an urban secondary school in Egor Local Government Area (LGA) of Edo State, Nigeria. The majority of the parents of the students are traders or civil servants. The study was conducted over a one-month period, 1st to 30th June, 2016.

Study group and sampling technique: In this study, the first public secondary school in a list of alphabetically arranged secondary schools in Egor LGA was selected. Thereafter, the students were randomly selected from among all students aged 10 to 16 years. Each of the selected students was given a written note explaining the nature of the study as well as a questionnaire to be completed by their parents/caregivers. The study involved a total of 98 students (49 subjects and 49 controls). The subjects (high BMI, ≥85th percentile) and controls (normal-BMI, 5th to <85th percentile) were matched for age and gender. The socio-economic status and ethnicity of the subjects and controls were similar as the school is a public school where there is no discrimination. The students attending the school were from various Nigerian social strata and ethnicity. Excluded from the study were students with a positive history or obvious clinical evidence of hypothyroidism, liver disease, chronic kidney disease, Cushing syndrome, diabetes mellitus or who were on drugs such as corticosteroids or oral contraceptives.

Anthropometric measurements: Following a standard procedure[20], the height was measured to the nearest 0.1cm, using a Holtian portable anthropometer and the weight was measured to the nearest 0.1kg, using a Seca Scale Balance with the subject in light clothing and barefoot. If a duplicate measurement differed by >0.5cm or >0.5kg respectively, a third measurement was performed and the average of the two closest measurements was recorded as the final value. To eliminate inter-observer error, all anthropometric measurements were done by one of the authors. The BMI of each of the subjects was computed, using the standard formula[20]. The blood pressure of the participants was measured by one of the authors and steps were taken to minimize errors.

Blood sample collection and serum lipid profile analysis: The details of the intended procedure was explained to each of the participants before collection of blood sample. Prior to sampling, the participants maintained their usual dietary pattern within the past 3 days preceding the study. Following an overnight fast (at least 12-hour fast), a venous puncture in the antecubital fossa was performed and 5ml of blood was collected into an appropriate sample container without anticoagulant and stored at 8^{O}C. After one hour, all samples were centrifuged at 3000rpm for 15 minutes and the serum aliquots were stored at -20^{O}C until assayed. The serum concentrations of total cholesterol (TC), HDL-C, TG and LDL-C were determined, using an automated analyzer with commercially available kits and following strictly the manufacturer's instructions throughout the assay procedures.

Definitions: In the present study, cutoff points recommended by the National Heart Lung Blood Institute (NHLBI) Expert Panel on Integrated Guidelines for Cardiovascular Health Risk Reduction in Children and Adolescents were used in defining dyslipidaemia[22]. In addition, the presence of any one of the following four criteria: high serum LDL-C, TG, TC or low HDL-C concentrations was considered as dyslipidaemia[9]. Hyperlipidaemia was defined by the presence of high serum TC or TG concentrations. VLDL-C was estimated by dividing the plasma triglyceride by five, reflecting the ratio of cholesterol to triglyceride in VLDL particles[21]. Based on NHLBI criteria, elevated or low serum lipid values were categorized into borderline and abnormal as follows: (i) Borderline: LDL-C ≥100mg/dl, HDL-C <45mg/dl, TG >130mg/dl, TC ≥170mg/dl and VLDL-C 18-26mg/dl. (ii) Abnormal: LDL-C ≥130mg/dl, HDL-C <35mg/dl, TG >130mg/dl, TC ≥200mg/dl and VLDL-C >26mg/dl. Normal weight, overweight and obesity were defined by BMI between 5th to <85th, 85th to <95th and ≥ 95th centiles, respectively.

Ethical issues: Ethical clearance certificate was obtained from Research and Ethics Committee of the College of Medical Sciences, University of Benin, Benin City, Nigeria (No. CMS/REC/2016/001). The administrative head of the school and the Ministry of Education gave permission for the conduct of the study. Written informed consent was obtained from the parents/caregivers of each of the study subjects. We obtained verbal assent from each of the participants and emphasized to them that their participation was entirely voluntary.

Statistical analysis: Data were entered into an Excel spread sheet after double checking their accuracy and analysed using the Statistical Package for Social Sciences (SPSS) version 20.0. Mean and standard deviation were used for quantitative data. Confidence intervals, frequency distributions and percentages were calculated. Differences between means were tested with t-test and prevalence was tested using Z-test. Significant p-values were set at <0.05.

Results

There was a total of 98 students, comprising 49 overweight/obese subjects and 49 normal-BMI controls, matched for age and gender. There were 29 girls and 20 boys in each group. The mean age of the participants was 12.9±1.2 years and ranged from 10-16 years. The socio-economic status and ethnicity of the subjects and controls were similar as the school was a public school where there is no discrimination. The anthropometric characteristics of the participants are seen in Table 1. The mean BMI and waist circumference were both significantly higher in subjects than controls, irrespective of gender.

Table 1: ***Anthropometry of the subjects and controls according to gender***

Characteristic	Subjects Male	Controls Male	t-statistic (p-value)	Subjects Female	Controls Female	t-statistic (p-value)
Mean weight (kg)	52.3±6.4	39.1±7.8	9.158 (<0.001)	40.6±5.2	36.3±8.4	3.047 (< 0.01)
Mean height (cm)	149.3±6.8	142.4±6.6	5.097 (<0.01)	146.8±7.3	140.3±5.6	4.945 (< 0.01)
Mean BMI (kg/m^2)	27.32.±72	16.8±2.15	9.800 (<0.001)	28.7±3.3	17.5±3.50	16.30 (< 0.001)
Mean WC (cm)	83.2±4.9	68.8±4.1	15.77 (<0.001)	88.9±5.2	69.1±6.7	16.342 (<0.001)
Mean HC (cm)	90.3±10.6	70.8±8.8	9.908 (<0.001)	102.3±8.7	72.5±8.6	17.052 (<0.001)
Mean WC/HC ratio	0.90±0.08	0.85±0.05	3.710 (<0.001)	0.86±0.05	0.80±0.06	5.378 (< 0.001)
Mean SBP (mmHg)	107.3±10.2	103.5±9.9	1.871 (>0.05)	105.0±9.4	101.5±9.3	1.853 (> 0.05)
Mean DBP (mmHg)	70.0±6.7	63.6±8.8	4.051 (<0.001)	65.7±9.1	62.1±9.6	1.905 (> 0.05)

BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, SBP: Systolic blood pressure DBP: Diastolic blood pressure

Of the 98 participants, 56 (57.1%) had at least one abnormal serum lipid concentration (dyslipidaemia). There was at least one "abnormal" lipid concentration in 31 [63.3%; 95% confidence interval (CI) = 49.8-76.8] overweight/obese adolescents with a corresponding prevalence of 51.0%; 95% CI = 43.9-58.1) in normal-weight adolescents; Z-test statistic = 1.085 p-value >0.05. Among overweight/obese participants, 21 (42.9%; 95% CI= 35.8-50.0) girls and 10 (20.4%; 95% CI= 14.6-26.2) boys had dyslipidaemia; Z-test statistic =2.468, p-value <0.05. For normal-weight participants, 15 (30.6%; 95% CI= 24.0-37.2) girls and 10 (20.4%; 95% CI=14.6-26.2) boys; Z-test statistic = 1.166, p-value >0.05.

Table 2 shows the prevalence rates of "borderline" and "abnormal" lipid and lipoprotein concentrations in subjects and controls.

Table 2: ***Prevalence of acceptable, borderline and abnormal lipid concentrations in subjects and controls***

Parameter	Subjects (n=49) n (%)	Controls (n=49) n (%)	Z-test (p-value)
High-density-lipoprotein cholesterol (mg/dl)			
Acceptable (>45)	10 (20.4)	16 (32.7)	1.392 (>0.05)
Borderline (40-45)	09 (18.4)	08 (16.3)	0.039 <0.05)
Abnormal (<40)	30 (61.2)	25 (51.0)	0.146 (>0.05)
Total cholesterol (mg/dl)			
Acceptable (<170)	46 (93.9)	48 (97.9)	1.032 (>0.05)
Borderline (170-199)	03 (06.1)	01 (02.1)	1.004 (>0.05)
Abnormal (≥200)	0 (0.0)	0 (0.0)	
Low-density-lipoprotein cholesterol (mg/dl)			
Acceptable (<110)	42 (85.7)	46 (93.9)	1.353 (>0.05)
Borderline (110-129)	06 (12.2)	03 (06.1)	1.053 (>0.05)
Abnormal (≥130)	01 (02.1)	0 (0.0)	0.145 (>0.05)
Triglyceride (mg/dl)			
Acceptable (<90)	40 (81.6)	44 (89.8)	1.167 (>0.05)
Borderline (90-129)	09 (18.4)	05 (10.2)	1.167 (>0.05)
Abnormal (≥130)	0 (0.0)	0 (0.0)	
Very-low-density-lipoprotein cholesterol mg/dl			
Acceptable (<18)	41 (83.7)	43 (87.8)	0.412 (>0.05)
Borderline (18-26)	08 (16.3)	06 (12.2)	0.582 (>0.05)
Abnormal (>26)	0 (0.0)	0 (0.0)	

In both overweight/obese and normal-weight participants, the most common type of dyslipidaemia was low HDL-C with a prevalence of 62.3% (95% CI= 55.6-69.2) in overweight/obese participants and 51.0% (95% CI=43.9-58.1) in normal-weight participants; Z-test statistic = 1.136, p-value >0.05. One (2.0%) of the 49 overweight/obese participants had a combined (atherogenic) dyslipidaemia but none among their normal BMI counterparts. The only participant with combined dyslipidaemia was an 11-year-old girl with waist circumference 96.5cm (>97th percentile), hip circumference of 101.6cm (>97th percentile), giving a waist/hip circumference ratio of 0.95. Her BMI was 26kg/m^2 (>95th percentile). She had a low HDL-C (31.2mg/dl) and an elevated LDL-C (141.4mg/dl). The mean serum VLDL-C was 15.5±6.6mg/dl, 95% CI=13.7-17.3, (range 7.8-24.1mg/dl) and 13.4±6.4mg/dl, 95% CI=11.6-15.2, (range 6.0-21.4mg/dl) in overweight/obese and normal BMI participants, respectively; t-statistic = 1.313, p > 0.05.

Discussion

We observed a high dyslipidaemia prevalence in both overweight/obese (63.3%) and normal BMI (51.0%) children and adolescents, suggesting that dyslipidaemia is a common health problem among the study population. Recently, two separate studies involving children and adolescents in Brazil reported comparable prevalence rates of 62.1% and 63.8%, respectively[23,24]. On the other hand, our prevalence rate was lower than the 75.6% found in India[6] but higher than 34.2%, 48.8%, 42.9% and 45.8% reported from Iran, Mexico, Turkey and Germany, respectively[5,28-27]. Such country-to-country variations in prevalence rates may be explained by differences in diet, eating behaviour, physical activity and genetic make-up. In addition, the cut-off values applied in the definition of dyslipidaemia and the method of serum lipid measurements may be contributory. Although in our study, the prevalence of dyslipidaemia was higher in overweight/obese than in normal BMI participants, the difference was not statistically significant. Previous studies have shown a similar trend[8,11,12]. The high prevalence of dyslipidaemia observed in this study is worrisome, considering that a previous study reported a high prevalence of clustering of CVD risk factors among adolescents in a rural southwestern part of Nigeria[28]. In that study, 72% of the adolescents showed clustering of two to four CVD risk factors. The present study did not investigate clustering of CVD risk factors.

Data from the present study revealed that a significantly higher proportion of overweight/obese girls than boys had dyslipidaemia. Similarly, the frequency of dyslipidaemia was higher in girls than boys in the normal BMI adolescents, suggesting that gender plays an important role in the epidemiology of dyslipidaemia. Other researchers have reported similar findings[8,23,24]. In contrast, an Iranian study showed that dyslipidaemia was more frequent in boys than girls[5]. Alternatively, there are reports of studies in India and Mexico indicating that there is no significant gender difference in the prevalence of dyslipidaemia[6,25]. Although females tend to have higher serum lipid levels, they ultimately have lower CVD risk than males in adulthood[29].

With regard to the pattern of dyslipidaemia, low serum HDL-C concentration was the most prevalent dyslipidaemia observed in the present study. This is in keeping with the observation among adolescents in Ghana[30], Iran[5], India[6] and Brazil[23] but inconsistent with the observation that hypertriglyceridaemia was the most prevalent dyslipidaemia among adolescents in China[9] and Turkey[26]. In Germany, elevated total cholesterol was the most frequent pattern of dyslipidaemia[27]. These variations in pattern of dyslipidaemia may be attributed to differences in diet and its interaction with the genes of individual adolescents in the various countries. This view is supported by reports of studies on nutrigenetics and nutrigenomics that have revealed interaction between diet, genes, and pattern of dyslipidaemia[31,32]. Within this context, the results of a study by Mahley RW, *et al*[33] revealed that consumption of a higher percentage of carbohydrate than the recommended macronutrient range is associated with low HDL-C levels. In Nigeria, a greater proportion of our diet is made up of carbohydrate with the potential of exceeding the recommended macronutrient range. Borderline serum lipid levels were common in our study population. In this regard, nearly one-fifth of our participants had borderline-high (90-129mg/dl) triglyceride and borderline-low (40-45mg/dl) HDL-C serum levels, respectively. We also observed that 12.2% of overweight/obese participants had borderline-high (110-129mg/dl) LDL-C levels. It is important to appreciate that these boundaries are arbitrary and designation of plasma lipid level as borderline-high or -low is associated with risk of CVD. The reason is because risk of CVD increases continuously in relation to values greater or lower than the lower limit of borderline-high or -low. Two percent of the subjects in our study had combined dyslipidaemia and this was comparable to 2.95% observed in India[6] but was lower than the 15.3% reported from Italy[34]. This finding may suggest a lower atherogenic tendency in our population compared with Caucasians. Although the percentage of students with combined dyslipidaemia in the present study was small, it represents a call for greater vigilance because this pattern is associated with a strong atherogenic tendency. In both the overweight/obese and normal-weight adolescents, no case of high serum levels of triglyceride (≥130mg/dl) or total cholesterol (≥200mg/dl) was found. This finding is in contrast with the results of some other studies with larger sample sizes[5,8,9,27]. The relatively small sample size in the present study may account for the negative finding. On the other hand, considering the established interaction between diet, genes, and pattern of dyslipidaemia[31,32], it may imply that hypertriglyceridaemia and hypercholesterolaemia are not common among school-going Nigerian children and adolescents. A future study with a larger sample size will be required to further examine our negative finding. One-sixth of overweight/obese participants had borderline serum VLDL-C levels but this was not statistically different from those of normal BMI participants. The absence of high serum levels of triglyceride (≥130mg/dl) in this study may explain the absence of VLDL-C in the abnormal category.

The present study has some strengths. The narrow age group studied minimized the effect of age on serum lipid levels, particularly cholesterol. In addition, overnight fasting for at least 12 hours minimized the effect of meals on serum lipid levels, particularly triglycerides. One limitation of the study is our inability to assess eating behaviour and physical activity levels of participants to provide for evidence-based preventive interventions. Despite this limitation, the study provided an insight into the magnitude of the problem of dyslipidaemia in children and adolescents in our population. The information so provided will be useful to health-policy makers, enabling them to implement action-oriented intervention for prevention and early control of CVD risk factors.

Conclusions

The prevalence of dyslipidaemia was high in both overweight/obese and normal BMI adolescent Nigerian students but higher in the former. Low HDL-C level was the most prevalent pattern of dyslipidaemia.

References

1. Couch SC, Daniels SR. Lipid disorders in children and adolescents. In: Sperling MA editor. Pediatric Endocrinology, 3rd edition. Philadelphia, Saunders Elsevier 2008: 839-854. https://doi.org/10.1016/B978-141604090-3.50025-9

2. Asato Y, Katsuren K, Ohshiro T, Kikawa K, Shimabukuro T, Ohta T. Relationship between lipid abnormalities and insulin resistance in Japanese school children. *Arteriosclerosis, Thrombosis, and Vascular Biology* 2006; **26**: 2781-6. https://doi.org/10.1161/01.ATV.0000245804.56871.31 PMid: 16990559

3. Tomeleri CM, Ronque ERV, Silva DRP, Cardosa CG, Fernandes RA, Teixeira DC,

et al. Prevalence of dyslipidaemia in adolescents: Comparison between definitions. *Revista Portuguesa de Cardiologia* 2015; **34**(2): 103-9.
https://doi.org/10.1016/j.repc.2014.08.020
PMid: 25660460

4. Yang S, Hwang JS, Park HK, Lee HS, Kim HS, Kim EY, *et al*. Serum lipid concentrations, prevalence of dyslipidaemia and percentage eligible for pharmacological treatment of Korean children and adolescents; Data from the Korea National Health and Nutrition Examination Survey IV (2007-2009). *PLoS ONE* 2012; **7**(12):e49253.
https://doi.org/10.1371/journal.pone.0049253
PMid: 23251338 PMCid: PMC3522657

5. Taheri F, Chahkandi T, Kazemi T, Bijari B, Zardast M, Namakin K. Lipid profiles and prevalence of dyslipidaemia in Eastern Iranian adolescents, Birjand, 2012. *Iranian Journal of Medical Sciences* 2015; **40**(4): 341-8.
https://doi.org/10.4103/2277-9531.162389
PMid: 26430695 PMCid: PMC4579764

6. Nijaguna N, Vani HN, Niranjan HS, Suresh TN, Sanjeeva GN. Study of lipid profile and prevalence of dyslipidaemia in adolescent school children from Karnataka. *International Journal of Pharmacy and Biological Sciences* 2015; **5**(1): 79-85.

7. de Carvalho DF, Medeiros CCM, de Oliveira Melo AS. Blood lipid levels and nutritional status of adolescents. *Revista Brasileira de Epidemiologia* 2007; **10**(4): 491-8.
https://doi.org/10.1590/S1415790X2007000400007

8. Kuo P, Syu J, Tzou IL, Chen P, Su H, Chu N. Prevalence and trend of dyslipidemia from 1996 to 2006 among normal and overweight adolescents in Taiwan. *BMJ Open* 2014; **4**: e003800.
https://doi.org/10.1136/bmjopen-2013-003800
PMid: 24578534 PMCid: PMC3939666

9. Ding W, Cheng H, Yan Y, Zhao X, Cheng F, Huang G, *et al.* 10-year trends in serum lipid levels and dyslipidaemia among children and adolescents from several schools in Beijing, China. *Journal of Epidemiology* 2016; **26**(12): 635-45.
https://doi.org/10.2188/jea.JE20140252
PMid: 27397598 PMCid: PMC5121432

10. Agirbasli M, Adabag S, Ciliv G. Secular trends of blood pressure, body mass index, lipids and fasting blood glucose among children and adolescents in Turkey. *Clinical Obesity* 2011; **1**: 61-7.
https://doi.org/10.1111/j.17588111.2012.00033.x
PMid: 25585905

11. Horta BL, Victora CG, Lima RC, Post P. Weight gain in childhood and blood lipids in adolescence. *Acta Paediatrica* 2009; **98**: 1024-8.
https://doi.org/10.1111/j.16512227.2009.01247.x
PMid: 19484844 PMCid: PMC2688671

12. Meral G, Uslu A, Yozgatli AŰ, Akcay F. Association of body mass index in lipid profiles in children. *Open Journal of Pediatrics* 2015; **5**: 141-6.
https://doi.org/10.4236/ojped.2015.52021

13. Hatami M, Tohidi M, Mohebi R, Khalili D, Azizi F, Hadaegh F. Adolescent lipoprotein classifications according to National Cholesterol Education Program (NCEP) for predicting abnormal lipid levels in adulthood in a Middle East population. *Lipids in Health and Disease* 2012; **11**:107
https://doi.org/10.1186/1476-511X-11-107
PMid: 22937812 PMCid: PMC3477115

14. Kavey RE. Combined dyslipidaemia in childhood. *Journal of Clinical Lipidology* 2015; **9**(Suppl 5): S41-S56.
https://doi.org/10.1016/j.jacl.2015.06.008
PMid: 26343211

15. Bosmworth NJ. Approach to identifying and managing atherogenic dyslipidemia: A metabolic consequence of obesity and diabetes. *Canadian Family Physician* 2013; **59**: 1169-80.

16. Berneis KK, Krauss RM. Metabolic origins and clinical significance of LDL heterogeneity. *Journal of Lipid Research* 2002; **43**(9): 1363-79.
https://doi.org/10.1194/jlr.R200004-JLR200
PMid: 12235168

17. Schafer JR, Soufi M, Steinberger J, Mayatepek E. Lipids and lipoprotein abnormalities. In: Sarafoglou K editor Pediatric Endocrinology and Inborn Errors of Metabolism. McGraw Hill Medical Companies, Inc, New York, 2009: 294-312.

18. Fujita K, Nozaki Y, Wada K, Yowela M, Fujimoto Y, Fujitake M, Eulo H, *et al*. Dysfunctional very-low-density lipoprotein synthesis and release is key factor in nonalcoholic steatohepatitis pathogenesis. *Hepatology* 2009; **50**: 772-80.
https://doi.org/10.1002/hep.23094
PMid: 19650159

19. Adiels M, Olfsson SO, Taskinen MR, Boren J. Overproduction of very low density lipoprotein is the hallmark of dyslipidaemia in the metabolic syndrome. *Arteriosclerosis, Thrombosis, and Vascular Biology* 2008; **28**: 1225-36.
https://doi.org/10.1161/ATVBAHA.107.160192
PMid: 18565848

20. Marfell-Jones M, Olds T, Stewart A, Carter L. International Standards for Anthropometric Assessment, 2nd edition. The International Society for the Advancement of Kinanthropometry, Australia, 2006.
https://doi.org/10.4324/9780203970157
PMid: 17432050

21. Kwiterovich PO Jr. Recognition and management of dyslipidaemia in children and adolescents. *Journal of Clinical Endocrinology and Metabolism* 2008; **93**:4200-9.
https://doi.org/10.1210/jc.2008-1270
PMid: 18697860

22. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; summary report. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents; National Heart, Lung and Blood Institute. *Pediatrics* 2011; **128**(Suppl 5): S213-S256.
https://doi.org/10.1542/peds.2009-2107C
PMid: 22084329 PMCid: PMC4536582

23. de Quadros TMB, Gordia AP, da Silva RCR, Silva LR. Predictive capacity of anthropometric indicators for dyslipidaemia screening in children and adolescents. *Journal of Pediatrics (Rio J)*: 2015; **91**(5): 455-63.
https://doi.org/10.1016/j.jped.2014.11.006
PMid: 26057185

24. Pereira PB, de Arruda IKG, de Souza Cavalcanti AMT, da Silva Diniz A. Lipid profile of school children from Recife, PE. *Arquivos Brasileiros de Cardiologia* 2010; **95**(5): 606-13.
https://doi.org/10.1590/S0066782X2010005000136
PMid: 20944894

25. Bililoni M, Salas R, De la Gurza Y, Villarreal JZ, Sureda A, Tur JA. Serum lipid profile, prevalence of dyslipidaemia and associated risk factors among Northern Mexican adolescents. *Journal of Pediatric Gastroenterology and Nutrition* 2016; **63**(5): 544-9.
https://doi.org/10.1097/MPG.0000000000001325
PMid: 27379432 PMCid: PMC5084629

26. Elmaoğullari S, Tepe D, Uçkturk SA, Kara FK, Demirel F. Prevalence of dyslipidemia and associated factors in obese children and adolescents. *Journal of Clinical Research in Pediatric Endocrinology* 2015; **7**(3):228-34.
https://doi.org/10.4274/jcrpe.1867
PMid: 26831558 PMCid: PMC4677559

27. Korsten-Reck U, Kromeyer-Hauschild K, Korsten K, Bumstark MW, Dickhuth H, Berg A. Frequency of secondary dyslipidemia in obese children. *Vascular Health Risk Management* 2008; **4**(5):1089-98.
https://doi.org/10.2147/VHRM.S2928
PMid: 19183757 PMCid: PMC2605332

28. Odunaiya NA, Grimmer K, Louw QA. High prevalence and clustering of modifiable CVD risk factors among rural adolescents in southwest Nigeria: implication for grass root prevention. *BMC Public Health* 2015; **15**: 661-9.
https://doi.org/10.1186/s12889-015-2028-3
PMid: 26169588 PMCid: PMC4501296

29. Njelekela MA, Mpembeni R, Muhihi A, Mligiliche NL, Spiegelman D, Hertzmark E, *et al.* Gender-related differences in the prevalence of cardiovascular disease risk factors and their correlates in urban

Tanzania. *BMC Cardiovascular Disorders* 2009; **90**: 30-7.
https://doi.org/10.1186/1471-2261-9-30
PMid: 19615066 PMCid: PMC2723083

30. Lartey A, Marquis GS, Aryeetey R, Nti H. Lipid profile and dyslipidemia among school-age children in urban Ghana. *BMC Public Health* 2018; **18**:320-8.
https://doi.org/10.1186/s12889-018-5196-0
PMid: 29510714 PMCid: PMC5840796

31. Pollin TI, Quartuccio M. What we know about diet, genes, and dyslipidemia: Is there a potential for translation? *Current Nutrition Reports* 2013; **2**(4): 236-42.
https://doi.org/10.1007/s13668-013-0065-z
PMid: 24524012 PMCid: PMC3918461

32. Fenech M, El-Sohemy A, Cahill L, Ferguson LR, French TC, Tai ES, et al. Nutrigenetics and nutrigenomics: Viewpoints on the current status and applications in nutrition research and practice. *Journal of Nutrigenetics and Nutrigenomics* 2011; **4**: 69-89.
https://doi.org/10.1159/000327772
PMid: 21625170 PMCid: PMC3121546

33. Mahley RW, Arslan P, Pekcan G, Pépin GM, Ağaçdiken A, Karaağaoğlu N, *et al*. Plasma lipids in Turkish children: impact of puberty, socioeconomic status and nutrition on plasma cholesterol and high density lipoprotein. *Journal of Lipid Research* 2001; **42**(12): 1996-2006.

34. Montali A, Truglio G, Martino F, Ceci F, Ferraguti G, Clociola E, *et al.* Atherogenic dyslipidaemia in children: Evaluation of clinical, biochemical and genetic aspects. *PLoS ONE* 2015; **10**(4):E012009.
https://doi.org/10.1371/journal.pone.0120099
PMid: 25897955 PMCid: PMC4405441