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Prevalence of Dyslipidemia among School-Age Children and Adolescents in Addis Ababa, Ethiopia

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Abstract

Objective Lipid abnormalities during childhood might be associated with a higher risk of atherosclerosis development in adulthood. In Ethiopia, there were no data on this area. The present work was aimed at assessing the lipid profile abnormalities among children and adolescents aged between 5 and 17 years, in Addis Ababa, Ethiopia.

Materials and Methods The present school-based cross-sectional study was done from March 2019 to October 2019 in the capital city, Addis Ababa. A total of 504 students were randomly recruited for this study. The total cholesterol, triglyceride, low-density lipoprotein, and high-density lipoprotein-cholesterol levels were determined using the Cobas c501 automated chemistry analyzer. The prevalence of lipid abnormalities was described in percentages. Bivariate and multivariate analyses were performed, and data with *p*-value less than 0.05 was considered statistically significant.

Results Dyslipidemia in at least one of the lipid profiles was observed in 322 (63.9%) school children, whereas only one of the participants had an abnormality in all four lipid profile tests. The prevalence of total cholesterol 200 mg/dL or higher, low-density lipoprotein 130 mg/dL or higher, high-density lipoprotein less than 40 mg/dL, and triglycerides 130 mg/dL or higher was in 14 (2.8%), 16 (3.2%), 294 (58.4%), and 46 (19.1%) participants, respectively.

Conclusion In the current work, the majority of the study participants had a normal lipid profile except increased prevalence of a reduced concentration of high-density lipoprotein-cholesterol. The overall prevalence of serum lipid abnormalities was 63.9%. Serum lipid levels did not show significant differences with sex, age, fasting habits, or obesity.

Keywords
- ► lipid profile
- ► dyslipidemia
- ► children
- ► adolescents

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Introduction

Nowadays, cardiovascular disease (CVD) is one of the principal causes of death globally, including in developing countries. It is mainly caused by a lipid abnormality (dyslipidemia), particularly associated with cholesterol and triglycerides (TGs). Lipoprotein metabolism abnormalities account for about half of the potential risk factors for CVDs.[1] Serum concentrations of all the four lipid profiles, particularly low-density lipoprotein cholesterol (LDL-C) are essential in both atherosclerosis assessment and CVD management.[2–4] Evidence from various studies suggested that the onset of atherosclerosis began in childhood and, in the absence of intervention, led to CVD later in life. Hence, early assessment of serum lipid abnormalities has a great role in the better management of dyslipidemia and prevention of future complications of CVD, which improves an individual's long-term health outcomes. The current clinical practice guidelines recommend universal screening of serum lipid concentrations during early life. Studies indicated that high serum concentrations of LDL-C and low serum levels of high-density lipoprotein-cholesterol (HDL-C) in children and adolescents were potentially associated with the attributable risk factors for CVDs in old age.[5–7]

Dyslipidemia was defined per the National Cholesterol Education Program (NCEP) reference limits, which are 200 mg/dL or higher for total cholesterol (TC) and 130 mg/dL or higher for LDL-C.[4] Similarly, the American Heart Association has recommended that TG concentrations of 130 mg/dL or higher, TC 200 mg/dL or higher, LDL-C 130 mg/dL or higher, and HDL-C less than 40 mg/dL be considered as abnormal for children.[8]

Identification of serum lipid levels in childhood is critical for developing an effective intervention to reduce mortality and morbidity associated with CVD later in life.[5–8] In the study area, we found no published study that assessed the prevalence of serum lipid abnormalities among school-age children and adolescents. Therefore, the current work was aimed to assess the distribution of TC, TG, LDL-C, and HDL-C in children, and the prevalence of altered levels of these parameters.

Methods and Materials

Study Design, Setting, Population, Ethical Issues, Sample Size Determination, and Sampling Procedure

A school-based cross-sectional study was performed on children and adolescents, aged between 5 and 17 years, from March 2019 to October 2019, in Addis Ababa, Ethiopia. The simple proportion formula was used to determine the sample size since the prevalence of serum lipid abnormalities among school-age children and adolescents in Ethiopia was not found, so we took prevalence $p = 50\%$, the expected margin of error $(d) = 0.05$ with a confidence interval (CI) level of 95%, and the minimum sample size, $n \approx 384$, but we recruited a total of 504 participants. Participants were selected from government and private schools in four randomly selected sub-cities. An ethical clearance letter was obtained from the Department of Medical Laboratory Sciences, College of Health Science of Addis Ababa University, and permission to perform the current work was obtained from Addis Ababa Health Bureau and the respective sub-cities and woredas. Study participants were selected through multistage random sampling. Initially, the four sub-cities were randomly selected based on the lottery method, namely Arada, Kirkos, Akaki, and Yeka; thus, randomly selected woredas under the selected sub-cities were included. The probability proportional to size sampling method was employed, where the size depends on the number of populations in a sub-city then woreda. Then study participants were selected using a convenient sampling method from the randomly selected sub-cities, then woredas through both school and village-to-village mobilization by the health extension workers and principal investigators. The eligibility criteria for the study participants included those who had lived in the study area for at least 6 months, were apparently healthy, had no known chronic diseases such as diabetes mellitus, CVDs, hypertension, cancer, and others, and no intestinal parasites. Using structured questionnaires, information on socio-demographic characteristics, a factor that affects serum lipid concentration such as habits of fasting and physical exercise, not taking medication that would affect lipid metabolism, or being treated for any acute and/or chronic diseases, and anthropometric data were collected. We use the fasting sample for assessing lipid abnormalities because the serum lipid profile was affected by food consumption especially the TG level. In the data collection process, there was an initial home and school visit by a health extension worker to provide information to the parents/guardians on fasting requirements. Then blood specimens were collected to determine TC, HDL-C, LDL-C, and TG. Before blood collection, volunteers were asked to fast overnight for 8 to 12 hours to minimize the dietary effect on the serum lipid profile. The sample collection was performed from 8:30 AM till 11:00 AM and small children were given the first chance during the phlebotomy procedure. Before the data collection, an information sheet was prepared and read to all study participants and the parents/guardians. Verbal consent from participants and written informed consent from parents/guardians were obtained. The names of the participants were coded by the number on the questionnaire, to ensure confidentiality. Screening test results were submitted to the participant's parents and the responsible body for intervention through health extension workers and data collectors.

Anthropometric Measurements

Following a standardized protocol, weight and height were measured by trained research staff. Standing heights were taken without shoes to the closest 0.1 cm using well-situated stadiometers. The weights were measured to the closest 0.1 kg using a digital balance. Weights were measured without heavy clothes and shoes, while heights were measured without shoes to get an accurate measurement. Body mass index (BMI) was calculated by multiplying one's weight in kilograms by one's height in meters (i.e., weight/height squared). Our study participants were classified as underweight (< 5th percentile), normal weight (5th–85th percentile), overweight (85th to

< 95th percentile), and obese (> 95th percentile) following Centers for Disease Control guidelines.

Sample Collection and Laboratory Analysis

For explaining the venous blood drawing procedure to the participants, from each individual, approximately 5 mL of venous blood was collected into vacuum tubes with separator gel and without anticoagulant by venipuncture. All blood samples were collected while the subjects were fasting for 12 hours. The blood collected in serum separator tubes was centrifuged within 1 hour of collection for 5 minutes at 4,000 rpm, and serum samples were stored frozen, and shipped to the laboratory following protocols. Finally, serum aliquots were stored at −80°C until analysis. Subsequently, serum concentrations of TC, TG, HDL-C, and LDL-C were analyzed using the Cobas c 501 (Roche Diagnostics. GmbH, Mannheim, Germany) automatic chemistry analyzer at the Ethiopian Public Health Institute, which is a nationally accredited laboratory. The lipid profile tests were performed based on the principle mentioned below in ►**Table 1**. During the test procedures, all samples were subjected to a single freeze–thaw cycle. Before any study participant's sample was processed, dual quality control (normal and pathological) and pooled serum samples were always performed, and then the study participant's sample was analyzed. Generally, analytical methods are regulated in accordance with the manufacturer's instructions; therefore, preventive maintenance, function checks, and quality control have always been done.

Dyslipidemia and its sub-classifications were diagnosed as abnormal serum lipid concentrations based on criteria from the NCEP. Therefore, TC 200 mg/dL or higher, TG 130 mg/dL or higher, LDL-C 130 mg/dL or higher, and HDL-C less than 40 mg/dL were considered abnormal.[4]

Statistical Analysis

Data analysis was performed using the statistical program SPSS version 23.0. Descriptive data were presented as means and standard deviation and categorical variables as percentages. Serum lipid values were described by mean ± standard deviation and at 95% CI. The prevalence of lipid abnormalities was described in percentages. Bivariate and multivariate analyses were performed and data with *p*-value less than 0.05 were taken as statistically significant.

The percentage of study participant abnormal lipid concentrations was calculated based on criteria from NCEP. And serum TC/HDL-C ratio was calculated and values greater than 4.5 were taken as a risk factor for CVDs.

Table 1 Laboratory analytical methods used for serum lipid profile tests with Cobas c501 Automated Chemistry Analyzer

Analytes	Analytical method used
Total cholesterol	Cholesterol oxidase/peroxidase
Triglyceride	Lipase/glycerol kinase/glycerol peroxidase
Low-density lipoprotein	Detergent cholesterol esterase/cholesterol oxidase/peroxidase
High-density lipoprotein	PEG-cholesterol esterase/oxidase/ peroxidase

Results

A total of 504 study participant students in both government and private schools were enrolled in the study. There were 252 (50%) males and 252 (50%) females in the age range of 5 to 17 years. The mean age was 12.73 ± 2.91 (males 12.66 ± 3.0 vs. females 12.79 ± 2.81) years. The majority of the study participants, 389 (77.18%), were found in the adolescence (≥ 10 years) age group, ►**Table 2**. The BMI (kg/m^2) for both genders was evaluated. The BMI in the age group 5 to 17 years for males (17.19 ± 2.87) was slightly different from females (18.42 ± 3.52). Similarly, the mean BMI in the age group 5 to 17 years for the combined sexes was 17.80 ± 3.27. Out of the total study population, 3.0% males and 1.8% females were classified as underweight, 3.0% males and 6.8% females were overweight, and 1.4% males and 3.6% females were obese. And the rest 80.56% of the study participants had normal BMI values (►**Table 2**).

The present study showed that female participants had slightly higher concentrations of TC, TGs, and LDL-C than their male counterparts. On the other hand, slightly lower

Table 2 Socio-demographic, anthropometric, and lifestyle characteristics of the study participants

Variables		Number	Percent (%)
Sex	Male	252	50
	Female	252	50
Age	5–9	115	22.82
	10–17	389	77.18
Maternal level of education	Illiterate	147	29.17
	Primary education (1–8 grades)	165	32.74
	Secondary education (9–10 grades)	123	24.40
	College diploma/ degree and above	69	13.69
BMI	Normal	406	80.56
	Underweight	24	4.80
	Overweight	49	9.80
	Obese	25	5.00
Physical activities	Yes	499	99.00
	No	5	1.00
Fasting habit	Yes	341	67.66
	No	163	32.34

Abbreviation: BMI, body mass index.

Table 3 Average values, 95% CI, and *p*-value of serum lipid distribution for sex, BMI, the habit of physical exercise, and fasting

Lipid profile	Mean ± SD	95% CI	*p*-Value				
			Sex	Age	BMI	Habit of exercise	Fasting habit
TC	141.33 ± 28.22	138.75–143.61	0.567	0.327	0.952	0.457	0.09
TG	87.66 ± 34.20	84.71–90.66	0.014[a]	0.516	0.203	0.661	0.775
LDL-C	78.24 ± 23.66	76.07–80.13	0.777	0.631	0.988	0.232	0.122
HDL-C	38.74 ± 9.90	37.81–39.60	0.050	0.499	0.556	0.993	0.44

Abbreviations: BMI, body mass index; CI, confidence interval; HDL- C, high-density lipoprotein-cholesterol; LDL- C, low-density lipoprotein-cholesterol; SD, standard deviation; TC, total cholesterol; TG, triglycerides.
[a]*p*-Values < 0.05 were considered as statistically significant, which is done by independent sample *t*-test.

levels of HDL-C were found in females than males. The mean concentrations of TC were 140.61 ± 31.27 versus 142.05 ± 24.84 mg/dL, for TGs 83.91 ± 31.88 versus 91.39 ± 36.05 mg/dL, for LDL-C 77.94 ± 25.83 versus 78.54 ± 21.31 mg/dL, and for HDL-C 39.60 ± 10.62 versus 37.87 ± 9.06 mg/dL for males and females, respectively. The serum TC/HDL-C ratio values greater than 4.5 were taken as high risk for CVDs. Hence, 45 (8.9%) male and 56 (11.1%) female participants had TC/HDL-C ratio greater than 4.5. Generally, the TC/HDL-C ratio was 3.55 and 3.75 for male and female participants, respectively.

The concentration of all serum lipids was not statistically significant (*p*-value > 0.05) with age and BMI. However, only the TG level was significant with sex *p*-value = 0.014 (►**Table 3**). None of the obese participants had hypercholesterolemia, high LDL-C, and low HDL-C levels. However, only 2.2% of obese students had hypertriglyceridemia. Based on these data, there were insignificant differences in the development of serum lipid abnormalities with age groups, sex, BMI, the habit of exercise, and fasting (►**Table 3**).

Based on the current findings, 57 of these 5.8% boys and 5.6% girls of the study participants had borderline (170–199 mg/dL) TC concentrations. Similarly, of 504 participants, 70 (14.0%) males and 78 (15.5%) females had borderline TG concentrations. Individuals with borderline HDL-C (i.e., 40–45 mg/dL) and LDL-C (i.e., 110–129 mg/dL) levels were 47 (9.3%) males and 50 (9.9%) females and 12 (2.4%) males and 14 (2.8%) females, respectively.

Serum lipid alteration in at least one of the lipid profiles was seen in 322 (63.9%) of school children and adolescents, while only one male participant had an abnormality in all four lipid profile tests. Of the total study participants, the prevalence of TC 200 mg/dL or higher, LDL-C 130 mg/dL or higher, HDL-C less than 40 mg/dL, and TGs 130 mg/dL or higher were 14 (2.8%), 16 (3.2%), 294 (58.4%), and 46 (9.1%), respectively.

Regarding the magnitude of lipid profile distribution by sex, 248 (49.2%) of females had normal TC and 10 (2.8) of males had high TC, while 28.2% of males and 30.2% of females had low HDL-C concentrations. While the total prevalence of dyslipidemia in at least one of the lipid profile tests was almost equal to sex (females 32.8% vs. males 31.2%). The prevalence of hypercholesterolemia was slightly higher in males 10 (2%) than in females 4 (0.8%); high concentrations of LDL-C of 11 (2.2%) in males and 5 (1%) in females. However, high hypertriglyceridemia of 28 (5.6%) in females versus 18 (3.6%) in males, and low HDL-C of 152 (30.2%) in females and 142 (28.2%) in males were seen (►**Fig. 1**).

In bivariate analysis, only the habit of fasting was considered for multivariate analysis with a *p*-value of 0.17. While performing multivariate analysis of dyslipidemia in at least one of the lipid profiles, after adjusting for traditional dyslipidemia risk factors, none of the factors were associated with serum lipid abnormality ($p > 0.05$) (►**Table 4**).

Discussion

The current study investigated the prevalence of dyslipidemia in school children and adolescents in Addis Ababa, Ethiopia. Based on the outcomes of the present work, female participants had slightly higher concentrations of TC, TG, and LDL-C and lower concentrations of HDL-C than their male counterparts. The overall prevalence of serum lipid abnormalities was 63.9%. Female students accounted for 32.7% of these, while male students accounted for the remaining 31.2%. After performing the adjusted odds ratio analysis, age, sex, BMI, and habit of fasting were not associated with the development of dyslipidemia (*p*-value > 0.05). This study revealed that females had a higher incidence of dyslipidemia, but the difference was not statistically significant. The prevalence of hypertriglyceridemia and low levels of HDL-C was higher in female participants than in male counterparts. According to the literature, lipid abnormalities in childhood are primarily associated with a small change in LDL-C concentration, with a predominance of HDL-C and TG alterations.[9] A study done in Spain showed higher levels of serum TC and LDL-C in children and adolescents along with very high levels of HDL-C.[10] Similarly, the current study obtained a high prevalence of low HDL-C of 59.3%, hypertriglyceridemia of 9.1%, and a low prevalence of LDL-C abnormalities. The report by Yang et al 2012 showed a low prevalence of serum lipid abnormalities, 19.7% lower than the current findings in school children.[11] In another study conducted by Taheri et al, dyslipidemia was detected in 31% of Iranian children. Other authors also reported that the prevalence of TC 200 mg/dL or higher, TG 130 mg/dL or higher, LDL-C 130 mg/dL or higher, and HDL-C less than 40 mg/dL was 13.4, 15.3, 8.5, and 11.3%, respectively.[12] Inconsistent, this study found that the lower prevalence of TC 200 mg/dL or higher in 2.8%, LDL-C 130 mg/dL or higher in 3.2%, and TGs 130 mg/dL in 9.1%, and the higher prevalence of

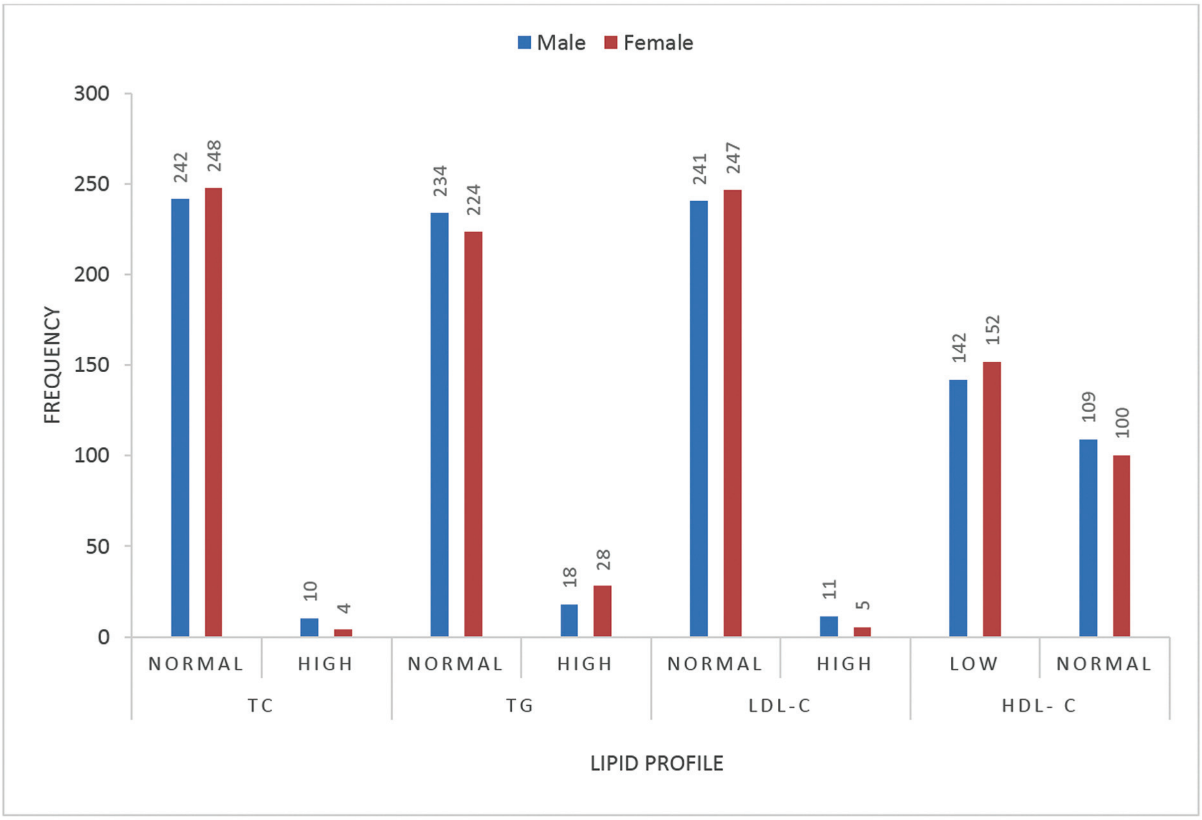

Fig. 1 Distribution of lipid profile by sex among children and adolescents, Addis Ababa, Ethiopia ($N = 504$).

Table 4 Associated factors with dyslipidemia among school-age children

Variable	Categories	Dyslipidemia		COR (95% CI)	*p*-Value	AOR (95% CI)	*p*-Value
		Yes No (%)	No No (%)				
Age in year	< 10 ≥ 10	76 (15.1) 246 (48.8)	39 (7.7) 143 (28.4)	1.13 (0.73–1.75)	0.57	NA	–
Sex	Male Female	157 (312) 165 (327)	95 (18.8) 87 (17.3)	0.87 (0.60–1.25)	0.45	NA	–
BMI	< 25 kg/m^2 ≥ 25 kg/m^2	312 (61.9) 10 (2.0)	175 (34.7) 7 (1.4)	0.8 (0.3–2.14)	0.65	NA	–
Habit of fasting	Yes No	214 (42.5) 112 (22.2)	127 (25.2) 51 (10.1)	0.76 (0.51–1.13)	0.17[a]	0.79 (0.52–1.19)	0.26

Abbreviations: AOR, adjusted odds ratio; BMI, body mass index; COR, crude odds ratio; NA, not applicable.
[a]*p*-Values < 0.25 were considered for multivariate analysis.

HDL-C less than 40 mg/dL in 58.4% of students. Furthermore, the Brazilian study reported a higher prevalence of hypercholesterolemia (20.1%) and a lower prevalence of low HDL-C (46.8%), and hypertriglyceridemia (7.8%) than the current work.[13] But there were population differences between these two studies. The Brazilian one was conducted on adolescents aged between 12 and 17 years only, but the current work includes both children and adolescents aged 5 to 17 years. Regardless of the population differences, the prevalence of high LDL-C was almost similar (Brazilian 3.5% vs. current study 3.2%).

A comparison between the mean levels of lipids in the present study and a Ghanaian study revealed that the concentrations of TC and LDL-C were comparable, but higher levels of HDL-C and lower levels of TG were found in the Ghanaian study. The proportion of Ghanaian participants with dyslipidemia was higher in TC (12.1%) and LDL-C (9.2%), but lower in TG (4.5%), HDL-C (28.2%), and TC/HDL-C ratio (6.6%) than the current findings.[14] However, this study revealed that a very high prevalence of low levels of HDL-C was 58.4% and the TC/HDL-C ratio was 20.0%.

Furthermore, the prevalence of hypercholesterolemia at 2.8% and hypertriglyceridemia at 9.13% in the current study were comparable with those of Thai school children at 1.2 and 10.6%, respectively.[15] On the other hand, the prevalence of dyslipidemia found in the current study (63.9%) is higher than that done in Salvador, Bahia, 2012.[16] The current prevalence of hypercholesterolemia (2.8%), increased LDL-C (3.2%), and increased TG (9.1%) were significantly lower than the prevalence in Germany (7.8, 6.1, and 22.1%, respectively). In contrast, the prevalence of decreased HDL-C in the current work was higher than that in Germany at 8.0%.[17] In addition, another study conducted by Hirschler et al among Argentinean children reported a higher prevalence of hypertriglyceridemia (28.8%) and a lower prevalence of low HDL-C (30.0%) than the current finding.[18]

According to a study in Tehran, high TC is the predominant manifestation of serum lipid alteration, followed by high LDL-C.[12] Another study in Saudi Arabia on school-age children revealed that high levels of TG were the most prevalent lipid abnormality.[19] However, the current study found that the highest prevalence of low levels of HDL-C was higher than all other lipid tests. Different studies have reported various prevalence rates of dyslipidemia. The differences in the prevalence of undesirable serum lipids in different countries may be due to variation in genetic, racial, socioeconomic characteristics, dietary habits, sample size, laboratory methods, and definitions of dyslipidemia. The current work found that the prevalence of hypercholesterolemia, high concentrations of LDL-C, and low HDL-C levels were higher in males than their female counterparts. However, the differences were not statistically significant (p-value > 0.05). In line with our findings, the Ghanaian study indicated that no significant differences were found in the lipid profile of females and males.[14] In contrast, a Colombian study showed that females had a greater proportion of abnormal TC levels.[20]

Serum lipid levels are influenced by various metabolic, genetic, and environmental factors as well as age, sex, and ethnicity.[7] Surprisingly, this study revealed that the prevalence of lipid alteration is not associated with increasing BMI. None of the obese participants had any serum lipid alterations. Similarly, a study done by Guerrero-Romero and Rodríguez-Morán in North Mexico showed that hypercholesterolemia was not associated with obesity.[21] In other words, several studies[12–17] found a high prevalence of serum lipid abnormalities in overweight and obese children. Even though obesity is one of the potential risk factors which aggravate serum lipid abnormalities, it is a routine practice in the clinical setting for health care providers to wonder that individuals with a normal BMI are found to have such abnormalities.[22] In this study, serum lipids were not shown to have significant differences with sex, age, the habit of fasting, and physical exercise among students. The possible reason is that students have very similar lifestyles. For instance, most of them have almost similar levels of physical exercise in school and nutritional status. Similarly, in a study conducted on Thai school children, there was no association between serum lipids and age, gender, or nutritional status.[15] The present study participants had normal fasting glucose levels, blood pressure, and no habit of smoking cigarettes, but we failed to assess the presence of familial hypercholesterolemia.

Conclusion

The majority of the study participants had a normal lipid profile except for the high prevalence of reduced levels of HDL-C. The overall prevalence of serum lipid abnormalities was 63.9%. Serum lipid levels did not show significant differences with sex, age, fasting habits, or obesity. Evidence from the current study revealed that the prevalence of dyslipidemia was high in school children in Addis Ababa, Ethiopia, and, thus, requires preventive measures.

To the best of our knowledge, this is the first attempt to assess the prevalence of serum lipid abnormalities among Ethiopian children and adolescents, as there are no published data on the subject. As a result, the current findings may point to the importance of early investigation and assessment of lipid profiles in childhood as a means of preventing serum lipid abnormalities in old age. Because several studies have shown that lipid abnormalities in childhood are associated with the presence of atherosclerosis and the risk of serum lipid alteration in adulthood, a larger study is recommended to investigate the prevalence and risk factors of serum lipid abnormality in other parts of the country to take early preventive measures to avoid dyslipidemia and associated diseases at the early stages.

Data Availability
Additional data will be available from the corresponding author upon reasonable request.

Declaration of Interest
None declared.

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