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An Assessment of Predisposing Factors of Atherogenic Dyslipidemia in an Urban Pediatric Population in Cameroon

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Abstract

Background: Dyslipidemia in childhood contributes to an increased risk of cardiovascular diseases later in life. This study sets out to determine the prevalence of dyslipidemia and describe the associations between selected variables and dyslipidemia in Cameroon urban children. **Methods:** This cross-sectional hospital-based study included 415 children (188 boys and 227 girls) between the ages of 5 and 16 years. Dyslipidemia was defined as an abnormal value of one or more of the following lipids: Total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C). Percentage body fat (%BF) was estimated using bio-electric impedance analysis. A structured questionnaire was used by parents to report physical activity, screen time and eating habits of the children. Relationships between predictors and dyslipidemia were assessed using multiple binary logistic regression analyses. **Results:** The prevalence of dyslipidemia was 46.0%. Dyslipidemic children had significantly higher %BF, TG and LDL-C and lower HDL-C than the normal children ($p < 0.05$). In multivariate analysis, obesity (OR 5.2, 95% CI 1.7 - 11.2, $p = 0.004$), short stature (OR 2.8, 95% CI 1.1 - 6.8, $p = 0.041$), physical activity < 60 minutes/day (OR 4.2, 95% CI 2.3 - 7.5, $p < 0.001$) and never/occasional consumption of fruits/vegetables (OR 2.9, 95% CI 1.2 - 7.1, $p = 0.017$) independently predicted dyslipidemia after adjusting for different variables. **Conclusion:** This study confirms that obesity, short stature, physical activity < 60 minutes/day and never/occasional consumption of fruits/vegetables were associated with dyslipidemia. Also, a high proportion of children had one or more lipid disorders. This is concerning and indicates the importance of assessing dyslipidemia in pre-school children in future studies.

Keywords

Dyslipidemia, Children, Percentage Body Fat, Stature, Cameroon

1. Introduction

Dyslipidemias are alterations of blood lipid levels, which result from disorders in lipoprotein metabolism. These alterations include an increase in the levels of total cholesterol (TC), triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C), and a decrease in the level of high-density lipoprotein cholesterol (HDL-C) [1]. Dyslipidemia is common in African countries and the number of children and adolescents affected is increasing. This is due to the nutrition transition, which is characterized by economic changes as well as changes in lifestyle and eating habits [2]. A recent report indicated that the pooled prevalence of dyslipidemia within Africa was 60.8%, 53.1%, 46.7% and 21.0% in East, South, West and Central Africa respectively [2]. In Cameroon, data on dyslipidemia in children is scarce. However, a recent cross-sectional analysis of children between the ages of 3 and 17 years in Cameroon indicated that the prevalence of hypercholesterolemia was 16.0% [3]. Dyslipidemia in childhood is an important cardiovascular risk factor. There is evidence that pediatric dyslipidemia is predictive of dyslipidemia in adulthood [4] and also increases the risk of cardiovascular disease [5]. For example, studies have revealed that unfavourable levels of TC, LDL-C and TC/HDL-C ratio in childhood are associated with increased thickening of the carotid intima-media complex later in life [6] [7]. Reports from different countries have shown that obesity, socioeconomic and lifestyle factors account for a high proportion of children with dyslipidemia. For example, a study among children in Ghana indicated that BMI-obese children had significantly elevated levels of TG and LDL-C than normal weight children [8]. Also, a report from Brazil indicated that obesity assessed using percentage of body fat in children and adolescents explained one fifth of changes in levels of TC [9]. In addition, it was observed in a study that followed up children for a period of 18 months that a 1 cm increase in waist circumference contributed to a 0.50 mg/dl and 0.21 mg/dl increase in mean TG and TC concentrations respectively [10]. With respect to physical activity, a randomized cluster trial in Australia indicated that 50 minutes of physical education classes organized twice a week contributed to a reduction of the prevalence of elevated LDL-C in school children over a four-year period [11]. Also, LeBlanc and Jansenn [12] reported that the risk of elevated TC was reduced by moderate-to-vigorous physical activity in youth. A screen time greater than one hour/day was associated with a higher prevalence of dyslipidemia among Chinese boys [13]. Concerning dietary habits, a cross sectional study revealed that children who skip breakfast had higher mean TC, TG and LDL-C concentrations than those who do not skip breakfast

[14]. Also, the risk of dyslipidemia was found to increase among children, who eat unhealthy foods (fried and salty foods, butter, snacks, meat-derived foods) when compared with those who ate healthy foods (fruits, vegetables, legumes and cereals) [15]. In addition, a study in a multi-ethnic group of children revealed that consumption of more than one servings per week of sugar-sweetened beverages (SSB) was associated with increased TG concentration [16]. Biologically, height was found to be inversely associated with TC and HDL-C in Japanese children [17]. Also, a recent report indicated that short stature is associated with increased LDL concentration in children [18]. There is evidence indicating that the proportions of children with dyslipidemia also depend on their ethnic origin [19], and it is unclear whether the above factors that contribute to dyslipidemia in different countries also apply to Cameroon children. Therefore, this study sets out to determine the prevalence of dyslipidemia and evaluate the relationships between selected factors and dyslipidemia in urban children.

2. Materials and Methods

2.1. Study Design and Study Participants

Our study involved cross-sectional hospital-based data and the participants were enrolled from May 2021 to December 2021 during their consultations at the outpatient unit of the Bamenda Regional Hospital (BRH) in the North West Region of Cameroon. During their visit to the hospital, 602 children and parents/guardians were approached by trained laboratory technicians and provided with consent information. The children were also asked to indicate if they had fasted overnight. Children were included in this study only after they had given consent to participate and had indicated that they fasted overnight. A total of 449 children aged between 5 and 16 years were recruited in the study. After further examination of the health records of the children during their visit in the hospital, 34 children were dropped and this included children with type 1 diabetes [20], those on antiretroviral medication [21], and children who had recently undergone surgery. Therefore, our analysis included 415 children (188 boys and 227 girls) with a mean age of 12.6 ± 2.7 years.

The sample size for this study was calculated using G*Power [22] version 3.1.9.6 (Heinrich-Heine-Universität, Düsseldorf, Germany) using logistic regression as the main statistical test. Dyslipidemia (presence versus absence) was the dependent variable. The parameters taken into consideration in the calculation were; an odds ratio of 1.5, a statistical power ($1 - \beta$) of 80% and a level of significance (α) of 5%. This gave a minimum sample size of 308.

2.2. Ethical Considerations

The guidelines laid down in the Helsinki Declaration were followed in this study. We obtained ethical and administrative clearances for this study from the Ethical Review Committee of The University of Bamenda (Ref. No. 2021/103H/UBa/IRB) and the Regional Delegation of Public Health of the North West Region of Cameroon respectively. Hospital clearance was also obtained from the Bamenda Regional Hospital. In addition, we obtained consent and verbal assent from the parents/guardians and children respectively before any study-related procedures were carried out.

3. Data Collection

3.1. Anthropometric and Percentage Body Fat Measurements

All measurements were carried out in the hospital premises by trained laboratory technicians. A portable stadiometer (SECA 213, Hamburg, Germany) was used to measure height to the nearest 0.1 cm with participants putting on no shoes. Body weight and percentage body fat (%BF) were measured using a segmental body composition analyzer (TANITA BC-418 MA, Tokyo, Japan), which employs bio-electric impedance analysis (BIA) with a single frequency of 50 Hz. The study participants with light clothing stood bare feet on the analyzer and held a pair of handgrips on each hand [23]. The body weight of each participant was recorded and also, the %BF readings were produced after approximately 30 seconds. In the absence of growth curves of %BF in our setting, we used the 85th and 95th centiles to classify the study participants as overfat and obese respectively as proposed by McCarthy *et al.* [23] for UK children. The z-scores of height were calculated using the WHO 2007 growth reference data for children between 5 and 19 years [24], and the study participants were further classified according to increasing quartiles of height z-score.

3.2. Physical Activity and Screen Time

In this study, we considered the following in the assessment of physical activity: household chores, working on the farms, football, handball, hide and seek, hopscotch, playing on the playground and walking to school. The parents and children reported the approximate number of hours that the children are involved in the above activities during the week (Monday to Sunday) [25]. The mean time in hours involved in the above activities per day was calculated and converted into minutes. The participants were then classified as follows: < 60 minutes/day, 60 - 90 minutes/day and >90 minutes/day. In order to assess screen time, the following activities were recorded: watching TV, playing video games, using android tablets and computers for internet. The parents and their children were asked to record the amount of time (hours) spent on the above activities during weekdays and weekends from the following categories: 1) one hour/day, 2), two hours/day, 3) three hours/day, 4) four hours/day, 5) five hours/day and 6) six hours/day. The average number of hours a day spent doing the above activities was calculated [26] and the children were categorized as follows: low (≤1 hour/day), moderate (>1 - 3 hours/day) and high (>3 - 6 hours/day).

3.3. Eating Habits

A food frequency questionnaire was developed by making use of previous studies [27] [28] to assess the eating habits of the children. The questionnaire was based on the frequency of consumption of selected food items and this included; fruits/vegetables, breakfast, snacking in-between meals, consumption of sugar sweetened beverages (SSB), confectionery and fried/salty foods. The frequencies of consumption of these items were categorized as follows: fruits/vegetables—never, occasionally, everyday; breakfast—skip/rarely, 1 - 2 times/week, 3 - 4 times/week, daily; snacking in-between meals—once a day, twice a day, ≥3 times a day. Also, the study participants were classified according to the consumption of sugar-sweetened beverages, confectionery and fried/salty foods as follows: <1 time/week, 2 - 4 times/week and 5 or more times/week.

3.4. Laboratory Procedures

All biochemical analyses were carried out in the Bamenda Regional Hospital laboratory. The lipid profile (TC, TG and HDL-C) was assessed enzymatically in fasting blood samples using an automated clinical chemistry analyzer (Randox Monaco, UK). Quality control was monitored daily using the Randox Assayed Multisera level 2 and 3 according to the manufacturer's instructions. The LDL-C concentrations were determined using the Friedewald equation [29]. Abnormalities in lipids were defined based on the Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents [30]. Dyslipidemia was defined by an abnormality in one or more lipid values as follows: TC ≥ 200 mg/dl; LDL-C ≥ 130 mg/dl and HDL-C < 35 mg/dl. Also, TG ≥ 100 mg/dl and ≥ 130 mg/dl were used for children between 0 - 9 years and between 10 - 19 years respectively [31] [32].

3.5. Statistical Analysis

All statistical analysis was performed using SPSS for Windows version 22.0 (IBM, 1 New Orchard Road Armonk, New York 10504-1722, US). The distribution of continuous variables was checked for normality using the Shapiro-Wilk test. The proportions of children with lipid disorders have been presented with their corresponding confidence intervals. Also, the comparison of proportions was tested using the Chi square test. The comparisons of continuous variables between groups were carried out using the Mann-Whitney *U*-test and results expressed as median (25th percentile - 75th percentile). Univariate and multivariate odds ratios (adjusted for age and gender) and their corresponding confidence intervals were calculated using binary logistic regression analysis. The multivariate model included age, gender and all variables that showed a significant relationship with dyslipidemia in the univariate analysis. The cut-off for statistical significance was set at a p-value of <0.05.

4. Results

4.1. Prevalence of Dyslipidemia

The overall prevalence of dyslipidemia in this study was 46.0%, with a slightly higher proportion of girls (46.8%) affected than boys (45.4%). However, this difference was not significant ($X^2 = 0.037$, $p = 0.843$). Figure 1 shows the prevalence of lipid disorders in boys and girls. A higher proportion of girls had elevated TC and LDL-C levels compared to boys. However, these differences were not significant. A significantly ($X^2 = 2.971$, $p = 0.032$) higher proportion of girls had lower HDL-C levels compared to boys.

4.2. Characteristics of the Study Population

Table 1 shows a comparison of categorized variables with respect to gender in the study population. Majority (79.6%) of the investigated population had normal levels of percentage body fat. More girls were overfat/obese (23.3%) than boys (16.5%). More than two-third of boys (66.5%) were in the first two quartiles of height z-score, while 57.3% of girls were in the third and fourth quartiles of height z-score. More than a quarter (28.4%) of the children did not meet the requirements of 60 minutes of physical activity a day. Also, 40.7% of the study participants had a high physical activity level. With respect to screen time, 27.7% and 15.6% of the children had a low and high screen time respectively, and more

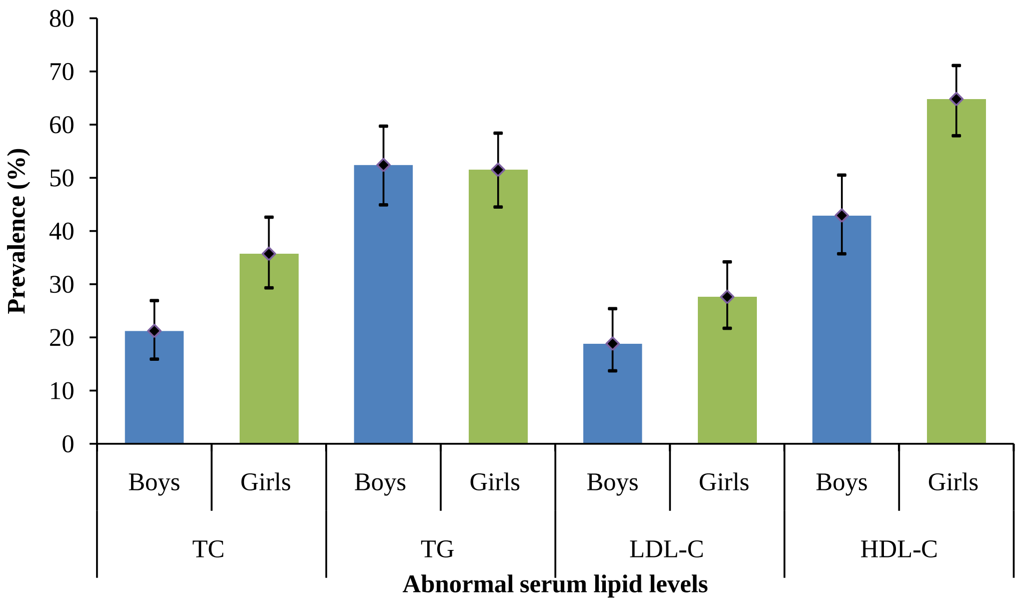

Figure 1. Prevalence of lipid disorders in boys and girls.

Table 1. Characteristics of the study population.

Variable	All children (N = 415)	Boys (N = 188)	(95% CI)	Girls (N = 227)	(95% CI)	*p*-value
	n (%)	n (%)		n (%)		
Percentage body fat						0.046
Obese	25 (6.0)	7 (3.7)	(1.8 - 7.5)	18 (7.9)	(5.4 - 12.7)	
Overfat	59 (14.2)	24 (12.8)	(8.7 - 18.3)	35 (15.4)	(11.3 - 20.7)	
Normal	331 (79.8)	157 (83.5)	(77.6 - 88.1)	174 (76.7)	(70.7 - 81.7)	

Continued

Height quartiles						<0.001
First quartile	103 (24.8)	59 (31.4)	(25.2 - 38.3)	44 (19.4)	(14.8 - 25.0)	
Second quartile	119 (28.7)	66 (35.1)	(28.7 - 42.2)	53 (23.3)	(18.3 - 29.3)	
Third quartile	102 (24.6)	30 (16.0)	(11.4 - 21.9)	72 (31.7)	(26.0 - 38.0)	
Fourth quartile	91 (21.9)	33 (17.6)	(12.8 - 23.6)	58 (25.6)	(20.3 - 31.6)	
Physical activity (min/day)						0.002
Low (<60 min/day)	118 (28.4)	50 (26.6)	(20.8 - 33.3)	68 (30.0)	(24.4 - 36.2)	
Moderate (60 - 90 min/day)	128 (30.8)	74 (39.4)	(32.7 - 46.5)	54 (23.8)	(18.7 - 29.7)	
High (>90 min/day)	169 (40.8)	64 (34.0)	(27.7 - 41.1)	105 (46.3)	(39.9 - 52.8)	
Screen time (hours/day)						0.001
Low (<1 hour/day)	115 (27.7)	56 (29.8)	(23.7 - 36.7)	59 (26.0)	(20.7 - 32.1)	
Moderate (2 - 3 hours/day)	235 (56.6)	116 (61.7)	(54.6 - 68.4)	119 (52.4)	(45.9 - 58.8)	
High (4 - 6 hours/day)	65 (15.7)	16 (8.5)	(5.3 - 13.4)	49 (21.6)	(16.7 - 27.4)	
Fruit and vegetables						0.080
Never	6 (1.5)	0 (0.0)	(0.0 - 2.0)	6 (2.6)	(1.2 - 5.7)	
Occasionally	374 (90.1)	172 (91.5)	(86.7 - 94.7)	202 (89.0)	(84.3 - 92.4)	
Everyday	35 (8.4)	16 (8.5)	(5.3 - 13.4)	19 (8.4)	(5.4 - 12.7)	
Breakfast						0.002
Skip/rarely	32 (7.7)	12 (6.4)	(3.7 - 10.8)	20 (8.8)	(5.8 - 13.2)	
1 - 2 times/week	72 (17.3)	20 (10.6)	(7.0 - 15.9)	52 (22.9)	(17.9 - 28.8)	
3 - 4 times/week	115 (27.7)	52 (27.7)	(21.8 - 34.5)	63 (27.8)	(22.3 - 33.9)	
Daily	196 (47.3)	104 (55.3)	(48.2 - 62.3)	92 (40.5)	(34.4 - 47.0)	
Snacks in-between meals						0.017
Once a day	227 (54.7)	112 (59.6)	(52.4 - 66.3)	115 (50.7)	(44.2 - 57.1)	
Twice a day	121 (29.2)	55 (29.3)	(23.2 - 36.0)	66 (29.1)	(23.6 - 35.3)	
≥ 3 times a day	67 (16.1)	21 (11.1)	(7.4 - 16.5)	46 (20.2)	(15.6 - 25.9)	
Sugar-sweetened beverages						0.100
< 1 time/week	159 (38.3)	73 (38.8)	(32.2 - 46.0)	86 (37.9)	(31.8 - 44.4)	
2 - 4 times/week	203 (48.9)	98 (52.1)	(45.0 - 59.2)	105(46.3)	(39.9 - 52.8)	
5 or more times/week	53 (12.8)	17 (9.0)	(5.7 - 14.0)	36 (15.9)	(11.7 - 21.2)	
Confectionery						0.074
< 1 time/week	116 (28.0)	61(32.4)	(26.2 - 39.4)	55 (24.2)	(19 - 30.2)	
2 - 4 times/week	244 (58.8)	108 (57.4)	(50.3 - 64.3)	136 (59.9)	(53.4 - 66.1)	
5 or more times/week	55 (13.2)	19 (10.1)	(6.6 - 15.2)	36 (15.9)	(11.7 - 21.2)	
Fried/salty foods						0.370
<1 time/week	52 (12.5)	26 (13.8)	(9.6 - 19.5)	26 (11.5)	(7.9 - 16.3)	
2 - 4 times/week	328 (79.0)	143 (76.1)	(69.5 - 81.6)	185 (81.5)	(75.9 - 86.0)	
5 or more times/week	35 (8.5)	19 (10.1)	(6.6 - 15.2)	16 (7.0)	(4.4 - 11.1)	

girls had a higher screen time. In addition, less than 10% of the children ate fruits and vegetables every day. A majority of the children (74.9%) ate breakfast at least 3 times/week, and a minority (7.7%) skipped breakfast. The consumption of snacks in-between meals was significantly higher among girls, with approximately half of the girls eating snacks at least twice in a day. Even though significant differences were not found in the consumption of sugar-sweetened beverages (SSB), confectionery and fried/salty foods between boys and girls, the consumption of these food items was higher among girls. More than 60% of girls consumed these items at least twice in a week.

4.3. Differences between Dyslipidemic and Non-Dyslipidemic Children

Table 2 shows the differences in continuous variables between non-dyslipidemic and dyslipidemic boys and girls. Dyslipidemic boys were significantly ($p < 0.05$) younger (median age = 11.8 years) than their peers with acceptable lipid levels (median age = 10.8 years). However, this difference was not observed in girls. Also, the median percentage body fat was significantly higher among boys and girls with abnormal lipid profiles when compared with those having acceptable lipid profiles. Children with dyslipidemia had significantly ($p < 0.001$) elevated median TG (154.7 mg/dl) and LDL-C (119.6 mg/dl) and significantly lower median HDL-C (2 mg/dl) when compared with children having normal lipid profiles - TG (78.9 mg/dl), LDL-C (72.5 mg/dl) and HDL-C (65.3 mg/dl). Median TC was higher among dyslipidemic children than children with acceptable lipid levels. However, the differences were not significant.

4.4. Relationships between Predisposing Factors and Dyslipidemia

The relationships between dyslipidemia and predisposing factors are shown on Table 3(a) and Table 3(b). In the univariate analysis, obesity, shortness, low

Table 2. Body fatness, height and serum lipid levels between normal and dyslipidemic children.

Variables	Boys		*p*-value	Girls		*p*-value
	Acceptable	Dyslipidemic		Acceptable	Dyslipidemic	
	Median (P_{25} - P_{75})	Median (P_{25} - P_{75})		Median (P_{25} - P_{75})	Median (P_{25} - P_{75})	
Age (years)	11.8 (10.2 - 14.6)	10.8 (9.1 - 14.3)	0.042	13.1 (11.2 - 15.5)	13.2 (11.8 - 14.8)	0.723
Height (m)	145.0 (132.0 - 162.0)	141.5 (133.0 - 141.5)	0.036	155.0 (147.0 - 160.0)	150.4 (145.0 - 159.8)	0.493
Height z-score	−0.24 (−0.96 - 0.36)	−0.22 (−1.30 - 0.58)	0.919	−0.30 (−0.83 - 0.21)	−0.30 (−0.67 - 0.57)	0.834
% BF	17.9 (15.7 - 20.2)	19.6 (17.3 - 22.0)	0.018	18.7 (16.1 - 22.4)	21.1 (19.0 - 23.8)	0.004
TC (mg/dl)	148.1 (99.1 - 180.9)	159.6 (120.6 - 165.4)	0.676	161.7 (147.3 - 177.6)	165.5 (140.1 - 207.4)	0.256
TG (mg/dl)	71.4 (57.6 - 93.9)	134.9 (90.0 - 182.4)	<0.001	77.1 (59.0 - 99.4)	140.6 (94.5 - 194.7)	<0.001
LDL (mg/dl)	70.1 (58.9 - 83.9)	96.4 (45.7 - 139.7)	<0.001	70.1 (56.4 - 94.8)	95.6 (59.4 - 157.3)	<0.001
HDL (mg/dl)	67.2 (56.7 - 74.6)	24.4 (-41.1 - 48.3)	<0.001	68.3 (56.3 - 77.2)	27.6 (−3.9 - 63.4)	<0.001

Table 3. (a) Prevalence and relationships between selected factors and dyslipidemia;(b) Prevalence and relationships between selected factors and dyslipidemia cont.

(a)

Variable	N	Dyslipidemia						
		Prevalence (%)	Univariate OR	(95% CI)	*p*-value	Multivariate OR	(95% CI)	*p*-value
Percentage body fat								
Obese	25	76.0	4.7	1.8 - 10.4	0.001	5.2	1.7 - 11.2	0.004
Overfat	172	48.6	1.5	0.9 - 2.2	0.061	1.4	0.8 - 2.1	0.195
Normal	218	39.9	1			1		
Height quartiles								
First quartile	103	55.3	3.9	1.4 - 4.7	0.015	2.8	1.1 - 6.8	0.041
Second quartile	119	40.3	0.8	0.2 - 3.1	0.798	0.9	0.4 - 1.7	0.632
Third quartile	102	42.2	0.7	0.3 - 1.7	0.447	0.4	0.2 - 1.3	0.092
Fourth quartile	91	39.6	1			1		
Physical activity (min/day)								
Low (<60 min/day)	118	69.5	4.1	2.5 - 6.8	<0.001	4.2	2.3 - 7.5	<0.001
Moderate (60 - 90 min/day)	128	38.3	1.1	0.7 - 1.8	0.623	1.1	0.7 - 1.9	0.710
High (>90 min/day)	169	35.5	1			1		
Screen time (hours/day)								
High (4 - 6 hours/day)	115	59.1	1.5	0.8 - 2.7	0.200	-	-	-
Moderate (2 - 3 hours/day)	235	38.7	0.7	0.3 - 1.1	0.129	-	-	-
Low (<1 hour/day)	65	49.2	1					

(b)

Variable	N	Dyslipidemia						
		Prevalence (%)	Univariate OR	(95% CI)	*p*-value	Multivariate OR	(95% CI)	*p*-value
Fruit and vegetables								
Never/occasionally	380	49.2	3.9	1.7 - 9.1	0.002	2.9	1.2 - 7.1	0.017
Everyday	35	20.0	1			1		
Breakfast								
Skip/rarely	32	56.3	1.7	0.8 - 3.6	0.178	-	-	-
1 - 2 times/week	72	50.0	1.3	0.7 - 2.2	0.334	-	-	-
3 - 4 times/week	115	45.2	1.1	0.7 - 1.7	0.751	-	-	-
Daily	196	43.4	1					
Snacks in-between meals								
Once a day	227	44.1	0.4	0.2 - 0.7	0.001	0.8	0.4 - 2.3	0.996
Twice a day	121	38.0	0.3	0.2 - 0.6	<0.001	0.6	0.3 - 1.4	0.252
≥3 times a day	67	67.2	1					

Continued

Sugar-sweetened beverages								
<1 time/week	159	43.4	0.5	0.3 - 1.1	0.097	-	-	-
2 - 4 times/week	203	45.3	0.6	0.3 - 1.2	0.145	-	-	-
5 or more times/week	53	56.6	1					
Confectionery								
<1 time/week	116	36.2	0.4	0.2 - 0.8	0.014	0.5	0.2 - 1.2	0.111
2 - 4 times/week	244	48.4	0.7	0.4 - 1.3	0.285	0.9	0.4 - 1.7	0.692
5 or more times/week	55	56.4	1			1		
Fried/salty foods								
<1 time/week	52	32.7	0.1	0.1 - 0.4	< 0.001	0.6	0.2 - 1.7	0.303
2 - 4 times/week	328	44.8	0.2	0.1 - 1.5	0.001	0.7	0.2 - 2.3	0.580
5 or more times/week	35	77.1	1			1		

physical activity and never/occasionally eating fruits and vegetables significantly ($p > 0.05$) increased the odds of dyslipidemia by 4.7, 3.9, 4.1 and 3.9 respectively, when compared with a healthy weight, tallness, high physical activity and eating fruits and vegetables daily. Also, eating snacks once/day was associated with a decreased risk of dyslipidemia (OR 0.4, 95% CI 0.2 - 0.7, $p = 0.001$) when compared with eating snacks more than three times/day. In addition, eating confectionery and fried/salty foods less than once/week were associated with lower risk of dyslipidemia when compared with eating these foods five or more times/week. After controlling for different variables in the multivariate analysis, obesity (OR 5.2, 95% CI 1.7 - 11.2), short stature (OR 2.8, 95% CI 1.1 - 6.8), low physical activity level (OR 4.2, 95% CI 2.3 - 7.5), and never/occasionally eating fruits/vegetables (OR 2.9, 95% CI 1.2 - 7.1) were independently associated with increased risk of dyslipidemia. However, the relationships between eating snacks in-between meals, consumption of confectionery, eating of fried/salty foods and dyslipidemia were no longer significant ($p > 0.05$) after the multivariate analysis.

5. Discussion

This study sets out to determine the prevalence of dyslipidemia and also to assess the relationships between selected factors and dyslipidemia in children. In our analysis in the North West Region of Cameroon, we found a high prevalence (46.0%) of dyslipidemia, which seems to affect more girls than boys. This prevalence is higher than that reported in a Brazilian study [15]. With respect to the different lipids studied, the proportions of children with abnormal lipid levels recorded in our study were higher than those reported in a study in Ghana in which the reported prevalence of TC, TG, LDL-C and HDL-C dyslipidemias were 12.1%, 4.5%, 9.2% and 28.4% respectively [8]. The prevalence of hypercholesterolemia in our study was also higher than that reported in a study carried out in the Center Region of Cameroon in which the prevalence of hypercholesterolemia was 16% [3]. This is concerning and indicates that dyslipidemia needs to be investigated in children at an early age. However, the prevalence estimates in our study were lower than those recorded in Turkey in which the prevalence of dyslipidemia in children was 67.8% [33]. Our study has also revealed that dyslipidemic children had significantly higher levels of percentage body fat (%BF) than their peers with acceptable lipid levels. There is evidence that obesity is on the rise in children in Cameroon [34], and this could be contributing to the high proportions of children with dyslipidemia. For instance, obesity in childhood has been reported to contribute to alterations in lipid levels, which is an important mediator in the development of cardiovascular disease in adulthood [5].

This current study has shown that after adjusting for different variables, being obese (%BF) significantly increased the odds of dyslipidemia in children. This is similar to findings from Ghana in which the prevalence of dyslipidemia was higher among children who are BMI-overweight/obese [8]. This is also confirmed in a recent review in which BMI-obesity and central obesity increased the odds of dyslipidemia by 2.36 and 2.33 respectively [2]. In addition, there is evidence that excess body fatness explained 21% of changes in TC and that obesity assessed using different measures (BMI, waist circumference, waist-to-height ratio, and %BF) was significantly associated with elevated levels of TC, TG and lower levels of HDL-C [9]. The alterations in lipid levels in obese subjects could be due to insulin resistance, which suppresses lipolysis resulting in an increase in levels of free fatty acids. These free fatty acids serve as substrate for the synthesis of TG in the liver. Insulin resistance also directly contributes to an overproduction of very-low-density lipoproteins and increased catabolism of HDL-C [35].

Low level of physical activity (<60 minutes/day) was associated with a higher risk of dyslipidemia in our sample of children. Also, majority (69.5%) of those with low levels of physical activity in our study had one or more lipid disorder. Similar findings were observed in a study in China [13]. Thus, there is need for these children to be physically active in order to lower their risk of having dyslipidemia. For instance, a report had indicated that school physical education classes held twice a week contributed to a reduction in the incidence of elevated LDL-C in children [11]. Also, a study by LeBlanc and Janssen revealed that moderate to vigorous physical activity was associated with a lower risk of having elevated TG [12]. Another report indicated that children who exercise once a week had higher TG levels when compared with their peers who exercise more than two times/week [36]. However, findings of a meta-analysis indicated that aerobic exercise had no effect on HDL-C [37]. In the multivariate analysis of our study, the risk of dyslipidemia increased amongst the children with a high screen time. Nevertheless, this was not statistically significant. Findings of a recent study indicate that every additional hour of watching TV contributed to a 2.6% decrease in HDL-C and a 7.0% increase in TG [38]. This could be explained by evidence indicating that watching TV is a sedentary activity and had been associated with a decrease in energy expenditure and an increase in the consumption of foods with high calories, sugar and fat [39].

Another important finding of our study is that never/occasionally eating fruits and vegetables was associated with an increased risk of dyslipidemia when compared with those who eat fruits and vegetables every day. This finding is in accordance with studies carried out in Brazil in which less frequent consumption of protective foods (including fruits and vegetables) was associated with elevated levels of LDL-C in children [15] [40]. This could be because fruits/vegetables have soluble fibres that have been found to protect against dyslipidemia. For example, there is evidence that soluble fibres contribute to a reduction in gastrointestinal transit time and also a reduction in blood cholesterol in both animal and human studies [41].

Our study confirms that short stature was associated with a higher risk of dyslipidemia. This is similar to findings of a recent study in which short stature was associated with elevated TC levels in Japanese children [17]. Also, the risk of elevated LDL-C increased among the shortest (first height quartile) school children when compared with the tallest (fourth height quartile) children in a recent US study [18]. In addition, a study among Korean adolescents indicated that shorter boys had an increased risk of hypertriglyceridemia [42]. However, a longitudinal study in the US did not find any significant association between standing height and TG concentration in adolescents [43]. The mechanisms of the relationships between height and dyslipidemia still need further investigations. Three hormones that play an important role in linear growth and therefore reflect nutritional status are; growth hormone (GH) thyroid hormone and insulin-like growth factor-1 (IGF-1). These hormones contribute to the development of healthy lipid profiles. For instance, a recent report had indicated that GH has a lipolytic effect and contributes to the improvement of lipid metabolism lowering TC and LDL-C concentrations [44]. Also, at the level of the liver, thyroid hormone functions in the synthesis and metabolism of fatty acids and cholesterol and a deficiency of thyroid hormone contribute to elevated levels of TC and TG [45]. In addition, insulin-like growth factor-1 (IGF-1) is an important modulator in lipid metabolism [14]. For example, a recent study revealed that IGF-1 had a protective effect against increased levels of LDL-C amongst children and adolescents with short stature [46]. Therefore, it can be suggested that children with adequate amounts of GH, thyroid hormone and IGF-1 are likely to have healthier lipid profiles. Furthermore, cholesterol is an important component of steroid hormones and cell membranes and a previous study had suggested that the level of cholesterol may be lowered in children with a fast linear growth due to its consumption [43]. This means children with a short stature are likely to have unfavourable levels of TC.

In the univariate analysis, the consumption of snacks in-between meals once a day was significantly protective against dyslipidemia when compared with consumption of snacks more than three times/day. Also, the consumption of confectionery and fried/salty foods < one time/week was protective against dyslipidemia when compared with the consumption of the respective foods five or more times/week. However, these relationships were no longer significant in the multivariate analysis. The consumption of sugar-sweetened beverages less than one time/week was protective against dyslipidemia when compared with the consumption of SSB more than five times/week but not statistically significant.

The above foods play a role in the development of cardiovascular diseases and a recent report indicated that moderate to high consumption of high-risk foods increased the risk of dyslipidemia (OR 1.49, 95% CI 1.01 - 2.19) in children and adolescents [16]. Another report indicated that the consumption of foods that are high in sugar and fat was associated with hypercholesterolemia (PR 1.6, 95% CI: 1.1 - 2.3) [21]. These differences, which contradict the findings of our current study could be related to differences in sampling techniques and sample size issues as well as differences in the clinical characteristics of the recruited participants.

Skipping breakfast increased the risk of dyslipidemia in our current study. However, this was not statistically significant. More than half of the children who skip/rarely eat breakfast had a disorder in one or more of the lipids studied. A recent report has indicated that prepubertal children who consume breakfast regularly had better lipid profiles than those who skip breakfast (OR 0.17, CI: 0.05 - 0.52) [14]. Also, a large study among European adolescents had indicated that breakfast skippers had worse lipid profiles when compared with breakfast consumers [47]. This could be explained by the fact that when children skip breakfast, there is the tendency for morning hunger to increase and this may lead to an increase in the consumption of snacks and high calorie foods later in the day [48].

6. Limitations of the Study

This study had limitations worth mentioning. The cross-sectional nature of the study does not permit us to establish causality. Also, the sample size is small and included children visiting an urban hospital in North West Cameroon. Thus, a larger and more representative sample is needed to get a clearer picture of dyslipidemia in Cameroon children. In addition, we did not assess the tanner stages of the children, and puberty could be a potential confounder in our analysis. Furthermore, physical activity, screen time and eating habits were assessed using questionnaires and we cannot rule out the possibility of reporting bias. Nevertheless, this current study presents the first population-based findings on relationships between selected factors and dyslipidemia in Cameroon children.

7. Conclusion

This study has shown that a high proportion of children had a disorder in one or more of the lipids studied, and those who were dyslipidemic had a higher median %BF. Also, the study has revealed that obesity, short stature, low physical activity level and never/occasional consumption of fruits/vegetables increased the risk of dyslipidemia in children after adjusting for different variables. Future studies that include a larger sample of children from both rural and urban settings are needed to come up with more reliable conclusions, on which intervention programmes could be based.

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Availability of Data and Material

Data and material are available from the corresponding author upon reasonable request.

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Authors' Contributions

LKN was responsible for the conception and design of the study, direct collection of data and processing, statistical analysis and drafting of the manuscript. LLN contributed to the conception and design of the study and participated in data collection as well as interpretation of data and drafting of manuscript. CTA and MBA contributed to the conception and design of the study as well as interpretation and analysis of data. All authors revised the manuscript and gave a final approval of the submitted version.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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