

Cardiometabolic Risk Factors and Associated Features in 5th Grade Schoolchildren in Ouagadougou, Burkina Faso (West Africa)

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Abstract: The onset of cardiometabolic risk factors in childhood may be tracked into adulthood. However, little is known about such risk factors particularly in African schoolchildren. We conducted in Ouagadougou the capital city of Burkina Faso (West Africa) a cross-sectional study in 5th grade pupils of 12 schools (4 private and 8 public of which 2 were periurban). Weight, height, and blood pressure (BP) were measured and fasting serum lipids and glycaemia were determined. Sample mean age was 11.8±1.4 y (207 children, 51% girls). Mean total cholesterol (TC), LDL-C, HDL-C and triglycerides were 133.9, 83.5, 45.1 and 67.1 mg/dl, respectively; glycaemia stood at 87.9±7.1 mg/dl. Systolic (SBP) and Diastolic Blood Pressure (DBP) were 103.2 and 62.3 mmHg respectively. The main risk factor was low HDL-C (19.3%) followed by high TC and LDL-C (11.6% each). Elevated SBP and DBP were 9.7% and 4.3%, respectively. Being a girl was independently associated with increased serum lipids including HDL-C paradoxically. BMI was independently associated with increased BP. While attending a private school was independently associated ($p<0.01$) with higher HDL-C and lower TG and DBP, attending urban (vs periurban) school and higher age were independently associated with lower HDL-C. A sizeable proportion of children exhibited cardiometabolic risk factors and therefore, preventive measures would appear timely in low income country schoolchildren, and not only strategies targeting malnutrition.

Keywords: Cardiometabolic, risk factors, blood lipids, blood pressure, schoolchildren, Burkina Faso, West Africa.

INTRODUCTION

Considered in the past decades as 'diseases of affluence' [1], chronic disorders such as cardiovascular diseases, cancer and diabetes are now hitting developing countries [2]. Obesity in particular has already become a major concern worldwide [3]. Other main risk factors for cardiovascular diseases include dyslipidemia, dysglycaemia and hypertension [4]. According to the World Health Organization (WHO), 80% of chronic disease deaths occur in developing countries [2] as a consequence of the global epidemiologic [5] and nutrition [6] transitions that are undergoing in these countries. Nutrition transition has been widely described as a shift in food habits coupled with sedentary lifestyle which fuels the global growing prevalence of these chronic diseases [7]. Yet, unhealthy food habits and lifestyles are spreading in children with a negative impact on their health status [8]. Moreover, there is an increasing concern about chronic disease risk factors in childhood since these might track into adulthood [9]. This is a particular issue for developing countries where undernutrition is still highly prevalent [10] and could add to the risk of chronic diseases later in life according to the theory of

the developmental origins of chronic diseases [11]. In Sub-Saharan Africa, the increasing prevalence of cardio-metabolic risk factors is now being documented [12, 13]. For example, in Burkina Faso, 15% prevalence of obesity was reported in a study conducted in 2004 [14] and hypertension had almost doubled within ten years in a sample of Ouagadougou adults [15, 16]. Few studies reported on blood pressure [17] and lipid profiles [18] in African schoolchildren. The existing data on lipid profile are quite old, focus on 7-8 year-old pupils [18] and do not give the complete picture of metabolic risk in schoolchildren [19]. Additionally, studies reported primarily on adolescents [20, 21] and under-five children [22] rather than elementary school children. In a previous paper [23], we reported that although the prevalence of overweight/obesity in urban schoolchildren of Ouagadougou was still low, it was double that reported 10 years ago [24]. Eating behaviours conducive to obesity tended to be widespread in these schoolchildren [25]. Other risk factors include early nutrition and family history. It is therefore crucial for developing countries to investigate cardiometabolic risk factors in the young population for prevention and surveillance. The purpose of the present study was to examine lipid profile, glycaemia and blood pressure in schoolchildren of the Ouagadougou Study and some of the associated socio-demographic factors.

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MATERIAL AND METHODS

Location, Design and Study Sample

This cross-sectional study was conducted in Ouagadougou, the capital city of Burkina Faso in West Africa. We collected data between February and March 2009 in 8 public and 4 private schools purposively selected for their motivation and capacity to participate in an intervention. Initially, 806 children (85% response rate) in 5th grade level were included in a large study assessing their nutritional status and different aspects of their life habits. However due to the high cost of assays, a sub sample of 208 pupils stratifying for sex was randomly drawn from the whole sample to assess blood lipids and glycaemia that we report in this paper. Details on school choice and sampling procedure were already described elsewhere [23].

Anthropometric and Biologic Measures (Serum Lipids, Glycaemia and Blood Pressure)

Weight and height measurements performed according to WHO standardized procedures were already detailed [23]. Body Mass Index (BMI) was computed as $\text{weight}/\text{height}^2$. The day prior to blood collection, pupils were given a note for their parents reminding them to send children the subsequent morning without eating anything but water. Children themselves were asked to observe this condition. Venous blood samples (15 ml) were collected in schoolchildren in the morning by two experimented biological technicians from the National Public Health Laboratory (NPHL) of Burkina Faso. Blood was collected in two different tubes for serum lipids and plasma glucose. After blood collection, breakfast was offered to children and blood samples kept in ice were immediately sent to the NPHL for analysis. Total cholesterol (TC), HDL-cholesterol (HDL-C), LDL-cholesterol (LDL-C), triglycerides (TG) and glucose levels were enzymatically determined with the Covas Mira plus autoanalyzer (Roche, Germany). The National Cholesterol Education Program (NCEP) cut-offs for children and adolescents were used to assess chronic disorders as follows: TC and LDL-C were considered as elevated for values ≥ 170 mg/dl and 110 mg/dl respectively and HDL-C was considered low for values < 35 mg/dl [26]. Hyperglycaemia (fasting plasma glucose ≥ 100 mg/dl) and elevated triglycerides (TG ≥ 150 mg/dl) were defined according to the International Diabetes Federation (IDF) consensus cut-offs in children and adolescents [27]. Blood pressure (BP) was measured in children with an aneroid

sphygmomanometer (Spengler, France) using an appropriate paediatric arm cuff according to a procedure described by the National High Blood Pressure Education Program (NHBPEP) [28]. Briefly, children sat quietly for 5 minutes in a quiet classroom. Then, two measurements separated by 10 min of rest for the systolic (SBP) and diastolic pressure (DBP) were performed by a trained medical student. The subject was seated in a restful position on a chair designed to maintain the cubital fossa of the right arm at heart level [28]. When the difference between two measurements exceeded 10 mmHg a third measure was performed and the mean of the two closer values were used to compute SBP and DBP that we used for analyses. NHBPEP formula was used to compute age-, sex- and height-specific BP percentile and children with SBP or DBP $\geq 90^{\text{th}}$ percentile were considered to have an elevated BP [28].

Ethical Considerations

The study was approved by the research ethics committees of the Faculty of Medicine of University of Montreal, Canada and the Ministry of Health of Burkina Faso. We also obtained signed authorization from the Ministry of Education and oral agreement from school principals before data collection. A signed informed consent form was provided by each parent or caregiver and children themselves had to agree to participate.

Statistical Analysis

Data were processed with SPSS.17 software (SPSS, Inc., Chicago IL) with 50% entered twice to ensure data quality. Independent t-test, oneway ANOVA and Chi-square tests were used as appropriate to perform comparisons. Multiple linear regression models were constructed to highlight associations of cardiometabolic risk and socio-demographic variables. All analyses were considered significant at $p < 0.05$.

RESULTS

Characteristics of Study Subjects

One child had incomplete data so that 207 children out of 208 were included in this study (Table 1). The sample consisted of 50.7% girls and the mean age was 11.8 ± 1.4 years (range 9-15 y). Almost 30 % of schoolchildren were from private schools whereas less than 1/5 were from the peri-urban area, as opposed to public schools and the urban area, respectively. Mean BMI was 16.0 ± 1.8 . Children from private schools were significantly taller than they counterparts from public

Table 1: Characteristics of Study Sample

Socio-demographics	Sample characteristics				
	N (%)	Age (y)	Weight (kg)	Height (cm)	BMI (kg/m ²)
All	207 (100)	11.8 ±1.4	33.3 ±6.8	143.5 ±8.6	16.0 ±1.8
Sex					
Boys	102 (49.3)	11.9 ±1.4	32.7 ±5.9	142.9 ±8.6	15.9 ±1.6
Girls	105 (50.7)	11.8 ±1.4	33.9 ±7.5	144.0 ±8.6	16.2 ±2.0
<i>p</i>		0.610	0.186	0.347	0.262
School type					
Public	146 (70.5)	11.8 ±1.2	32.7 ±6.4	142.5 ±7.8	16.0 ±1.6
Private	61 (29.5)	11.9 ±1.7	34.7 ±7.6	145.9 ±9.8	16.1 ±2.3
<i>p</i>		0.679	0.080	0.018	0.613
School location					
Urban	171 (82.6)	11.8 ±1.4	33.5 ±7.0	143.7 ±8.6	16.1 ±1.9
Peri-urban	36 (17.4)	11.8 ±1.3	32.1 ±5.9	142.4 ±8.8	15.7 ±1.2
<i>p</i>		0.904	0.264	0.383	0.142

schools ($p < 0.05$) and their weight tended to be higher. Age and BMI did not vary significantly according to sex and school type or location.

Blood Variables and Pressure Profiles

Table 2 displays mean values for blood variables in schoolchildren included in the study. Mean serum lipids levels ranged from 45.1 mg/dl (HDL-C) to 133.9 mg/dl (TC) whereas mean glycaemia (Gly) stood at 87.9 mg/dl. SBP and DBP were 103.2 and 62.3 mmHg respectively. Compared to boys, girls had higher TG ($p < 0.05$), TC ($p < 0.01$), and LDL-C but also HDL-C ($p < 0.05$). A significant difference was also found according to age for TC and LDL-C ($p < 0.05$) with younger and older children having higher values. SBP also increased with age ($p < 0.05$). Overall we found that except for TC (141.2 vs. 130.9 mg/dl), private school children had a lower risk profile compared to public school children with lower DBP (60.1 vs. 63.2 mmHg, $p < 0.01$), lower TG (59.5 vs. 70.3 mg/dl, $p < 0.01$) and higher HDL-C level (50.6 vs. 42.8 mg/dl, $p < 0.001$) although no difference was found between the number of boys and girls in public and private schools. Comparing urban and peri-urban schoolchildren, only LDL-C was significantly higher in the former than the latter (85.0 mg/dl and 76.5 mg/dl respectively, $p < 0.05$). Glycaemia did not vary according to sex, age and school characteristics.

Prevalence of Cardiometabolic Risk Factors

The main risk factor in this population sample (Table 3) was low HDL-C (19.3%) followed by high TC

and LDL-C (11.6% each). Only 1.9% and 2.4 % of children showed hyperglycaemia or hypertriglyceridemia whereas elevated SBP and DBP affected 9.7% and 4.3% schoolchildren, respectively. Stratifying by sex, age and school characteristics, unfavourable profiles were more common in girls and among pupils from public schools. Specifically compared to boys, girls were three times as many with high LDL-C (18.1% vs 4.9%, $p < 0.01$) and elevated SBP (14.3% vs 4.9%, $p < 0.05$). Additionally, significantly more children from public schools were affected by low HDL-C (26.7% vs 1.6%, $p < 0.001$) and elevated DBP (6.2% vs no case, $p < 0.05$) compared with their peers from private schools. Although not significant, it is of note that all four hyperglycaemia cases were found in the urban, and none in the periurban area.

Factors Associated with Lipids, Glycaemia and Blood Pressure

Table 4 displays multiple linear regression models of blood variables on socio-demographics. While models were not significant to explain glycaemia, they explained 6 % to 20.9% of the variance of other blood variables. Being a girl was independently associated with increased serum TG and cholesterol fractions including HDL-C. BMI was positively and independently associated with increased SBP and DBP ($p < 0.01$) and age was negatively associated with HDL-C ($p < 0.05$). Attending a private school appeared protective as it was independently associated ($p < 0.01$) with higher HDL-C, and lower TG and DBP although also with

Table 2: Mean (SD) Lipids, Glycaemia and Blood Pressure in Schoolchildren of Ouagadougou

Socio-demographics	N (%)	Biological Variables						
		Blood variables (mg/dl)					Blood pressure (mmHg)	
		TC	LDL-C	HDL-C	TG	Gly	SBP	DBP
All	207 (100)	133.9 ±28.5	83.5 ±22.3	45.1 ±13.4	67.1 ±28.8	87.9 ±7.1	103.2 ±9.2	62.3 ±6.7
Sex								
Boys	102 (49.3)	128.1 ±26.8	79.8 ±21.2	43.0 ±13.0	63.0 ±25.6	87.2 ±7.7	102.2 ±8.5	62.3 ±6.7
Girls	105 (50.7)	139.6 ±29.1	87.1 ±22.8	47.2 ±13.4	71.1 ±31.2	88.5 ±6.4	104.3 ±9.8	62.2 ±6.7
<i>p</i> [†]		0.004	0.019	0.026	0.045	0.168	0.100	0.936
Age (years)								
9-10	61 (29.5)	140.0 ±32.5	87.4 ±24.9	47.5 ±14.2	60.9 ±25.2	88.4 ±7.1	102.2 ±9.8	61.8 ±6.6
11-12	103 (49.8)	128.9 ±27.4	79.6 ±21.5	44.1 ±12.8	69.3 ±29.7	87.3 ±7.2	102.4 ±8.3	62.1 ±6.2
13-15	43 (20.8)	137.3 ±23.1	87.5 ±18.7	44.3 ±13.3	70.7 ±30.7	88.4 ±6.8	106.7 ±9.8	63.4 ±7.9
<i>p</i> [†]		0.038	0.039	0.253	0.132	0.525	0.021	0.468
School type								
Public	146 (70.5)	130.9 ±29.7	82.6 ±23.4	42.8 ±14.4	70.3 ±31.4	87.4 ±7.3	103.5 ±9.3	63.2 ±6.8
Private	61 (29.5)	141.2 ±24.2	85.7 ±19.4	50.6 ±8.2	59.5 ±19.4	88.9 ±6.4	102.7 ±9.0	60.1 ±5.9
<i>p</i> [†]		0.018	0.366	< 0.001	0.003	0.175	0.552	0.002
School location								
Urban	171 (82.6)	135.2 ±27.7	85.0 ±22.1	44.7 ±13.2	67.8 ±29.7	88.1 ±7.0	102.9 ±9.0	62.2 ±7.0
Peri-urban	36 (17.4)	127.7 ±32.0	76.5 ±22.1	47.2 ±14.0	63.7 ±24.1	86.7 ±7.6	104.9 ±10.1	62.5 ±5.2
<i>p</i> [†]		0.152	0.038	0.300	0.440	0.275	0.240	0.847

[†] χ^2 test; [†]Oneway ANOVA; TC= Total Cholesterol; LDL-C= Low Density Lipoprotein-Cholesterol; HDL-C= High Density Lipoprotein-Cholesterol; TG= Triglycerides; Gly= Glycaemia; SBP= Systolic Blood Pressure; DBP= Diastolic Blood Pressure.

Table 3: Dyslipidemia and High Blood Pressure Prevalence in Schoolchildren of Ouagadougou According to Sex, Age and School Characteristics (χ^2)

Socio-demographics	N	N (Prevalence, %)						
		High TC	High LDL-C	Low HDL-C	High TG	High Gly	Elevated SBP	Elevated DBP
All	207	24 (11.6)	24 (11.6)	40 (19.3)	5 (2.4)	4 (1.9)	20 (9.7)	9 (4.3)
Sex								
Boys	102	8 (7.8)	5 (4.9)	22 (21.6)	2 (2.0)	2 (2.0)	5 (4.9)	5 (4.9)
Girls	105	16 (15.2)	19 (18.1)	18 (17.1)	3 (2.9)	2 (1.9)	15 (14.3)	4 (3.8)
<i>p</i>		0.097	0.003	0.420	0.675	0.977	0.022	0.700
Age (years)								
9- 10	61	11 (18.0)	9 (14.8)	11 (18.0)	1 (1.6)	0 (0.0)	8 (13.1)	3 (4.9)
11-12	103	9 (8.7)	10 (9.7)	21 (20.4)	3 (2.9)	3 (2.9)	7 (6.8)	3 (2.9)
13-15	43	4 (9.3)	5 (11.6)	8 (18.6)	1 (2.3)	1 (1.3)	5 (11.6)	3 (7.0)
<i>p</i>		0.173	0.621	0.926	0.876	0.415	0.369	0.529
School type								
Public	146	15 (10.3)	18 (12.3)	39 (26.7)	5 (3.4)	3 (2.1)	17 (11.6)	9 (6.2)
Private	61	9 (14.8)	6 (9.8)	1 (1.6)	0 (0.0)	1 (1.6)	3 (4.9)	0 (0.0)
<i>p</i>		0.359	0.610	< 0.001	0.143	0.843	0.135	0.047
School location								
Urban	171	20 (11.7)	22 (12.9)	34 (19.9)	5 (2.9)	4 (2.3)	15 (8.8)	8 (4.7)
Peri-urban	36	4 (11.1)	2 (5.6)	6 (16.7)	0 (0.0)	0 (0.0)	5 (13.9)	1 (2.8)
<i>p</i>		0.921	0.213	0.657	0.299	0.354	0.345	0.611

TC= Total Cholesterol; LDL-C= Low Density Lipoprotein-Cholesterol; HDL-C= High Density Lipoprotein-Cholesterol; TG= Triglycerides; Gly= Glycaemia; SBP= Systolic Blood Pressure; DBP= Diastolic Blood Pressure.

Table 4: Factors Associated with Glycaemia, Blood Pressure and Serum Lipids in Schoolchildren, Ouagadougou

Factors	Biological variables													
	Blood variables (md/dl)										Blood pressure (mmHg)			
	Gly		TC		LDL-C		HDL-C		TG		SBP		DBP	
	β^{\dagger}	p	β^{\dagger}	p	β^{\dagger}	p	β^{\dagger}	p	β^{\dagger}	p	β^{\dagger}	p	β^{\dagger}	P
Sex 0= boys, 1=girls	0.086	0.221	0.185	0.007	0.151	0.030	0.140	0.035	0.143	0.035	0.088	0.167	-0.019	0.776
Age	-0.075	0.317	-0.135	0.066	-0.085	0.249	-0.160	0.024	0.131	0.072	0.079	0.224	-0.055	0.442
School type 0=public, 1=private	0.079	0.283	0.147	0.039	0.020	0.779	0.318	<0.001	-0.216	0.002	-0.032	0.628	-0.237	0.001
School location 0=peri-urban, 1=urban	0.047	0.525	0.046	0.514	0.128	0.076	-0.172	0.013	0.113	0.111	-0.102	0.122	0.038	0.585
BMI	0.069	0.365	0.102	0.164	0.109	0.144	0.046	0.517	0.067	0.356	0.401	<0.001	0.259	<0.001
R²	0.027	0.358	0.087	0.002	0.060	0.029	0.140	<0.001	0.091	0.002	0.209	<0.001	0.128	<0.001

[†]Standardized; TC= Total Cholesterol; LDL-C= Low Density Lipoprotein-Cholesterol; HDL-C= High Density Lipoprotein-Cholesterol; TG= Triglycerides; Gly= Glycaemia; SBP= Systolic Blood Pressure; DBP= Diastolic Blood Pressure.

higher TC. Attending an urban school was independently associated with lower HDL-C than a periurban school ($p < 0.01$).

DISCUSSION

In this study, we reported data on serum lipids, glycaemia and blood pressure in a subsample of 207 randomly selected schoolchildren (11.8 ± 1.4 y) living in Ouagadougou, the capital city of Burkina Faso. Serum lipids were quite similar to those of studies conducted elsewhere in Africa and other developing countries. In the early 80's, one of the first and rare studies on serum lipids in school boys aged 7-8 y from three west African countries (Ghana, Ivory Coast and Nigeria) reported TC and HDL-C ranging respectively from 102-136 mg/dl and from 31-47 mg/dl [29]. Interestingly, data on these two lipid fractions in children from urban Ghana (136 and 41 mg/dl) and urban Nigeria (130 and 47 mg/dl) were close to the results of ours also conducted in urban area and in a neighbouring country. Compared to recent findings in South Africa, our data showed higher TG (58 vs 67 mg/dl) and TC (130 vs 134 mg/dl) [21]. We would have expected lower serum lipid values in a country such as Burkina Faso which is one of the lowest income countries in the world, whereas South Africa enjoys a higher income and also at a more advanced stage of the nutrition transition [30]. This suggests that nutrition-related chronic diseases are no longer a concern only in intermediate income developing countries.

Physical activity, obesity and diet notably saturated and trans fatty acids are known to influence blood lipids [31-33], and unhealthy eating patterns combined with sedentary lifestyles are rapidly spreading in emerging countries [7, 34]. Our data tend to reflect these diet and lifestyle shifts towards western patterns, although blood lipid levels were generally lower than reported in children in developed countries (except for low HDL-C) [18]. We found that almost 1 child out of 5 had low HDL-C and almost 12% presented with elevated TC and LDL-C. These elevated TC and LDL-C are very close to those reported in Turkish (7-18 y) and Brazilian (mean age 10y) pupils although the Turkey study used different cut-offs [35, 36], but lower than found in Iranian 12y-old children [37]. The percentage of children with low HDL-C in our study was far higher than reported in children from Turkey (6.6%) [35] and adolescents (13-19 y) from Tunisia (1.2%) [20]. Although caution must be paid when comparing these results because of the influence of age [38], they confirm that even in areas where malnutrition is still a major public health concern, chronic disease risk factors could also be present even in schoolchildren. For example, in adults of the Benin Study, underweight and micronutrient intake inadequacies were associated with low HDL-C [39]. We also reported previously that poor micronutrient status based on anaemia or low serum retinol affected up to 40% of the children of the present study [23]. Family history, and in-utero or early life malnutrition have also been associated with chronic

disease risk later on in life [40-42]. Given the intergenerational impact of malnutrition [43], the growing prevalence of chronic diseases in adults [2] and persistent malnutrition in mothers and under-five children [44] should be considered when trying to explain these cardiometabolic risk factors in Ouagadougou pupils aged 11.8 years.

Consistently higher values for TC, LDL-C, HDL-C and TG have been reported in girls [18, 21, 35]. We found the same trend in the linear regression models of the present study for TC and LDL-C. Beyond biological differences according to sex [38], lifestyle and food habits could also be at play as girls seem to be more sedentary [45]. However, girls also showed significantly higher HDL-C, which is preventive vis-à-vis CVD [31].

We also observed that younger and older children had higher levels of TC and LDL-C compared to the intermediate age group, whereas HDL-C tended to decrease and TG, to increase with age. Such a U-curve distribution for TC and LDL-C with age in children was documented more than 10 years ago in a review on pooled data from 26 countries including African countries [18]. HDL-C also tended to decrease beginning at 11 years of age [18] which is in accordance with our results showing a negative association between HDL-C and age in regression models. The age-related decline in HDL-C was attributed to hormonal changes associated with puberty in the Bogalusa study [46].

Regarding school characteristics, private schoolchildren had a more favourable risk profile. Although TC was higher, so was HDL-C, whereas TG and DBP were lower. Indeed, multivariate models highlighted private school attendance as independently associated with higher HDL-C level, lower TG level and lower DBP controlling for age and sex. In a study in Rio de Janeiro schoolchildren, those attending private schools also showed higher HDL-C compared to their peers from public schools [36]. However, the results of another Brazilian study are at variance with our findings, with lower HDL-C (41.75 mg/dl vs 50.6 mg/dl) and higher TG (86.70 mg/dl vs 59.5 mg/dl) [47].

Although weight status, diet and physical activity are known to be associated with cardiovascular diseases markers [4], we did not observe significant differences in BMI that could explain the private vs public school discrepancy in cardiometabolic risk factors. This suggests that the better risk profile in private schoolchildren could find an explanation in better food

habits. We indeed reported in a recent paper that they scored higher for nutrient-rich food consumption than public schoolchildren [25]. However quantitative intake data were not available to assess the relationship with blood pressure.

SBP and DBP levels were in general lower (roughly by 6mm Hg and 4 mmHg, respectively) than that reported in Ghanaian schoolchildren [17] and in schoolchildren with a mixed ethnicity background living in UK [48]. It is possible that this reflects different levels of development and urbanization between Burkina Faso, Ghana and the UK. A study in an adult sample of Ouagadougou found that the more the subjects stayed in the city the more they were likely to be hypertensive [16]. This is in contrast with the findings of the Benin study among adults, with lower BP in the large city compared with a small city and a semi-rural location [13]. The proportion of subjects with elevated SBP in our study (9.7 %) was the same as reported in Tunisian adolescents (9.6%) [49]. Beyond other risk factors linked to urbanization and unhealthy lifestyles, malnutrition should also be considered to explain this comparative level with Tunisia. In sub-Saharan schoolchildren, those who were born with a low birth weight were found to be twice as likely to be hypertensive compared to normal birthweight children [50]. We also found a positive age-related gradient of blood pressure like in Ghana [17]. This is a plausible consequence of biological maturation as compared to our results, lower BP was observed in Indonesian prepubertal children aged 6-9 y [51].

Another interesting finding of our study is that only BMI was positively and independently associated with both SBP and DBP. Furthermore, the association of BMI with SBP was stronger than any other association of a determinant with a cardiometabolic risk factor. A similar observation was reported elsewhere [16, 17, 51]. The role of weight status in the aetiology of hypertension implies the need to prevent obesity right at school age given the growing prevalence of hypertension in Burkina Faso [16] and the propensity of schoolchildren to gain weight as we observed recently [52].

The peri-urban area is generally less urbanized than the city proper. LDL-C was significantly higher in urban compared to peri-urban schools, but this difference was no longer significant in multivariate analyses. However, lower HDL-C was independently associated with urban setting of the school in linear regression analysis, which tends to confirm that urbanization enhances the

risk for dyslipidemia, possibly because of more unhealthy food consumption and more sedentary habits. We did not observe SBP and DBP differences between periurban and urban school children, unlike the observed differences between private and public schools.

Finally in the present study, hyperglycaemia was uncommon, with only 1.9 % of children above the 100 mg/dl cut-off [27] and no case above 110 mg/dl [53]. Notwithstanding, given the sizeable proportion of children with at-risk lipid profiles and elevated SBP, strategies to prevent common dietary and lifestyle risk factors of chronic diseases are compelling to halt the growing prevalence of nutrition-related chronic diseases in the adulthood.

CONCLUSION

Our study brings an update on schoolchildren biological data that have been published a long time ago. It also fills the paucity of data on cardiometabolic risk factors in African primary school children. It is one of the first studies giving a broad picture of the parameters described as determinants of chronic diseases. However, some limitations should be underlined. The cross-sectional nature of the study cannot allow for cause and effect relation between our findings and nor they can be generalized to all schoolchildren.

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AUTHORS' CONTRIBUTIONS

CD, HD and OR designed the study. CD collected and analysed the field data under the supervision of HD and the co-supervision of OR. CD drafted the paper, HD and OR reviewed the draft. All authors read and approved the submitted manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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