



Prevalence of Metabolic Syndrome Among Overweight and Obese Algerian Schoolchildren in Annaba

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Type of Publication: Original Research Paper

Conflicts of Interest: Nil

Abstract

Metabolic syndrome (MS) is a clinico-biological entity recognized by the World Health Organization (WHO), characterized by the association in a single individual of visceral obesity, lipid abnormalities (elevated triglycerides and low HDL-cholesterol), glucose intolerance, and hypertension. It is defined by the presence of at least three out of five diagnostic criteria [1]. Additional abnormalities frequently observed in MS include elevated levels of C-reactive protein (CRP) and plasminogen activator inhibitor-1 (PAI-1), both of which promote thrombosis, as well as fatty liver disease and hyperuricemia [1].

Keywords: NIL

Introduction

Metabolic syndrome (MS) is a clinico-biological entity recognized by the World Health Organization (WHO), characterized by the association in a single individual of visceral obesity, lipid abnormalities (elevated triglycerides and low HDL-cholesterol), glucose intolerance, and hypertension. It is defined by the presence of at least three out of five diagnostic criteria [1]. Additional abnormalities frequently observed in MS include elevated levels of C-reactive protein (CRP) and plasminogen activator inhibitor-1 (PAI-1), both of which promote thrombosis, as well as fatty liver disease and hyperuricemia [1].

In children and adolescents, the International Diabetes Federation (IDF) considers central obesity—a key predictor of insulin resistance—as a prerequisite for the diagnosis of MS, which must be accompanied by at least two other metabolic abnormalities [2]. However, there is currently no universal consensus on the diagnostic criteria for MS in pediatric populations due to variability in physiological parameters such as

age, sex, height, and pubertal status. According to the WHO's 2003 report, the alarming rise in metabolic disorders over recent decades is closely linked to the increasing prevalence of overweight and obesity, both of which are strongly associated with elevated cardiovascular risk—even in younger age groups, including children [3]. Obesity during adolescence has been shown to increase the risk of coronary heart disease in adulthood by a factor of 12 and of atherosclerosis by a factor of 7 [4]. Vascular dysfunction, including arterial stiffness and endothelial impairment, has been reported in obese children as early as childhood [5]. Although most obese children are asymptomatic, the early detection of metabolic abnormalities may have prognostic value for future cardiovascular risk [6].

The overall prevalence of MS in adults is estimated at 15% in Europe and 23.7% in the United States [1]. In children, precise prevalence rates are less well established. However, it is clear that MS is

significantly more prevalent in overweight and obese children than in those with normal weight. In the United States, the prevalence of MS ranges from 24% to 51% among obese African-American and Caucasian adolescents, compared to only 1–3% in those with normal body mass index (BMI) [1]. In France, a study based on the NCEP-ATP III definition reported a 14% prevalence of MS among a cohort of 200 obese children [7].

In Algeria, the prevalence and characteristics of MS in overweight and obese children remain poorly documented. In particular, no epidemiological data are currently available for the city of Annaba, one of the two major urban centers in eastern Algeria. This lack of local data justifies the present study, which aims to determine the prevalence of MS and its individual components in a population of overweight and obese schoolchildren in Annaba.

Materials And Methods:

Study Population

This cross-sectional study was conducted over a two-year period (2011–2013) and included 179 schoolchildren aged 5 to 15 years, identified as having an elevated body mass index (BMI). These students were selected from public schools affiliated with the Public Health Establishment of Proximity (EPSP) in Annaba, eastern Algeria.

Out of a screened population of 3,496 students, 632 were classified as overweight or obese based on the International Obesity Task Force (IOTF) criteria [10]. Among them, 179 children whose parents provided informed consent underwent further clinical and biochemical evaluations.

Clinical Assessment

For each participant, weight, height, and waist circumference (WC) were measured twice, and the average of the two readings was recorded. Waist circumference was measured in the standing position with arms relaxed at the sides, midway between the lower margin of the last rib and the iliac crest, at the end of a normal expiration, in accordance with WHO guidelines [8].

Waist circumference values were interpreted using McCarthy et al.'s reference tables, with values at or above the 90th percentile considered abnormal [9].

BMI was calculated as weight (kg) divided by height squared (m^2) and interpreted using IOTF reference curves [10].

Blood pressure was measured on the screening day using a calibrated sphygmomanometer with an appropriate cuff size. Measurements were taken on the right arm after 5 minutes of rest, in a supine or seated position when necessary. Two measurements were recorded and averaged. Blood pressure values were interpreted based on the 1996 reference thresholds [11].

Biochemical Analyses

Blood samples were collected after an overnight fast. The following parameters were assessed at the Biochemistry Laboratory of the University Hospital Center (CHU) of Annaba:

Fasting blood glucose: enzymatic method using hexokinase ; Total cholesterol: colorimetric method ; HDL-cholesterol: homogeneous phase enzymatic colorimetric method ; Triglycerides : enzymatic method using Randox reagents

Definition of Metabolic Syndrome

According to the NCEP-ATP III criteria adapted for children, metabolic syndrome was defined as the presence of at least three of the following five abnormalities:

1. Abdominal obesity: WC $\geq$ 90th percentile (McCarthy reference) [9]
2. Hypertension: systolic or diastolic blood pressure $\geq$ 95th percentile [11]
3. Low HDL-C: < 1.03 mmol/L (< 40 mg/dL), or < 10 th percentile based on pediatric reference values [12]
4. Elevated triglycerides: > 1.24 mmol/L (> 110 mg/dL), or > 90 th percentile [12]
5. Impaired fasting glucose: fasting glucose > 6.1 mmol/L [13]

Statistical Analysis

Data entry and analysis were performed using Epi Info 2000 software.

Qualitative variables were expressed as frequencies and percentages.

Quantitative variables were expressed as means and standard deviations.

Comparisons between means were made using the Student's t-test, while proportions were compared using the chi-square test.

Associations between continuous variables were assessed using the Pearson correlation coefficient (r).

A p-value < 0.05 was considered statistically significant.

Ethical

The study was conducted in strict compliance with data confidentiality. All information was anonymized and processed in accordance with the ethical principles of the Declaration of Helsinki.

Considerations

Results :

Anthropometric Characteristics

Among 3496 screened students, 632 (18.1%) exhibited a high BMI, including 5.9% with obesity. From this group, 179 children (28.32% of cases) with obesity or overweight were enrolled in the study.

The study population comprised 179 schoolchildren aged 5–15 years, including 98 males (54.7%) and 81 females (45.3%), yielding a sex ratio of 0.83. Participants were stratified into two age groups: **5–10 years**: 33 girls and 28 boys, **10–15 years**: 48 girls and 70 boys (total: 118 students). Based on BMI classification, 57% (102/179) were overweight, and 43% (77/179) were obese.

Prevalence of Metabolic Abnormalities

Metabolic syndrome (MS) criteria were observed as follows: **Abdominal obesity**: 92.2%; **Low HDL-cholesterol**: 37.98%; **Hypertriglyceridemia**: 30%; **Impaired fasting glucose (IFG)**: 3.9%; **Hypertension (HTN)**: 15.08% (2.8% isolated systolic HTN, 3.9% isolated diastolic HTN, 8.5% combined). The severity of obesity significantly influenced lipid/carbohydrate abnormalities, abdominal obesity, and HTN ($p = 0.0153$). A positive linear correlation was observed between: BMI and abdominal obesity ($p < 0.0001$) (Fig. 1); BMI and triglycerides ($p = 0.014$) (Fig. 2); Triglycerides and abdominal obesity ($p = 0.051$) (Fig. 3). Similarly, BMI correlated with systolic ($p < 0.0002$) and diastolic ($p < 0.001$) HTN (Fig. 4), as did abdominal obesity ($p < 0.0001$; Fig. 5). No significant linear relationship was found between BMI and HDL-cholesterol ($p = 0.348$).

Dyslipidemia and Hypertension

Dyslipidemia was detected in 108/179 children (67.98%), primarily characterized by hypertriglyceridemia (30%) and hypo-HDL-cholesterolemia (37.98%). Lipid abnormalities and HTN were more prevalent in girls than boys across both age groups, though the difference was not statistically significant ($p > 0.05$) (Table 3). Notably, obese children exhibited higher rates of dyslipidemia and HTN compared to overweight children ($p = 0.0153$) (Table 4).

Glycemic Abnormalities

Fasting blood glucose levels ranged from 3.11 to 6.75 mmol/L. Seven children (3.9%) had IFG (6.1–6.9 mmol/L), while 16 (8.93%) met the American Diabetes Association threshold (≥ 5.6 mmol/L). No cases of type 2 diabetes were identified.

Metabolic Syndrome Prevalence

The overall prevalence of MS was 18.43% (33/179). Although not statistically significant ($p = 0.39$), MS was more frequent in: **Girls** (14.52%) vs. boys (3.91%); **older children** (10–15 years: 11.73%) vs. younger (5–10 years: 6.70%; $p = 0.76$); **obese** (15.08%) vs. overweight (3.35%) participants (Table 5).

Discussion

The present study provides new epidemiological data on the prevalence of metabolic syndrome (MS) and its components among overweight and obese schoolchildren in Annaba, eastern Algeria. Our findings indicate a relatively low prevalence of MS in this population compared to other national and international studies, despite a significant association between the degree of obesity and the presence of metabolic abnormalities.

The prevalence of MS in our sample (15.03% in obese and 3.35% in overweight children) is markedly lower than the rates reported in previous Algerian studies. In a 2012 study conducted in Algiers using the same NCEP-ATP III criteria, the prevalence was reported at 35% among obese and 22.9% among overweight children [14]. Similarly, a 2016 study in Constantine, which applied modified IDF thresholds, found MS in 28.8% of obese, 9.8% of overweight, and 1.8% of normal-weight adolescents ($p < 0.0001$) [15].

When compared to neighboring countries using similar diagnostic criteria, our MS prevalence also appears relatively low. A Tunisian study reported higher rates (25.3% in obese and 7.6% in overweight children), while a Moroccan study found a prevalence of 22% among overweight and obese children combined [16,17]. In contrast, our results are closer to the findings of French studies using comparable criteria, where MS prevalence among obese children ranges from 10% to 15% [18]. However, MS prevalence in the United States remains significantly higher, ranging from 24% to 51% among overweight adolescents, depending on ethnicity and criteria used [12].

The observed variations in MS prevalence across studies can be largely attributed to differences in the diagnostic definitions used. A 2023 review of 26 publications on MS in children aged 6–12 years identified four main diagnostic frameworks: those of Cook et al., the IDF, the NCEP-ATP III, and De Ferranti et al. [20]. Our choice to apply the NCEP-ATP III definition was based on its wide acceptance in pediatric studies, its exclusion of insulin resistance (a parameter not measurable in our laboratory), and its suitability for comparison with existing literature.

Hypertension was one of the most prevalent MS components in our cohort, affecting 15.08% of participants. This rate is higher than that reported in Algiers (10.6%) [14], similar to that found in Morocco (16%) using the same definition [17], but significantly lower than the rate reported in Tunisia (73%), where a less stringent threshold (≥ 90 th percentile) was used [16]. In Côte d'Ivoire, a recent study among 82 overweight and obese children recorded a 10.98% prevalence using IDF criteria [22].

It should be noted that our rates of systolic (2.81%) and diastolic hypertension (3.9%) are considerably lower than those reported by Maisonneuve in a 2009 French study (38.1% and 19.3%, respectively) [18]. This discrepancy may be explained not by diagnostic criteria—since the 95th percentile was uniformly applied—but rather by methodological differences. In most studies, including ours, blood pressure was measured on a single occasion, which may overestimate or underestimate its true prevalence. Several authors recommend repeated measurements to improve diagnostic reliability [22]. Further studies with standardized protocols are needed for accurate

blood pressure profiling in children with elevated BMI.

Our results show that dyslipidemia is one of the most common metabolic disturbances in obese children. We observed a high prevalence of low HDL-C (37.98%) and elevated triglycerides (30%). These abnormalities are well documented in the literature as markers of insulin resistance [23]. We also found a significant positive correlation between BMI and triglycerides ($p = 0.014$), and an inverse correlation between BMI and HDL-C, although the latter was not statistically significant ($p = 0.348$), likely due to the limited sample size. These findings are consistent with the Moroccan study, which reported similar trends [17].

Our lipid profile data are comparable to those of the Algerian series: low HDL-C (37.98% vs 36%), high TG (30% vs 22.6%), high LDL-C (7.9% vs 9.5%), and total cholesterol (10.7% vs 10.9%). However, when compared to a 2009 study conducted in eastern Algeria among 13–19-year-olds [24], our rates are notably higher for low HDL-C (2.7-fold) and high TG (3-fold), whereas LDL-C and total cholesterol levels are similar. In contrast, studies conducted in Abidjan [22], Morocco [17], and the Middle East [25] reported lower rates of these lipid abnormalities. These discrepancies likely reflect differences in genetic predisposition, dietary habits, physical activity levels, and socioeconomic factors.

The prevalence of impaired fasting glucose in our study (3.9%) was similar to that observed in Algiers (3.7%) [14], but lower than that reported in eastern Algeria (10.6%) [24]. In European studies, fasting hyperglycemia in children with high BMI ranges from 1% to 3.5%, and was as low as 0.8% in the Maisonneuve study [18]. Higher rates were reported in Lithuania (6.9%) [19].

It is important to note that fasting blood glucose has low sensitivity in detecting carbohydrate metabolism disorders in children. A study cited by Maisonneuve [18] showed that fasting glucose alone detected only 33% of type 2 diabetes cases and 32% of glucose intolerance cases, compared to the oral glucose tolerance test (OGTT). The absence of diabetes in our cohort, and in other Algerian studies, likely reflects the late onset of carbohydrate disturbances, which typically follow earlier lipid and blood pressure abnormalities.

Waist circumference (WC), as a proxy for visceral adiposity, was highly prevalent in our cohort (92.2%), similar to the 95.9% reported by Maisonneuve [18], and significantly higher than the 63.7% reported in Algiers [14]. WC was positively correlated with triglyceride levels and inversely associated with HDL-C, although not significantly due to limited statistical power ($p = 0.051$). These associations confirm the central role of android obesity in the development of metabolic complications and its strong link to insulin resistance.

Limitations Of The Study

Although the prevalence of metabolic syndrome (MS) generally correlates with the prevalence of obesity, the relationship is not fully understood. Some obese individuals may not exhibit any metabolic abnormalities, while others with normal body weight may develop features of MS. Our study focused exclusively on children with elevated BMI, without including a control group of normal-weight participants. Furthermore, the relatively small sample size ($n = 179$) limits the generalizability of our findings to the broader pediatric population.

These limitations suggest the need for larger, well-designed case-control studies that include children across different BMI categories (normal-weight, overweight, and obese) to better understand the determinants and distribution of MS and its individual components in the pediatric population.

Conclusion

Our findings confirm that childhood obesity is associated with a significant prevalence of metabolic abnormalities, which may contribute to the early onset of cardiovascular risk factors. These results highlight the urgent need for early preventive strategies, including the promotion of healthy dietary habits and regular physical activity, particularly in school settings. Implementing such measures during childhood may reduce the burden of metabolic and cardiovascular diseases in adulthood.

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Table 1: Influence of BMI on Biological Parameters, Waist Circumference (WC), and Blood Pressure (BP)

Metabolic parameter	BMI (25-30)		BMI (30-35)		p
Hypertriglyceridemia	20	11,2%	33	18,4%	0,013
Low HDL-C	32	17,8%	36	20,1%	
Elevated fasting glucose	2	1,1%	5	2,7%	
HTN	13	7,2%	14	7,8%	
Elevated waist circumference	100	55,8%	67	36,4%	

Table 2: Distribution of Lipid Profile Abnormalities by Weight Status

	TG>1.24	HDL-C<1.03	Chol 5.17	LDL-C ≥3,36	Total
Overweight (OW)	20 (11,36%)	32(17,6%)	14 (7,95%)	11 (6,25%)	77
Obesity (OB)	33 (18,75%)	36(20,45%)	5 (2,84%)	3 (1,70%)	77
OW, OB combined	53 (30%)	68 (37,98%)	19 (10,7%)	14 (7,9%)	154

Table 3: Distribution of Metabolic and Hypertension Abnormalities by Age Group and Sex

Parameter	[5-10[			[10-15]			5-15		
	Male N %	Female N %	p	Male N %	Female N %	p	Male N %	Female N %	p
TG	7 3,9	15 8,4	0,695	12 6,70	19 10,6	0,275	19 10,6	34 19	0,415
HDL-C	15 8,4	19 10,6		14 7,82	20 11,1		29 16,2	39 21,8	
TC	2 1,1	5 2,8		7 3,91	5 2,79		9 5,02	10 5,6	
LDL-C	2 1,1	1 1,1		7 3,91	4 2,23		9 5,02	5 2,8	
Hypertension	2 1,1	4 2,23		6 3,35	15 8,38		8 4,4	19 10,6	

Table 4: Distribution of Dyslipidemia and Hypertension by BMI Category

Parameters	Overweight		Obesity		P
Triglycerides	20	11,2%	33	18,4%	
HDL-C	32	17,8%	36	20,1%	
TC	14	7,8%	05	2,8%	
LDL-C	11	6,1%	03	1,7%	
Hypertension	13 7,2%		14	7,8%	0.0153

Table 5 :Metabolic Syndrome Prevalence by Sex and Age Group

	Overweight	obesity	Total	P
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Male	0	0%	7	3,91%	7	3,91%	0.39
Female	6	3,35%	20	11,17%	26	14,52%	
Total	6	3,35%	27	15,08%	33	18,43%	
Age							
[5-10[	3	1,67%	9	5,02%	12	6,70%	0.76
[10-15]	3	1,67%	18	10,05%	21	11,7%	
Total	6	3,35%	27	15,08%	33	18,43%	

Figure 1: Correlation between abdominal obesity and BMI

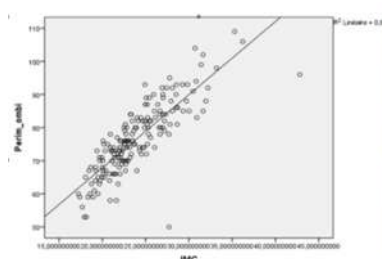


Figure 2: Correlation between triglyceride levels and BMI

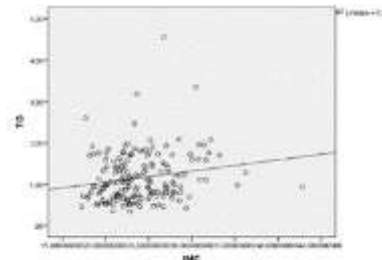


Figure 3: Correlation between triglyceride levels and abdominal obesity

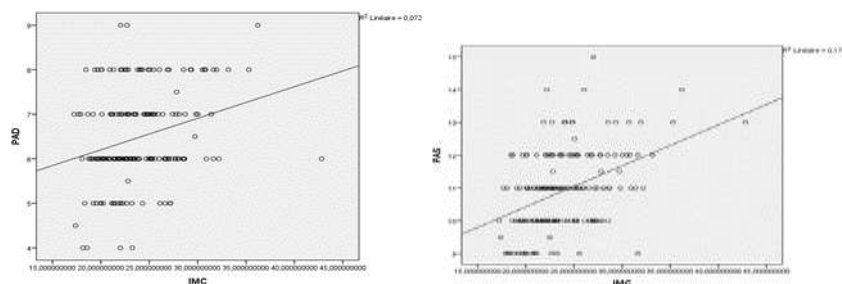


Figure 5: Correlation between hypertension and abdominal obesity

