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Predictive Factors of Obesity and their Relationships to Dietary Intake in Schoolchildren in Western Algeria

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ABSTRACT

Background: *Obesity has reached epidemic proportions world-wide. Its risk factors are poorly studied, especially among children in developing countries such as Algeria.*

Objectives: *The purpose of this study was therefore to determine the prevalence and risk factors of obesity in Algerian schoolchildren 6 to 8 years aged by conducting a school-site retrospective cohort study in Tlemcen Department (western Algeria).*

Material and Methods: *From 2008 to 2010, socio-demographic characteristics, body mass index (BMI), physical activity categories, lifestyle and nutritional habits of 1520 children (839 boys and 681 girls), at entrance into primary school, were recorded using a self-administered questionnaire.*

Results: *Among the 1520 participants, 99 (6.5%) were obese. Birthweight ≤ 2.5 kg and ≥ 4 kg, early introduction of solid foods and low physical activity were significantly associated with obesity (p<0.001). Additionally, mother's and grandmother's BMI ≥30 kg/m², fewer children in the household, higher parental education, household income and the presence of familial obesity may predispose significantly to childhood obesity (p<0.001). Furthermore, child's BMI was significant positively correlated with total energy, fat and saturated fatty acid (SFA) intakes (p<0.01). Mother's and grandmother's BMI were significant positively correlated with child total energy, fat and SFA intakes. Physical activity score was significant negatively correlated with child total energy, fat and SFA (p<0.01) intakes in obese children.*

Conclusion: *Mother's and grandmother's obesity, excess energy and fat intakes and low physical activity are the strong predictors of childhood obesity in Algeria. Preventive measures should focus on the promotion of physical activity and maternal and children nutritional education.*

Keywords: childhood obesity, etiology, nutrition, prevalence

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BACKGROUND

The prevalence of obesity in children has increased significantly in developed countries, but also, although less rapidly, in developing ones (1-4). Both genetic and environmental factors have been identified as potential causes of obesity (5-7), but the relative significance of each or the interplay between the two may vary. The rise in the prevalence of obesity might result from the increasingly sedentary lifestyle of western civilization associated with a reduction in daily physical activity and/or from changes in eating behaviour, both quantitatively and qualitatively. Whatever the complexity of risk factors, excess body weight and obesity always result from an imbalance between energy intake and energy expenditure with a positive energy balance due to either excessive calorie intake, decreased calorie expenditure or both. Other scientists have looked at the composition of the diet and reported that excessive consumption of dietary fat may be a more important determinant of obesity than excessive consumption of either carbohydrate or protein (8)

Children obesity is associated with many adverse health effects, such as hyperlipidemia, hypertension, abnormal glucose tolerance, respiratory disorders, orthopedic problems, low self-esteem and social discrimination (9-12). Moreover, children obesity is also a predictive factor for obesity in adult age (13). This worldwide epidemic has not spared North Africa population, in which there is a dramatic increase in the rate of obesity (14). The mortality and the multitude of adverse outcomes associated with this disease provide evidence of the need for a clear understanding of the predictors and causes of obesity during childhood to develop effective strategies for obesity prevention.

However, there are few data from Algerian children, where situation is believed to be worrying (15). Additionally, there are no interventional studies specifically designed to reduce the prevalence of obesity in Algeria. Since lifestyle and eating habits vary considerably from one country to another, it will be particularly important to adapt each program to the population involved.

The purpose of this study was therefore to estimate the prevalence of obesity in a representative sample of schoolchildren in Tlemcen, a western department of Algeria, and to provide information on child and parental predictors of children obesity. Special attention was focused on the relationships of energy intake and diet composition with child obesity predictors. This is the first report on obesity in a representative sample of children 6 to 8 years old in Western Algeria. ❑

MATERIAL AND METHODS

Subjects

The present study is part of a large national survey sponsored by the Ministry of Higher Education and Scientific Research, and the French Foreign Office (International Research Extension Grants, TASSILI) that was performed in Tlemcen (Algeria) during school years 2008 – 2010. It was designed to determine the prevalence and risk factors of childhood obesity.

The study population consisted of primary schoolchildren aged 6 and 8 years old in different public institutions located in Tlemcen department. A total of 42 classes from 22 elementary schools were selected using the multistage sampling method. Schools were selected taking into account the available records of the Ministry of National Education of Algeria, in an attempt to obtain a representative sample from the overall population of Tlemcen. 1520 children 6 – 8 years old from these elementary schools participated in this cohort study. Inclusion of subjects was on a voluntary basis. Children with eating disorders including dieting, genetic disorders of obesity, physical limitations, other co-morbid conditions, or treated by medications that could affect eating or physical activity were excluded.

All children were included in the screening process where they were measured for their weight and height. Body Mass Index (BMI) was calculated for each child for the purpose of categorisation into obese, overweight and normal weight groups. Factors that contribute to the development of obesity (infant, parent and family data) were collected using parent self-administered questionnaires and during a face-to-face interview.

All parents of participating infants gave informed written consent to participation and the study had the approval of the National Research Ethics Committee.

Anthropometric measurements

Anthropometric measurements (height and weight) were conducted for all children and were carried out at the beginning of the school year, during school medical visit. Measurements were performed by us and by the schools physicians. BMI was calculated by dividing weight (Kg) with standing height squared (m^2). Children were defined as obese if they had a BMI greater than the 95th percentile of the reference values for age and sex according to the International Obesity Task Force's gender and age-specific cutoff points (16). Children with a BMI between the 85th and 95th percentile were defined as overweight. Children were defined as normal weight if their BMI were less than the 85th percentile of the reference values for age and sex.

Child predictors

Birth weight, duration of breast feeding and timing (in months) of the introduction of solid foods were recorded in all children.

Physical activities were reported in a 7 day recall of all activities (physical education classes and outside school) including type, duration and intensity. A structured questionnaire was completed for each child (17,18). Specifically, regular involvement in any sport or other activity, duration of involvement and the frequency of strenuous exercise sessions per week were reported. Strenuous exercise was defined as a session of moderate and/or intense exercise of at least 15 min/session, which caused the child to sweat. Special questions were addressed to weekly leisure-time activities. Specifically, they were asked about the time spent in homework, reading, computer or video games and television watching. The amount of time in hours each subject spent in light, moderate and hard activity was then calculated. The activities were given intensity values based on metabolic equivalents (METS). One MET (1 kcal/kg/h) requires 3.5 ml of oxygen per kg of body weight per min. To make the energy cost calculations, light activities were assigned an average of 1.5 METS, moderate activities 4 METS and hard activities 6 METS or more. To calculate the activity score, the hours spent in each activity category were multiplied by the average MET for the category and summed over all categories.

Parental predictors

Family income, family size, material possessions, and highest educational level of the household were reported by parents on self-administered demographic questionnaires.

Information on parental age, height, weight, BMI and the presence of familial obesity was also recorded. All mothers were asked to report their own mother's height and weight in order to calculate grandmother's BMI. In parents, obesity was defined as BMI >30 Kg/m^2.

Measurement of dietary intake

The 24 hours (h) multiple pass recall (MPR) was performed as described by Montgomery et al. (19), basically consisting of a quick list of all foods and drinks consumed, a detailed description and a review with the interviewer probing for information on time/occasion, forgotten foods and food details. Accurate details and estimation of consumption are obtained by appropriate questions regarding food identification, preparation and ingredients, portion sizes and the use of household implements. Food models and cup size portions were used to assist in volume estimation. In the present study, authors administered the 24 h MPR on three separate occasions to include one weekend day and two weekdays. The child and the mother were interviewed together. Values for energy intake and nutrients were derived from intake records using the nutritional analysis program with database of food composition (REGAL Windows, France).

Statistical Analysis

Data are expressed as means ± standard deviation or as percentage. The outcome variable in the analysis was obesity in children. Statistical differences between obese and normal weight children of the same sex were determined with an unpaired Student's *t* test, after checking for normality of variable's distribution. Otherwise, a Mann-Whitney test was performed. The association between individual child and parental predictors and obesity was measured by the Odds Ratio (ORs) with a 95% Confidence Interval (95%CI). The comparison of frequencies and the OR statistical significance were done by the Chi-Square test with Yates correction. Pearson's bivariate correlation coefficients between predictors of children obesity and dietary consumption were measured. The correlation level between BMI and nutrients was used to evaluate the relationship between children's food consumption and their weight status. Statistical analysis was performed using STATISTICA software, version 4.1 for Windows (Statsoft, Paris, France). The level of significance was set at p <0.05. ❑

RESULTS

Based on the screening sample of 1520 schoolchildren, 99 were obese, 125 were overweight and 1296 were normal-weight. The prevalence of obesity among the schoolchildren was therefore 6.5%. There was no difference between the proportions of obesity in girls (6.2%) and in boys (6.8%) (p=0.698). The prevalence of overweight (8.2%) was higher among male (8.8%) than female (7.5%) children, but the difference did not reach statistical significance (p >0.05).

Tables 1 and 2 present the results of the association analysis with obesity. As indicated in Table 1, unlike weighing between 2.6 and 3.9 kg, birthweight ≤2.5 kg and ≥4 kg were significantly associated with obesity (p <0.0001). Additionally, non-breastfeeding and breastfeeding for seven months or more appear to be non significant factors associated with the obesity risk (p>0.05). However, breastfeeding during the first six months of life appears to be significantly protective against obesity (OR=0.58, p=0.02). Moreover, the introduction of solid foods at an early age (≤4 months) represents a high risk factor for obesity (OR=7.64, p=0.0001). Interestingly, a low physical activity was significantly associated with risk of obesity (OR=30.51, p<0.0001); on the contrary, higher or moderate-level physical activity was significantly associated with protection against obesity.

Table 2 shows that rates of mother's and grandmother's BMI greater than or equal to 30 kg/m² may predispose significantly to childhood obesity (respectively, OR=26.51, OR= 26.13, p <0.0001 for all two). Additionally, fewer children in the household (OR=10.06), higher parental education (OR=24.16) and household income (OR=10.79) and the presence of familial obesity (OR=21.93) were associated to the higher risk of children obesity (p <0.0001).

Among the 1296 normal-weight children, 140 age- and sex-matched subjects were voluntary to participate in the nutritional survey as controls (Table 3). As expected, BMI was significantly higher in obese boys and girls compared with the normal weight groups. Mother's and grandmother's BMI were significantly increased in obese compared to non obese groups for both sexes. Physical activity score was significantly lower in obese than in normal

Factors	Obese children n=99	Normal-weight children n=1296	OR (95%CI)	p
Birthweight category				
≤2.5 Kg	n=33	n=193	2.86 (1.79-4.56)	0.001
2.6-3.9 Kg:	n=23	n=879	0.14 (0.09-0.24)	0.0001
≥4 Kg	n=43	n=224	3.67 (2.36-5.72)	0.001
Duration of breastfeeding				
0 (never)	n=33	n=356	1.32 (0.83-2.08)	0.2552
≤6 months	n=37	n=655	0.58 (0.37-0.91)	0.0155
≥7 months	n=29	n=285	1.47 (0.91-2.36)	0.1207
Introduction of solid foods				
≤4 months	n=50	n=124	7.64 (5.10-10.25)	0.0001
4-6 months	n=27	n=747	0.28 (0.17-0.44)	<0.0001
≥6 months	n=22	n=425	0.59 (0.35-0.98)	0.0393
Physical activity				
Light	n=55	n=51	30.51 (18.27-51.10)	<0.0001
Moderate	n=35	n=900	0.24 (0.15-0.38)	<0.0001
Hard	n=9	n=345	0.28 (0.13-0.57)	0.0002

TABLE 1. Child predictors of obesity at 6-8 years

OR: odds ratio, CI: confidence interval. p-value for significance.

weight children (p <0.0001 for all comparisons).

Daily macronutrients and micronutrients intakes of the children are shown in Table 4.

The obese children of both sexes reported a higher median energy intake than did the normal weight subjects (p<0.0001). In boys as in girls, there was no significant difference in protein and in carbohydrate intakes, expressed as percentages of total energy intake, between obese and non-obese groups (p>0.05). However, fat intake and saturated fatty acids (SFA) were significantly increased in obese children (p<0.0001). Fiber, iron, calcium, vitamin A and vitamin E intakes did not differ significantly between obese and normal-weight groups. Both obese boys and girls had higher cholesterol, sodium, potassium, magnesium and phosphorus intakes than their non-obese counterparts (p<0.0001). Additionally, obese children had statistically lower vitamin C intake than normal-weight group (p<0.0001).

Pearson's correlations among nutrient intakes of children and strong predictors of child obesity are shown in Table 5. Only dietary variables which were significantly different between obese and normal-weight children were tested. Child BMI was significant positively correlated with total energy, fat and SFA intakes (respectively, r=0.397, p=0.0000; r=0.304, p=0.0022; r=0.240, p=0.0167). Mother's BMI was significant positively correlated with child total energy (r=0.316, p=0.0014), fat (r=0.312, p=0.0017) and SFA (r=0.230, p=0.0220) intakes. Additionally, there were significant positive relationships between grandmother's BMI and total energy (r=0.236, p=0.0187), fat (r=0.256, p=0.0105) and SFA (r=0.209, p=0.0379) intakes. Physical activity score was significant negatively correlated with

Factors	Obese children n=99	Normal-weight children n=1296	OR (95%CI)	p
Father's BMI				
<25 Kg/m^2	n=11	n=147	0.98 (0.48-1.93)	0.9247
25-29 Kg/m^2	n=73	n=969	0.95 (0.58-1.55)	0.9144
≥30 Kg/m^2	n=15	n=180	1.11 (0.60-2.02)	0.8424
Mother's BMI				
<25 Kg/m^2	n=17	n=370	0.52 (0.29-0.91)	0.0203
25-29 Kg/m^2	n=21	n=852	0.14 (0.08-0.24)	<0.0001
≥30 Kg/m^2	n=61	n=74	26.51 (16.19-43.53)	<0.0001
Grandmother's BMI				
<25 Kg/m^2	n=11	n=396	0.28 (0.14-0.85)	0.01
25-29 Kg/m^2	n=27	n=825	0.21 (0.13-0.35)	<0.0001
≥30 Kg/m^2	n=61	n=75	26.13 (15.97-42.88)	<0.0001
Children in household				
1-3	n=49	n=115	10.06 (6.35-15.96)	<0.0001
4-6	n=27	n=689	0.33 (0.20-0.53)	<0.0001
≥6	n=23	n=492	0.49 (0.30-0.82)	0.0048
Parental education				
Primary school	n=14	n=757	0.12 (0.06-0.21)	<0.0001
High school	n=32	n=480	0.81 (0.51-1.28)	0.4067
Higher education	n=53	n=59	24.16 (14.65-39.90)	<0.0001
Household income				
Low	n=19	n=361	0.62 (0.36-1.05)	0.0802
Medium	n=32	n=831	0.27 (0.17-0.42)	<0.0001
High	n=48	n=104	10.79 (6.77-17.19)	<0.0001
Familial obesity				
Yes	n=69	n=123	21.93 (13.42-35.98)	<0.0001
No	n=30	n=1173	0.05 (0.03-0.07)	<0.0001

TABLE 2. Parental predictors of obesity at 6-8 years

OR: odds ratio, CI: confidence interval. p-value for significance.

Variable	Obese n=99		Normal-weight n=140	
	Male n=57 X±SD	Female n=42 X±SD	Male n=80 X±SD	Female n=60 X±SD
Age (year)	6.9±1.3	7.1±0.9	7.2±1.4	6.9±1.2
p	0.2051	0.3627	-	-
BMI (Kg/m²)	24.50±2.11	23.67±2.09	16.98±2.43	16.33±3.54
p	<0.0001	<0.0001	-	-
Birthweight (kg)	3.96 ± 0.76	3.89±0.9	3.15±1.11	3.44±1.1
p	<0.0001	0.0311	-	-
Maternal BMI (Kg/m²)	30.57 ± 3.77	29.45±3.11	23.44±1.76	24.50±0.89
p	<0.0001	<0.0001	-	-
Grandmother BMI (Kg/m²)	29.77 ± 2.34	30.11±3.02	24.20±1.75	24.57±1.05
p	<0.0001	<0.0001	-	-
Physical activity score	27.44 ± 1.35	29.01±1.09	35.58±1.56	37.44±1.25
p	<0.0001	<0.0001	-	-

TABLE 3. Characteristics of schoolchildren of the nutritional survey

Data are expressed as means ± standard deviation (X±SD). Statistical differences between obese and normal weight means for each sex were based on independent sample t-test or on Mann-Whitney test. Statistically significant when p<0.05, and highly statistically significant when p<0.001.

child total energy (r=-0.259, p=0.0096), fat (r=-0.282, p=0.0047) and SFA (r=-0.246, p=0.0141) intakes in obese children. ❑

DISCUSSION

Childhood obesity is a clinical and public health concern in both developed and developing nations. Its prevalence varies in different geographic regions and also in different ethnic groups. This is the first study establishing the prevalence and etiologic factors of obesity in a representative sample of schoolchildren in Western Algeria. Our results showed that the prevalence of obesity in Algerian schoolchildren aged 6-8 years was 6.5%. The rate of obesity in children found in this study was in line with that observed in children for the same age group in Eastern Algeria and in other developing countries (4,15,20), but lower than that found among children in developed societies (1,21-23). Our results showed that risk factors of childhood obesity in developing countries were similar those found in developed countries. Various environmental factors have been implicated in the etiology of the increased prevalence of obesity, such as specific aspects of the home environment and family lifestyle, and sedentary activities and lack of physical activities (3-9,15).

In our study, a significant correlation was found between the children's obesity and birth weight, breastfeeding, early introduction of solid foods, physical activity, mother's and grandmother's obesity, fewer children in the household, increased parental education, high household income and familiar obesity. The protective effect of breastfeeding on the risk of childhood obesity was found to be statistically significant in this study, in agreement with some previous studies (24-26). The late introduction of solids has been shown to have a beneficial effect on childhood health (27). Similarly, early introduction of solid foods was associated with an increased risk of obesity as mentioned by our results. In our study, there were a significant association between birth weight and childhood obesity. The relationships between children obesity and birth weight were reported by some studies (5,28,29). Sedentary lifestyle and lack of physical activity are thought to have an important role in the etiology of obesity (7,8). Higher BMI was associated with lower activity levels (30). In this study, the prevalence of child obesity decreased with physical activity in either girls or boys. Indeed, physical activity score was reduced in obese children compared to controls.

Several studies have underlined the importance of socio-economic factors and reported the positive association of lower education and lower socioeconomic status with obesity (31, 32). The present study proved the influence of the socioeconomic status on child obesity risk.

Variable	Obese n=99		Normal-weight n=140	
	Male n=57 X±SD	Female n=42 X±SD	Male n=80 X±SD	Female n=60 X±SD
Energy (Kcal/day)	2139.33±180.42	2043.55±123.47	1715.35±108.50	1688.74±133.72
p	<0.0001	<0.0001	-	-
Protein (%)	12.08±3.23	12±2.55	12.34±2.76	12.71±3.12
p	0.6136	0.2265	-	-
Fat (%)	36.53±1.11	34.44±1.04	32.50±1.45	30.50±1.35
p	<0.0001	<0.0001	-	-
SFA (%)	14.22±1.27	15.20±1.28	10.08±1.04	11.23±1.30
p	<0.0001	<0.0001	-	-
Carbohydrate (%)	52.62±3.74	52.48±3.36	53.55±3.81	51.94±3.50
p	0.1582	0.4375	-	-
Cholesterol (mg)	183±17.89	189±10.77	124±15.66	126±12.08
p	<0.0001	<0.0001	-	-
Fiber (g)	17.92±2.75	17.14±2.17	17.25±2.35	16.85±1.75
p	0.1279	0.4577	-	-
Sodium (mg)	1680±135	1518±144	1083±106	1052±174
p	<0.0001	<0.0001	-	-
Potassium (mg)	3100±188	2520±207.55	1986.5±197.83	1687.39±184.12
p	<0.0001	<0.0001	-	-
Magnesium (mg)	243.40±15.08	249±11.35	155.24±14.75	158.56±10.50
p	<0.0001	<0.0001	-	-
Phosphorus (mg)	657±27.53	638.55±43.65	465±35.80	438.50±38.45
p	<0.0001	<0.0001	-	-
Iron (mg)	7.55±1.13	7.63±1.44	7.75±0.96	8.02±1.15
p	0.2664	0.1321	-	-
Calcium (mg)	719.83±70.78	700.54±104.67	733.49±88.06	683.5±98.45
p	0.3343	0.4039	-	-
Vitamin A (µg)	312±86.62	345.15±85.50	300.25±50.60	323±57.55
p	0.3199	0.1244	-	-
Vitamin C (mg)	31.42±2.75	30.50±2.56	59.18±4.35	54.11±2.23
p	<0.0001	<0.0001	-	-
Vitamin E (mg)	6.65±1.31	6.95±1.45	6.28±1.44	6.84±1.08
p	0.1263	0.6615	-	-

TABLE 4. Parental predictors of obesity at 6-8 years

Data are expressed as means ± standard deviation (X±SD). Statistical differences between obese and normal weight means for each sex were based on independent sample t-test or on Mann-Whitney test. Statistically significant when $p<0.05$, and highly statistically significant when $p<0.001$.

However, family's higher socioeconomic status, as shown by fewer children in the household, increased parental education and high household income, was associated with increased risk of child obesity, as also shown in eastern Algeria (15). The emergence of obesity in developing countries affected primarily the higher socioeconomic strata of the population (33).

The study has shown that maternal obesity is a significant predictive factor for child obesity. The same finding has been found in many studies (4,5,9). Li et al. (23) found that mother's BMI explained the largest portion of the variance in child fatness. Prevalence of obesity among children was also increased with grand mothers' obesity. Data on the relationships between grand parent's BMI and childhood obesity are limited, making comparisons difficult. Our data suggested that higher grandmother's BMI is a marker not only for her own daughter obesity risk, but is also associated with obesity risk in her daughter's offspring. More importantly, the influence of genetic contributions to

Variable	Child BMI (kg/m²)	Maternal BMI (kg/m²)	Grandmother BMI (kg/m²)	Physical activity score
Energy (Kcal/day)	0.397	0.316	0.236	-0.259
p	<0.0001	0.0014	0.0187	0.0096
95%CI	0.22 to 0.55	0.13 to 0.48	0.04 to 0.41	-0.43 to -0.06
Fat (%)	0.304	0.312	0.256	-0.282
p	0.0022	0.0017	0.0105	0.0047
95%CI	0.11 to 0.47	0.12 to 0.48	0.06 to 0.43	-0.45 to -0.09
SFA (%)	0.240	0.230	0.209	-0.246
p	0.0167	0.0220	0.0379	0.0141
95%CI	0.04 to 0.42	0.03 to 0.41	0.01 to 0.39	-0.42 to -0.05
Cholesterol (mg)	0.107	0.065	0.060	0.071
p	0.2918	0.5227	0.5552	0.4850
95%CI	-0.09 to 0.30	-0.13 to 0.26	-0.14 to 0.25	-0.13 to 0.26
Minerals (mg)	0.134	0.089	0.122	0.067
p	0.1861	0.3810	0.2290	0.5099
95%CI	-0.06 to 0.32	-0.11 to 0.28	-0.08 to 0.31	-0.13 to 0.26
Vitamin C (mg)	-0.103	-0.020	0.039	0.130
p	0.3103	0.8442	0.7015	0.1997
95%CI	-0.29 to 0.10	-0.22 to 0.18	-0.23 to 0.16	-0.07 to 0.32

TABLE 5. Pearson's correlations of children's BMI and child obesity predictors with dietary consumption (n=99)

Only dietary variables that were significantly different between obese and normal-weight children were tested for correlations with child obesity predictors. Minerals represent the sum of sodium, potassium, magnesium and phosphorus intakes in children. Statistically significant correlations when p<0.05, and highly statistically significant when p<0.001.

differences between obese and non-obese families cannot be ignored.

Obese children in this study, both boys and girls, reported a higher energy intake compared with the control groups. Other researchers have reported that excessive energy intake is the primary cause of child obesity (34). Other scientists looked at the composition of the diet and reported that excessive consumption of dietary fat may be a more important determinant of obesity than excessive consumption of either carbohydrate or protein (35,36). McGloin et al. found dietary fat was the only macronutrient which significantly predicted body fatness (36). Those observations imply that diet composition, as well as energy balance, are associated with obesity. Our findings showed that both male and female children had significantly higher fat intake, especially SFA than control groups. Dietary cholesterol intake was also found to be higher in these obese children than in controls. There is much evidence to indicate a positive linear trend between cholesterol intake and low density lipoprotein cholesterol concentration, and therefore increased risk of coronary heart disease (CHD) (37). Plasma cholesterol response to this dietary cholesterol excess may be of importance in evaluating long term consequences of obesity in these school children.

When micronutrient intakes are concerned, obese children had higher intakes of sodium, potassium, magnesium and phosphorus and lower intake of vitamin C than controls. These findings could be linked to the growing consumption of energy-dense foods (34). An increased consumption of snacks, caloric beverages, and fast foods and a decreased intake of legumes, vegetables, and fruits by children has been shown repeatedly to be associated with obesity and excess weight gain (34,36,38).

In our study, positive and significant correlations were found between children BMI and total energy, fat and saturated fat intakes, in agreement with previous studies (36,39). Mother's and grandmother's BMI were also significantly correlated to children total energy, fat and saturated fat intakes, reflecting probably similarities in mother's and offspring's dietary intakes. Results from this study suggested that risk factors tended to co-occur within the family such that mothers who were obese consumed a greater energy and fat intakes which influence children's consumption. Previous research has identified similarities in parents' and children's BMI, dietary practices, and physical activity (40,41).

The relationship between physical activity score and dietary intake is of great interest. The finding supported the idea that active person eat less foods rich in fat and energy. Beneficial associations between physical activity and healthy food choices such as fruits and vegetables have been described in studies in children (42). In our study, obese children were less active and had higher energy and fat intakes than did the non-obese children.

Some limitations of this paper should be noted. First, all data were from parental and children self-report and thereby subject to possible attention, comprehension, memory, and recording errors. Measurement of physical activity is difficult and also subject to error. Children spend much of their time in unstructured activities, thus making it difficult to assess activity accurately using a structured activity questionnaire. Second, it is possible that other unknown confounders may have influenced the results of this study, such as genetic factors. The correlations between child and mother's, grandmother's BMI might be attributed to the genetic predisposition or to family and mothers' eating habits.

In conclusion, both biological and environmental factors have been associated with school childhood obesity in Western Algeria. The strong relationship was detected between mother's and grandmother's obesity, excess energy and fat intakes, low physical activity and the prevalence of childhood obesity. The prevalence of obesity in children in Algeria can be mainly attributed to their improper diet composition which was related to maternal influence.

Future interventions that target increased physical activity and dietary treatment such as lower energy and fat intake and greater vegetables and fruits consumption may be effective strategies to decrease the childhood obesity in Algeria. This study highlights the necessity of incorporating mothers in the treatment of childhood obesity. ❑

COMPETING INTERESTS

The author(s) declare that they have no competing interests.

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