

Original article

Comparative mapping approach of energy intake and expenditure of obesity prevalence among school adolescents

Fouzia Yous^{a,*}, Salim Zaabar^a, Omar Aoun^{a,b}, Nawel Adjeroud-Abdellatif^a, Khodir Madani^c^a Laboratoire de Biomathématiques, Biophysique, Biochimie et Scientométrie (L3BS), Faculté des Sciences de la Nature et de la Vie, Université de Bejaia, 06000, Bejaia, Algérie^b Département de Microbiologie et de Biochimie, Faculté des Sciences, University of M'sila, 28000, M'sila, Algérie^c Centre de Recherche en Technologies Agro-alimentaires. Route de Targua Ouzemmour, 06000, Bejaia, Algérie

ARTICLE INFO

Article history:

Received 26 January 2021

Accepted 15 March 2021

Keywords:

Obesity

Adolescents

Prevalence

Physical activity level

Total energy intake

SUMMARY

Objective: This study aims to describe the prevalence of overweight and obesity in an obesogenic environment among adolescents in the wilaya of Bejaia (eastern Algeria), and to assess their Physical Activity Level (PAL), Daily Energy Expenditure (DEE) and Total Energy Intake (TEI).**Methods:** A cross-sectional study was carried out on a sample of 3038 adolescents consisting of 1635 girls and 1403 boys in middle and high schools in 19 regions of Bejaia. The average age was 14.78 ± 2.53 . Two questionnaires were assigned to collect data on their nutritional habits (24-h dietary call) and physical activity levels. BMI measurement was adopted in this study to determine the weight status of this sample and to assess the distribution of BMI, PAL, DEE, TEI over geographical areas of an administrative territory using the Student test descriptive statistical method ($p < 0.05$).**Results:** The prevalence of obesity and overweight was equal to 3.3%, the physical activity level in adolescents was 1.72 ± 0.21 , with boys more likely to participate in sports than girls (16.5% for boys and 6% for girls). However, energy intake (3775.44 ± 719.07 kcal/day), energy expenditure (3144.13 ± 850.54 kcal) and body mass index (30.51 ± 2.99 kg/m²) were high. Body mass index (BMI) is negatively correlated with PAL ($r = -0.05$) and positively correlated with TEI ($r = 0.31$) and DEE ($r = 0.30$), these results show that DEE and TEI factors play an important role in the prevalence of BMI with excessive consumption of high carbohydrate (614.55 g) and fat (98.9 g) foods, which is due to poor diet and are related to insufficient level of physical activity. The mapping shows that there is a disparity between the studied parameters: high BMI, low PAL and consumption of unhealthy foods (DEE, TEI).**Conclusion:** The lack of physical activity and the imbalance between energy intake and expenditure are the main factors that could lead to an increased risk of obesity in adolescents.

© 2021 European Society for Clinical Nutrition and Metabolism. Published by Elsevier Ltd. All rights reserved.

1. Introduction

The prevalence of overweight and obesity is a phenomenon that affects all countries in the world, particularly the United States [1]. Obesity is a worldwide epidemic that affects all ages [2]. Childhood obesity becomes a risk factor for hypertension, diabetes, heart disease, some types of cancer and adult mortality [3–5]. According to Mahbuba [6] the estimation of the overall prevalence of

childhood obesity will reach approximately 60 million by 2020. The global strategy addresses two main risk factors responsible for the increasing burden of non-communicable diseases; the bad food-based diet and physical inactivity, which account for about 60% of deaths worldwide and 47% of global disease management [7,8]. A nutritional transition exists in developed and developing countries [9,10]. Body mass index (BMI) is used as an indicator of weight status (obesity, overweight) [11–13]. Children and adolescents

* Corresponding author.

E-mail addresses: yousfou01@gmail.com, Fouzia.yous@univ-bejaia.dz (F. Yous).

having BMIs characteristic of obesity and overweight are more at risk of becoming obese adults [14–16]. BMI has been used to estimate the probability of overweight in children and adolescents, with attribution limit values, such as the 85th or 95th percentile of baseline data [17–19]. This can help children and adolescents who are at risk and need close monitoring [20,21]. Among adolescents, the causes that determine the extent of overweight and obesity, in addition to the consumption of energy-dense foods, include physical activity levels and sedentary behavior [22,23]. Physical inactivity has been identified as the fourth main risk factor for full mortality, causing 3.2 million deaths according to the World Health Organization (WHO) [24]. Physical activity has increasingly played an important role in disease prevention and health promotion efforts in the United States [25–27]. Excessive food consumption and lack of physical activity are key indicators contributing to the obesity epidemic [28]. Consequently, obesity occurs when the energy balance between energy intake and expenditure is positive [28–31]. In Algeria, school health could be the basis for preventive actions against nutritional deficiencies and overweight among young people [32]. To the best of our knowledge this is the first epidemiological study on the prevalence of obesity in Bejaia city (Algeria). The objective of this study is to determine the Body mass index, the level of physical activity and thus to evaluate the balance between energy intake and expenditure among adolescents (11–23 years) in an obesogenic school environment.

2. Methodology

2.1. Study setting

The study was conducted in the wilaya of Bejaia, which is an Algerian wilaya (equivalent to a department or province) located on the Mediterranean Sea at 220 km east of Algiers, it includes 19 Dairas (sub-department) and 52 communes. These communes of Bejaia had 160 middle schools and 60 high schools. These results are not representative of the whole Algerian country, they are only characteristic of the wilaya of Bejaia.

2.2. Study population

The study involves middle and high school students, hence the interest in having a representative sample of the school population (91810 enrolled students). Our sample consists of 3038 students: male (1403 boys) and female (1635 girls).

This sample includes adolescents of both sexes; the mean age is 14.78 ± 2.53 . The study is carried out on all 19 Daira composing the territory of the wilaya; it concerns students from the first average year to the third year of secondary school in all colleges and high schools in the wilaya of Bejaia (Eastern Algeria) during the 2017–2018 school year. Within the framework of this study, we reached 160 middle schools and 60 secondary schools.

2.3. Procedure

This is a cross-sectional descriptive epidemiological survey whose objective is to describe the epidemiological status on a territory to demonstrate the prevalence of overweight and obesity on a sample of students in the wilaya of Bejaia. It is characterized by population sampling, without selection either on exposure or on disease [33,34]. The information was gathered from a questionnaire. Data that characterized the student (name, first name, age and gender) were collected, their anthropometric characteristics (weight and height); and schooling (name of school), and information on food consumption, 24-h recall and physical activity of

students were also required. The questionnaire consisted of a series of questions (16 questions) divided into two sections: 24-h recall and physical activity.

2.3.1. Determination of anthropometric parameters

The anthropometric parameters (weight and height) were measured using a scale and a height gauge. The measurement technique was carried out using WHO recommendations. The body mass index (BMI) is calculated by dividing the weight (W) expressed in kilograms by the square of the height (H) expressed in meters [35] as follow (Eq. (1)):

$$BMI = \frac{W}{H^2} \quad (1)$$

For adults there is a unique BMI reference value by classifying the weight status of the adult according to WHO, overweight is noted when BMI value is between 25 and 29.99 kg/m², and when it is greater than 30 kg/m² the person is obese [36].

In children under 18 years old, the BMI is used as part of the adolescent follow-up, the obtained results are reported on corpulence curves defined by Cole [37].

Overweight can be expressed as a “BMI Z-score” which provides a numerical indication of deviation from the median for gender and age; BMI Z-score is used in clinical practice to accurately quantify overweight and obesity. The WHO recommends the indication of overweight by a Z-score > +1 SD. Obesity is indicated by a Z-score > +2 SD. Z-score expresses the number of standard deviations below or above the reference mean or median value for an anthropometric variable [38].

2.3.2. Daily energy expenditure (DEE)

Daily energy expenditure (DEE) decreases gradually with age due to the decline in rest energy expenditure (REE) and physical activity level (PAL) [39].

DEE was calculated based on physical activity level (PAL) and base metabolism (BM) following this formula (Eq. (2)):

$$DEE = BM \times PAL \quad (2)$$

The DEE is expressed in Kcal.

2.3.3. Basal metabolic (BM) rate

For a child from 10 to 18 years old, basal metabolism can be predicted, with a measurement uncertainty of 5–10% by the following relationships (FAO/WHO/UN 1986) [40,41]:

$$\text{Boys : } BM = (69.4 \times W) + (322 \times H) + 2392$$

$$\text{Girls : } BM = (30.9 \times W) + (2016.6 \times H) + 907$$

W: is weight in kg and H: represents height in meters.
So:

$$\text{Boys : } BM = (16.6 \times W) + (77 \times H) + 572$$

$$\text{Girls : } BM = (7.4 \times W) + (482 \times H) + 217$$

BM is expressed in Kcal.J⁻¹(KJ.J⁻¹ × 0.239 Kcal.J⁻¹).

2.3.4. Physical activity level (PAL)

Energy expenditure was assessed using data collected on school activity (number of hours spent in school), daily and leisure activities according to Table 1 [42]. Physical Activity Level was calculated according to the following formula (Eq. (3)):

Table 1

Activities classification of children and adolescents aged between 10 and 18 years in 7 categories according to physical activity level (PAL).

Category	PAL	Different activities
A	1	Sleep and nap, extended rest
B	1.75	Sitting position. (TV, computer, homework, meals, transportation)
C	2.1	Standing position (shopping, cooking, short trips, toilet)
D	2.6	Light activities of low intensity (games can be active)
E	3.5	Moderate activities (brisk walking, manual work.)
F	5.2	Sports activities (club training, physical education and sports ...)
G	10	Sports competition

$$PAL = \frac{\text{Coefficient of the PAL} \times \text{duration (hours)}}{24} \quad (3)$$

Energy expenditure is related to physical activity for 24 h [43,44]. A PAL of 1.0–1.4 characterizes sedentary individuals, while a PAL of 1.9–2.5 corresponds to very active individuals [44–47].

2.3.5. 24-Hour dietary recall

The adolescents food consumption is estimated using the “24-h recall” method [48]. This method consists of describing food intake during the 24 h preceding the survey (composition of each meal, name of food). These questions aim to find out the frequency of food consumption; meals and daily consumption to detail the food groups intake (such as sugary drinks, vegetables, fruits and dairy products) of adolescents during the three main meals (breakfast, lunch and dinner), and during snacks (morning and evening) and questions on snacking (food eaten, timing of snacking, snacking practice, frequency) and also the frequency of consumption of drinks during and outside meals. The 24-h recall was calculated based on the energy value of each food, the energy intake supply is available (kcal per 100 g of food) and the nutrient content (proteins, fat and carbohydrates in grams per 100 g of food). According to the protein, lipid and carbohydrate content of each food, daily protein, lipid and carbohydrate intakes have been calculated for each consumed food. Then the sum of all the consumed foods was calculated. Thus, we obtained the consumed amount of protein, fat and carbohydrates per day.

2.4. Mapping of bejaia

We opted for a mapping approach in our study in order to make the results of our research more visible with a representation of variable differences such as DEE and TEI over the whole territory, and also to determine and/or disparities of these variables within the territory.

2.5. Statistical analysis

Principal component analysis (Pearson correlation) ($p < 0.05$) was used to determine body mass index (BMI), physical activity level (PAL), daily energy expenditure (DEE) and total energy intake (TEI) using STATISTICA version 7.1 software. The Z-test ($p < 0.05$) was used to compare averages of BMI, PAL, DEE, TEI of girls with those of boys, as well as to compare averages of low activity levels with those of high activity levels in overweight and obese girls and boys using XLSTAT 2009. The data are presented as mean $\pm$ standard deviation (SD). The mapping software MapInfo Professional 8.0 was used to demonstrate the significant difference between all the Daira in the wilaya of Bejaia (see Table 1).

3. Results

3.1. Body mass index (BMI)

Table 2 shows that averages of BMI for the different sexes are: 32.71 ± 2.48 and 32.62 ± 2.63 kg/m² for obese girls and boys; respectively, with significant difference at ($p = 0.486$). The mean BMI for overweight girls and boys are: 28.028 ± 0.967 and 28.252 ± 0.940 kg/m², respectively (Table 2).

Obese girls had an upper BMI Z-score of +1, whereas obese boys had a lower BMI Z-score of +1 with standard deviation with a significant difference ($p < 0.0001$). The mean Z-score BMI for overweight girls and boys are lower +1 SD with significant differences at ($p < 0, 0001$) (Table 2).

3.2. Physical activity level (PAL)

The PALs for obese girls and boys were: 1.61 ± 0.12 , 1.85 ± 0.21 , respectively (Table 2). The average PALs for overweight girls and boys were: 1.60 ± 0.12 and 1.85 ± 0.23 , respectively (Table 2).

Table 3 results show that different low-intensity activities represented 94% in obese girls and only 6% for high-intensity activity with a significant difference ($p < 0.007$), and 84% low-intensity activities in obese boys and 16% for high-intensity activity with a significant difference ($p < 0.034$). In overweight adolescents, girls also exhibited 94% of low intensity and 6% of high activity with a significant difference ($p < 0.033$), while boys showed a low level of physical activity (84%) and only 16% of sports activity with a significant difference ($p < 0.009$). In this study, girls were more physically inactive than boys.

3.3. Daily energy expenditure (DEE)

From Table 2 we can see that the mean DEE of obese girls was equal to 2551 ± 266.28 kcal, which was lower than that of obese boys (4089.53 ± 640.93 kcal). The results of Table 2 shows that the mean DEEs of overweight girls and boys were 2402.92 ± 242.01 and 3779.62 ± 1424.86 kcal, respectively.

3.4. Total energy intake (TEI)

The analysis of daily food intake among adolescents showed that girls usually consume 3255.6 kcal/day (recommendation for girls 2900 kcal/day) with fat amount of 89.6 g and a very high frequency of carbohydrate (493.7 g). Boys consume 4386.61 kcal/day (recommendation for boys 3500 kcal/day) with fat value of 108.29 g and also a very high frequency of carbohydrate (735.4 g) (Table 4). For obese students, the results show that the TEI for girls was 3307 kcal/day, while that for boys was 4483.75 kcal/day (Table 2). For the TEI of overweight students, Table 2 shows that the mean value for boys was 4284.90 ± 447.34 kcal/day, which is higher than that of girls (3185.51 ± 372.24 kcal/day), with a significant difference ($p < 0.0001$).

Table 2
Basic characteristics of studied obese and overweight population.

	Obese			Overweight		
	Girls (868)	Boys (722)	P	Girls (767)	Boys (681)	P
Age (year)	15.15 ± 2.59 {11–22}	15.09 ± 2.61 {11–23}	0.653	14.85 ± 2.46 {11–22}	14.74 ± 2.4 {11–21}	0.417
BMI (kg/m ²)	32.71 ± 2.48	32.62 ± 2.63	0.488	28.028 ± 0.967	28.252 ± 0.940	<0.0001
BMI Z-score	1.74	0.24	<0.0001	0.50	0.30	<0.0001
DEE (kcal)	2551 ± 266.28	4089.53 ± 640.93	<0.0001	2402.92 ± 242.01	3779.62 ± 1424.86	<0.0001
PAL	1.61 ± 0.12	1.85 ± 0.21	<0.0001	1.60 ± 0.12	1.85 ± 0.23	<0.0001
TEI (kcal)	3307 ± 408.93	4483.75 ± 509.86	<0.0001	3185.51 ± 372.24	4284.90 ± 447.34	<0.0001

BMI: body mass index; DEE: daily energy expenditure; PAL: physical activity level; TEI: total energy intake; {}: extreme.
P: values for comparisons between boys and girls (<0.05), performed with Z tests.

Concerning the 24-h dietary recall, the results presented in Table 4 show the frequency of consumption of the different food groups distributed according to the 4 daily intakes (breakfast, lunch, dinner and snacking between meals), which is very high in carbohydrates and lipids. Table 5 shows the classification of food groups for meals.

3.5. Principal component analysis (PCA)

PCA was used in this research to determine the degree of correlation between the different variables (BMI, NAP, DEE and TEI) (Figs. 1 and 2). The aim is to verify which factor influences the BMI variable, i.e. the one that causes overweight or obesity (3.3%), our results disprove that the prevalence is due to the influence of the studied following factors.

For obese girls the results showed a strong positive correlation between TEI and DEE ($r = 0.61$) and between PAL and DEE ($r = 0.48$), however a positive proportional mean correlation between PAL and TEI ($r = 0.32$), and a weak positive correlation between BMI and DEE ($r = 0.16$) were illustrated. We noted that there is a weak negative correlation between BMI and PAL ($r = -0.05$) and between BMI and TEI ($r = -0.007$) (Fig. 1a).

Concerning obese boys, the results showed a strong positive correlation between DEE and TEI ($r = 0.87$), between DEE and PAL ($r = 0.63$) and between PAL and TEI ($r = 0.54$). A weak positive correlation between DEE and BMI ($r = 0.15$) and between TEI and BMI ($r = 0.09$) were noted. While, there is a weak negative correlation between BMI and PAL ($r = -0.06$) (Fig. 1b).

In the case of overweight girls, the results show a strong positive correlation between DEE and TEI ($r = 0.65$) and between DEE and PAL ($r = 0.56$). We noted a positive proportional mean correlation between PAL and TEI ($r = 0.35$), between DEE and BMI ($r = 0.31$), and between TEI and BMI ($r = 0.30$), but a weak positive correlation between PAL and BMI ($r = 0.09$) (Fig. 2a).

For obese boys, the results indicate a strong positive correlation between PAL and TEI ($r = 0.58$), and a positive mean proportional correlation between DEE and TEI ($r = 0.33$), between DEE and PAL ($r = 0.26$), between BMI and TEI ($r = 0.23$), and a weak positive correlation between BMI and DEE ($r = 0.11$); while, there is a weak negative correlation between BMI and PAL ($r = -0.05$) (Fig. 2b).

Our results show that the most influential factor on the BMI variable is the NAP with a lower degree (1.72) represented with a negative correlation ($r = -0.16$). DEE has also an influence on the prevalence of high energy intake ($r = 0.23$) and low energy expenditure ($r = 0.15$). These results show that DEE and TEI factors play an important role in the prevalence of BMI with excessive consumption of high carbohydrate (614.55 g) and fat (98.9 g) foods, which is due to poor diet and are related to insufficient physical activity.

3.6. Bejaia mapping

The results (Fig. 3) indicate that there is a territorial disparity concerning the distribution of overweight and obese students defined by the BMI, these indices are variable from one zone to another.

The mapping shows that certain areas (Bejaia, Akbou, Sidi Aich, Barbacha, Darguina, Elkseur, Ighil Ali, Souk El Tenine, Ouzellaguen) are strongly characterized by obesity (Fig. 3a), and by overweight (Darguina, Chmini, Sidi Aich, Elkseur, Akbou, Beni Maouche, Ighil Ali, Tichy, Timezrit) (Fig. 4a).

Low physical activity level (PAL) is dominant in both territories: obese (Fig. 3b) and overweight (Fig. 4b) students; but high expenditure and energy intake are dominant in both territories: obese (Fig. 3c and d) and overweight (Fig. 4c and d) students.

4. Discussion

4.1. Prevalence of obesity and overweight

The prevalence of obesity and overweight was equal to 3.3%. Compared to other studies in our country, our prevalence result is lower than that of Oulamara [49], in which the prevalence of overweight varied from 22.8 to 28.3% for a young child population (6–10 years) concerning a small cohort of 509 subjects. However, our research work is based on a different population, that is of 11–23 years old, so these are different biometric obesity prevalence characteristics that could cause disparities in prevalence calculation. In the work of Addor [50] obesity was more frequent in younger children compared to adolescents. Our study concerns a larger cohort sample, which includes a sample of 3038 obese and overweight subjects from a representative sample of the school population (91 810 enrolled students) in the wilaya of Bejaia.

We are facing an obesity phenomenon that sets up a weight status, meaning a prevalence of overweight and obesity in the Maghreb territory. These countries (Algeria, Tunisia, Morocco) have probably the same problem of public health as the most industrialized countries; so our results are concomitant with those of Maghreb countries [51]. Obesity and overweight in Tunisia were equal to 2.4 and 6.3%, respectively. In Morocco, the prevalence of obesity and overweight were 3.41 and 7.29%, respectively among 12–18 years aged adolescents [52], these values are lower than that found in developed countries [53]. According to WHO, the obesity rate in developed countries is twice as high as in developing countries; in the USA (2009–2010) 16.9% of children and 12–19 years aged adolescents were obese [21].

This study shows that changes in BMI include drastic changes in BMI Z-score based on the patient's age, gender and initial BMI. So

Table 3
PAL hours of boys and girls according to different activities.

	Different activities				PAL hours of obese girls				PAL hours of obese boys				PAL hours of overweight girls				PAL hours of overweight boys			
	N° of hours (h)	N° of hours as % of total hours	Low and high intensity activities (%)	P	N° of hours (h)	N° of hours as % of total hours	Low and high intensity activities (%)	P	N° of hours (h)	N° of hours as % of total hours	Low and high intensity activities (%)	P	N° of hours (h)	N° of hours as % of total hours	Low and high intensity activities (%)	P	N° of hours (h)	N° of hours as % of total hours	Low and high intensity activities (%)	P
Low-intensity activities	1	10.92	45.5	94.2	0.007	10.34	43.08	83.6	0.034	11	45.84	93.9	0.033	10.27	42.79	83.5	0.009			
	Sleep and nap, extended rest	1.75	6.23	25.96		4.5	18.75			6.23	25.95			4.5	18.75					
	Sitting position	2.1	2.8	11.66		2.56	10.67			2.7	11.25			2.64	11					
	Standing position	2.6	2.66	11.08		2.66	11.08			2.61	10.87			2.63	10.95					
	Light low-intensity activities	3.5	1.26	5.26	5.8	2.27	9.46	16.4		1.37	5.8	6.1		2.33	9.7	16.5				
	Moderate activities	5.2	0.13	0.54		1.36	5.67			0.09	0.37			1.36	5.66					
	Sports activities	10	0	0		0.31	1.29			0.003	0.01			0.3	1.25					
	Sports competition																			
	Total	24 h	100	100		24 h	100	100		24 h	100	100		24 h	100	100				
High-intensity activities																				

the change in BMI Z-score is a logical choice to measure adiposity change over time [54].

Correct estimation of anthropometric Z-scores is relevant for clinical patients care as well as for clinical studies since it is used for the classification of obesity with implications for treatment and/or nutritional intervention [38].

4.2. Physical activity level (PAL)

PAL and caloric intake are among the main risk factors for developing obesity. Boys (PAL = 1.85) are more likely to participate in sport than girls (PAL = 1.61). In addition, boys often practice more physical activity than girls in European countries [55,56].

This result showed that obese students present a significant decrease in the number of physical activity sessions and their duration (1.5 h for girls; 4 h for boys) [57–59]. In addition, this study evaluated physical inactivity by: time spent sleeping (10 h), sitting (6 h for girls and 4.5 h for boys), standing and light activities (2 h). We found that girls are more sedentary than boys (94% for girls; 83% for boys). The higher level of time spent watching television and lack of sleep, as well as the lower PAL, due to parents negligence, are the greatest risks of physical inactivity among children and adolescents [27,60,61].

During the period of adolescence, there is a significant relationship between changes in the difference in PAL and changes in BMI. The results of many previous studies are comparable to our results [62]. According to Meininger [63] numerous studies showed that there is a link between the increase in the prevalence of childhood obesity and the current trend towards their greater sedentariness.

4.3. Daily energy expenditure (DEE)

In this study, we showed that DEE is of the order of 3144.13 kcal in adolescents, it was greater when increasing weight status and low PAL. These results have been reported in other studies [64] in which DEE was significantly greater in obese than in the non-obese subjects.

Results also indicate that the energy balance is of the order of 631.31 kcal/day, this positive rate of stored energy shows that the TEI exceeds the DEE causing obesity [64]. Several previous studies showed that associations between snack food consumption, fast foods and overweight are reducing the diet energy density [65–67].

Here we determined the physical activity role in adolescent's obesity development. Energy expenditure is related to the PAL, so it is the main factor in determining energy expenditure. Epidemiological studies have shown the importance of activity in preventing weight gain [68]. Levine's team at the Mayo Clinic in the United States has just demonstrated a very significant relationship between spontaneous physical activity and adiposity in slim and obese subjects [69].

4.4. Total energy intake (TEI)

Our results indicate that the daily diet provides a sufficiently high amount of energy; we found that fat absorption often exceeded recommendations, so the nutrition of most adolescents is not balanced. TEI is of the order of 3775.44 kcal divided into food groups. We noticed a very high consumption of the different sweet food groups that are distributed over the different daily intakes, in breakfast, adolescents consumed 129.55 g of carbohydrates, 51.3 g as a snack, 170.7 g for lunch, 68.5 g as a snack, 136.5 g for dinner, and snacked between meals 58 g of carbohydrates.

More boys (66.2%) report snacking between main meals by eating a large amount of different sweeter food groups (chocolate,

Table 4
Food groups that should be consumed at each meal.

Gender	Meals	Food	Energy (kcal)	Proteins (g)	Lipids (g)	Carbohydrates (g)
Boys	Breakfast	Cakes; biscuit; chocolate; bread; croissant; rusks; cheese; yoghurt; jam; honey; milk only; coffee with milk; chocolate milk; fruit juice; orange juice; chocolate drink (Candy choco)	743,4	8	8,2	159,4
	Snack	Bread; pizza; cakes; biscuit; chocolate; cheese; yoghurt; conferring; honey; deli meats; sweets; fruit juice; orange juice; chocolate drink (Candy choco); apple; banana; pear; date; orange; rusks	420,61	2,4	6,29	88,6
	Lunch	Bread; fish; chicken; eggs; lentil; dry bean; chickpea; dry pea; potato; carrot; courgette; pepper; tomato; green bean; green pea; spinach; salad; apple; banana; pear; orange; yoghurt; cheese; pasta; rice; semolina as an Algerian traditional meal; couscous; fruit juice; lemonade; coca; orange juice	1215	48,2	29,4	189,4
	Taste (lightmeal)	Cakes; biscuit; chocolate; pizza; bread; croissant; rusks; cheese; yogurt; jam; honey; milk only; coffee with milk; chocolate milk; fruit juice; orange juice; chocolate drink (Candy choco)	530,3	6,4	34,3	49
	Dinner party	Bread; meat; fish; chicken; eggs; potato; carrot; courgette; pepper; tomato; cauliflower; green bean; peas; spinach; salad; apple; banana; pear; date; orange; strawberry; pasta; rice; semolina as an Algerian traditional meal; couscous; fruit juice; lemonade; coca	1070,2	35,2	28,6	168
	Snacking	Cakes; biscuit; chocolate; pizza; bread; croissant; rusks; cheese; yoghurt; jam; honey; milk only; coffee with milk; chocolate milk; fruit juice; orange juice; chocolate drink (Candy choco)	407,1	17,4	1,5	81
	Breakfast	Cakes; biscuit; chocolate; bread; croissant; rusks; cheese; yoghurt; jam; honey; butter; milk only; coffee with milk; chocolate milk; fruit juice; orange juice; chocolate drink (Candy choco)	566,2	9	14,6	99,7
	Snack	Bread; pizza; cakes; biscuit; chocolate; cheese; yogurt; yoghurt; conference; margarine; honey; deli meats; sweets; fruit juice; orange juice; chocolate drink (Candy choco); apple; banana; pear; date; orange; rusks	296,6	17,4	19	14
	Lunch	Bread; meat; fish; chicken; eggs; lentil; dry bean; chickpea; dry bean; small dry pea; potato; carrot; courgette; pepper; tomato; cauliflower; green bean; peas; spinach; salad; apple; banana; pear; date; orange; cheese; yoghurt; paste; rice; semolina as an Algerian traditional meal; couscous; fruit juice; lemonade; coca; orange juice	936,4	47	15,6	152
	Taste (lightmeal)	Cakes; biscuit; chocolate; pizza; bread; croissant; rusks; cheese; yoghurt; jam; honey; milk only; coffee with milk; chocolate milk; fruit juice; orange juice; chocolate drink (Candy choco)	380,2	3	1,8	88
Girls	Dinner party	Bread; meat; fish; chicken; eggs; potato; carrot; courgette; pepper; tomato; cauliflower; green bean; peas; spinach; salad; apple; banana; pear; date; orange; strawberry; rice; semolina as an Algerian traditional meal; couscous; fruit juice; lemonade; coca; orange juice	809,4	33	28,6	105
	Snacking	Cakes; biscuit; pizza; bread; rusks; croissant; cheese; yoghurt; jam; honey; milk only; coffee with milk; chocolate milk; fruit juice; orange juice; chocolate drink (Candy choco)	266,8	9,2	10	35

Table 5
Preference classification by percentages of food groups for consumed meals.

Most consumed foods at breakfast	Most consumed foods as a snack (at 10 am)	Most consumed foods at Lunch	Most consumed foods at snack time (at 4:00 pm)	Most consumed foods at dinner	Most popular snack foods (in the evening)
Cakes (6.5%), biscuits (26.5%), chocolate (24.7%), croissants (23.7%), rusks (22.1%), jam (30.8%), honey (46.8%), coffee with milk (55.1%), and chocolate milk (24.7%).	Pizza (14.8%), yoghurt (15.8%), jam (32.2%), sweets (45.3%), cold cuts (18.5%), chocolate drink (Candy choco) (42.7%), fruit juice (19.5%).	Bread (98.6%), chicken (91.9%), meat (5.5%), fish (2.1%), eggs (32.2%), dried vegetables (lentils (46%), dried beans (15%), chickpeas (20.9%), peas (21.1%), vegetables (potatoes (48.8%), carrots (60.5%)), fruit (apples (37.3%), pears (22.5%), oranges (41.7%), dates (49.6%)), sweet drinks (lemonade (56.5%), coca cola (36.4%)).	Cakes (16.4%), biscuits (26.8%), chocolate (47.8%), rusks (26.8%), pizza (5.1%), croissants (10%), yoghurt (6.3%), jam (11.3%), dairy coffee (38.6%), and chocolate milk (20.9%).	Foods that make up dinner are the same as those for lunch except that dried vegetables are replaced by cereal products: Pasta (33.5%), rice (47%), and semolina as the Algerian traditional meal; couscous (13.6%).	Biscuit (23.7%), pizza (30.6%), cheese (14.4%), rusk (21.3%), yoghurt (14.8%), jam (32.7%), coffee with milk (218.4%), chocolate milk (15.2%), fruit juice (11.6%), chocolate drink (Candy choco) (18.86%).

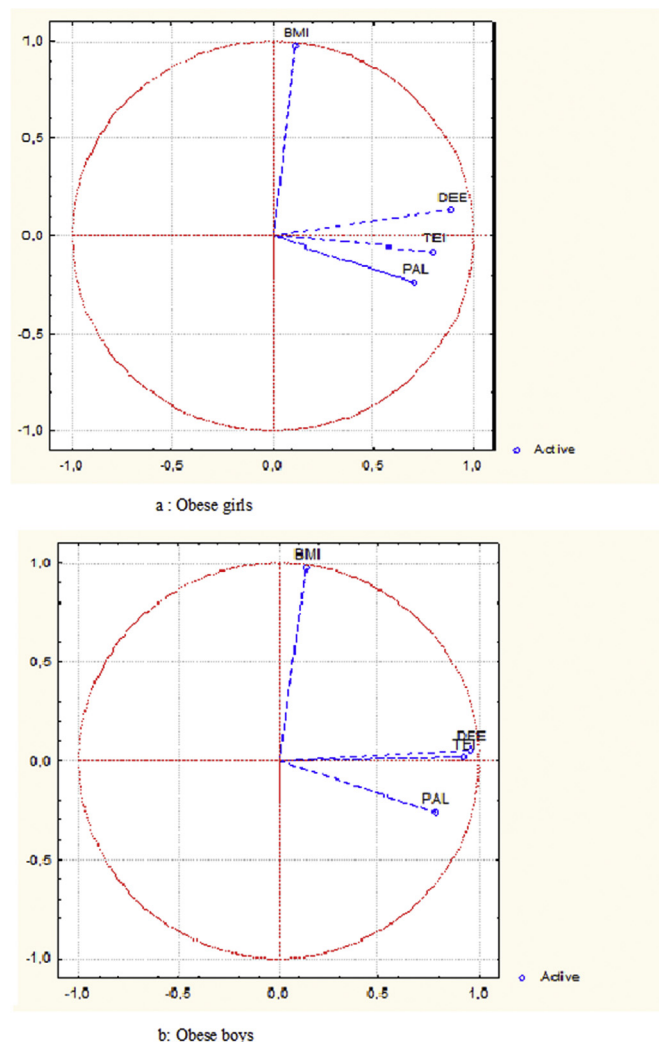


Fig. 1. Principal component analysis (PCA) of body mass index (BMI), physical activity level (PAL), daily energy expenditure (DEE) and total energy intake (TEI) among obese girls and boys.

jam, honey, sweetened drinks). The consumption of fast food shows adverse effects on the quality of care that may increase the risk of obesity in children and adolescents [70].

We found that TEI provides a high amount of energy, and we noted bad dietary habits. These behaviors were caused by high energy density foods rich in carbohydrates and fats. According to Nielsen [71] adolescents obtain an exposed increase in their TEI away from home, usually in fast-food restaurants.

4.5. Principal component analysis (PCA)

We mainly conclude that BMI correlated positively with TEI ($r = 0.31$) and negatively with DEE and PAL ($r = -0.06$). These results show that high BMI and fat mass stored in adipose tissue are caused by poor nutrition and excessive consumption of foods rich in carbohydrates and fat, and are related to insufficient PAL and sedentary life.

The ratio of high BMI and low PAL are the main cause of obesity because energy requirement appears to be a direct function of high BMI. These changes in energy expenditure and intake were evident during periods of stable body weight change and tended to be in a direction tending to return subject to one's initial weight.

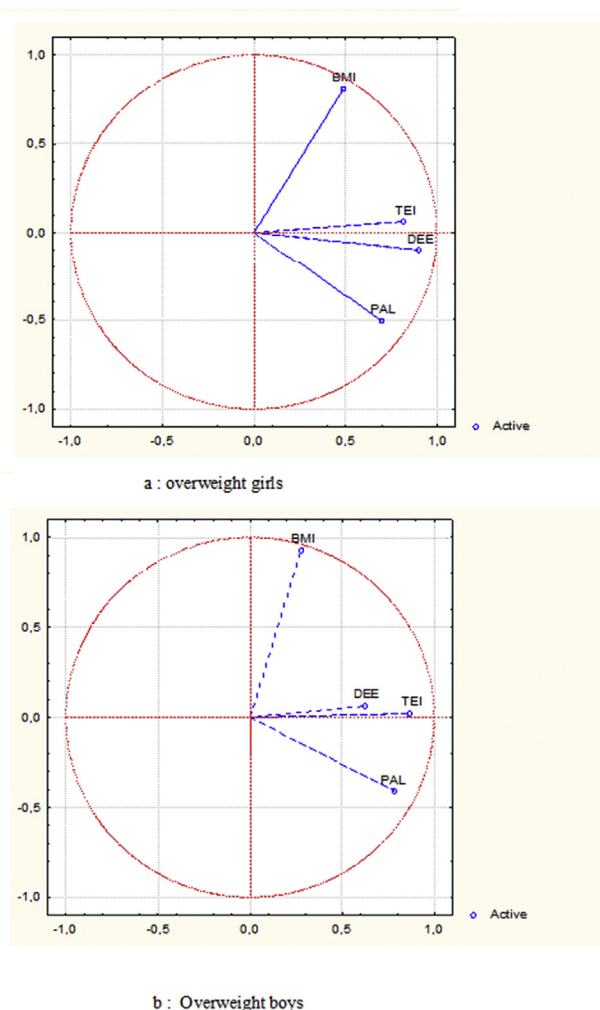


Fig. 2. Principal components analysis (PCA) of body mass index (BMI), physical activity level (PAL), daily energy expenditure (DEE) and total energy intake (TEI) among overweight girls and boys.

Physical activity has a significant impact on energy expenditure and the total 24-h energy balance. Adolescents often spend most of their time sleeping and napping, resting for a longer period (11 h) over the 24 h. This results in physical inactivity and sedentary living ($r = -0.06$). In addition, the basal metabolic rate of sedentary adolescents is mainly attributed to changes in body composition by increasing weight status; these changes appear to be the main factors increasing energy expenditure ($r = 0.29$) and energy intake ($r = 0.31$) rich in carbohydrates and fats. Body weight gain can therefore be seen as an adaptive change to over-feeding [72].

The energy balance gives a full and rich amount of micro-nutrients because of eating habits with high consumption of sweet products, this explains a less balanced diet during the period of adolescents compared to adults, where protein and carbohydrate reserves are very little, while the mass of adipose tissue can change markedly [73,74].

4.6. Bejaia mapping

Figs. 3 and 4 show that there is a disparity in territory that can be found from one zone to another, but this disparity in anthropometric parameters (BMI, PAL, DEE, TEI) means that there is an

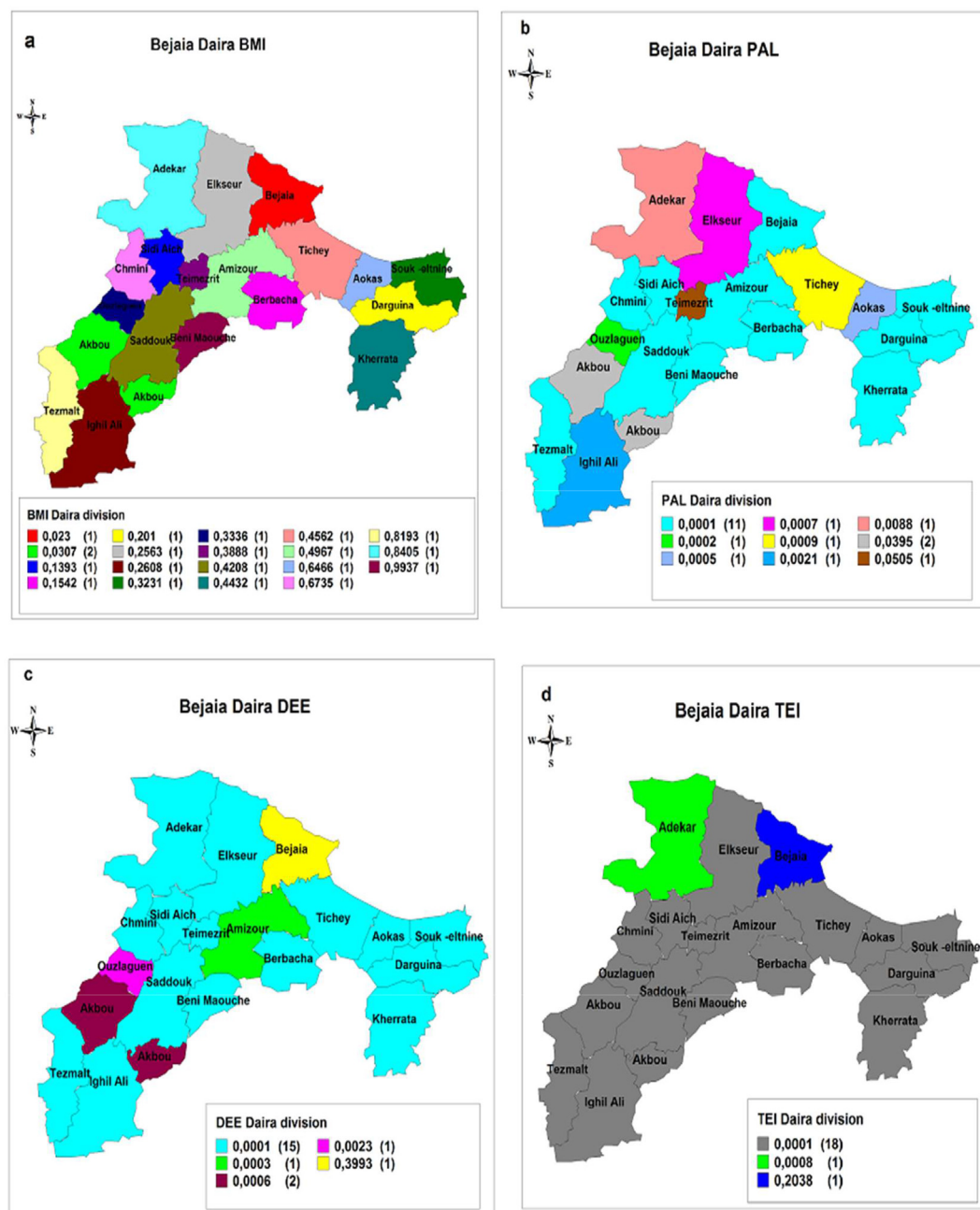


Fig. 3. Student's test ($p < 0.05$) to compare the averages of body mass index (BMI), physical activity level (PAL), daily energy expenditure (DEE) and total energy intake (TEI) of obese girls with those of obese boys of all Bejaia Daira.

epidemic in all territories with a degree of significance between each zone corresponding to the cited territory. These data show the extent to which overweight and obesity status has been established.

Regarding the PAL (Figs. 3b and 4b), we saw that there is a territorial disparity regarding the sports practice of our adolescents that drops significantly. Both parameters provide information on the emergence of other parameters justifying the status and level of physical activity and one influences the other; but the BMI index and PAL are not the only factors that generate weight status, the eating behaviors represented by DEE (Figs. 3c and 4c)

and TEI (Figs. 3d and 4d) are imposed as parameters reinforcing the existence of the epidemic. The Mapping demonstrates that there is disparity regarding the studied parameters: high BMI, low PAL and unhealthy food consumption (DEE, TEI).

5. Conclusion

The results show that the high level of the body mass index (BMI) as well as the fat mass stored in the adipose tissues was caused by poor nutrition, and by an insufficient level of physical activity and sedentary life. For this, an adequate level of physical

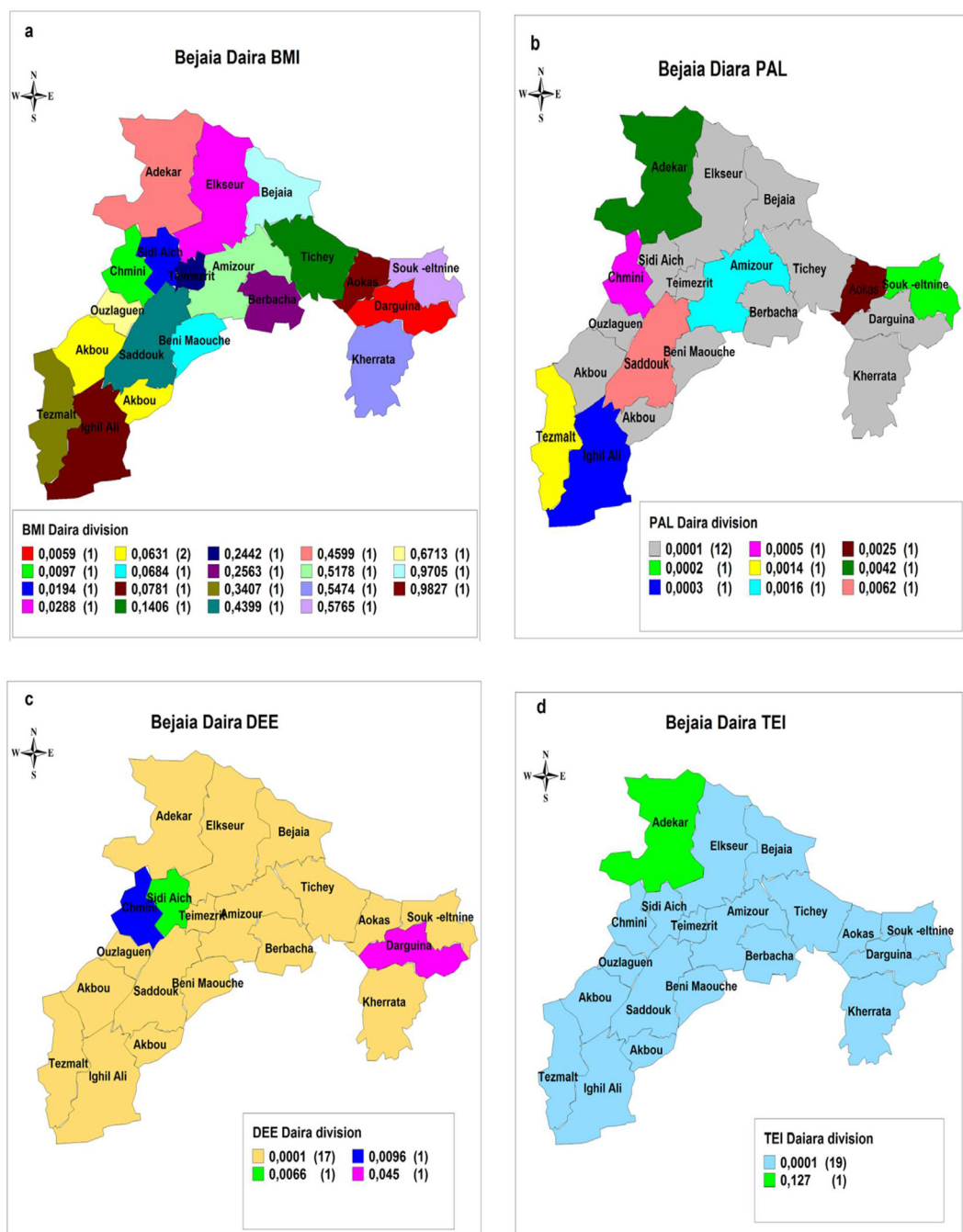


Fig. 4. Student's test ($p < 0.05$) to compare the averages of body mass index (BMI), physical activity level (PAL), daily energy expenditure (DEE) and total energy intake (TEI) of overweight girls with overweight boys of all Bejaia Daira.

activities, taking into account lifestyle and diet, are recommended to further improve adolescent's health. To this end the continuation of the reform at the level of educational establishments by increasing the hourly volume of sport and physical education is an important action that must be taken into consideration.

Research involving human participants

All authors certify that the study was performed in accordance with the ethical standards, and confirm that all participants were consent to be involved in this work as well as their corresponding visited schools.

Funding

None.

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgments

We wish to acknowledge the Ministry of Higher Education and Scientific Research of Algeria.

References

- [1] Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. *Jama* 2004;291:2847–50.
- [2] Maffei C, Castellani M. Physical activity: an effective way to control weight in children? *Nutr Metabol Cardiovasc Dis* 2007;17:394–408.
- [3] Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. *N Engl J Med* 1992;327:1350–5.
- [4] Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. *Prev Med* 1993;22:167–77.
- [5] Maffei C, Moghetti P, Grezzani A, Clementi M, Gaudino R, Tato L. Insulin resistance and the persistence of obesity from childhood into adulthood. *J Clin Endocrinol Metab* 2002;87:71–6.
- [6] Mahbuba S, Mohsin F, Rahat F, Nahar J, Begum T, Nahar N. Descriptive epidemiology of metabolic syndrome among obese adolescent population. *Diabetes & Metabolic Syndrome: Clin Res Rev* 2018;12:369–74.
- [7] Waxman A. WHO global strategy on diet, physical activity and health. *Food Nutr Bull* 2004;25:292–302.
- [8] Organization WH. The world health report 2003: shaping the future. World Health Organization; 2003.
- [9] Hakeem R. Socio-economic differences in height and body mass index of children and adults living in urban areas of Karachi, Pakistan. *Eur J Clin Nutr* 2001;55:400.
- [10] Maire B, Lioré S, Gartner A, Delpeuch F. Transition nutritionnelle et maladies chroniques non transmissibles liées à l'alimentation dans les pays en développement. *Cahiers d'études et de recherches francophones/Santé*. 2002;12:45–55.
- [11] Lopes VP, Malina RM, Gomez-Campos R, Cossio-Bolaños M, de Arruda M, Hobold E. Body mass index and physical fitness in Brazilian adolescents. *Jornal de pediatria* 2018.
- [12] Katzmarzyk PT, Srinivasan SR, Chen W, Malina RM, Bouchard C, Berenson GS. Body mass index, waist circumference, and clustering of cardiovascular disease risk factors in a biracial sample of children and adolescents. *Pediatrics* 2004;114:e198–205.
- [13] Han JC, Lawlor DA, Kimm SY. Childhood obesity. *Lancet* 2010;375:1737–48.
- [14] Harris R. Nutrition in the 21st century: what is going wrong. *Arch Dis Child* 2004;89:154.
- [15] Pande S, Ranjan R, Kratsyuk VA. Is Body Mass Index a potential biomarker for anemia in obese adolescents? *J Nut Intermediary Metabol* 2019;15:1–2.
- [16] Pinhas-Hamiel O, Newfield R, Koren I, Agmon A, Lilos P, Phillip M. Greater prevalence of iron deficiency in overweight and obese children and adolescents. *Int J Obes* 2003;27:416.
- [17] Guo SS, Roche AF, Chumlea WC, Gardner JD, Siervogel RM. The predictive value of childhood body mass index values for overweight at age 35 y. *Am J Clin Nutr* 1994;59:810–9.
- [18] Himes JH, Dietz WH. Guidelines for overweight in adolescent preventive services: recommendations from an expert committee. *Am J Clin Nutr* 1994;59:307–16.
- [19] Kuczmarski RJ. CDC growth charts. United States; 2000.
- [20] Guo SS, Wu W, Chumlea WC, Roche AF. Predicting overweight and obesity in adulthood from body mass index values in childhood and adolescence. *Am J Clin Nutr* 2002;76:653–8.
- [21] Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999–2010. *Jama* 2012;307:483–90.
- [22] Al-Dalaeen A, Al-Domi H. Factors associated with obesity among school children in Amman, Jordan. *Malaysian J Nut* 2017;23.
- [23] Al-Domi HA, Faqih A, Jaradat Z, Anfal A-D, Jaradat S, Amarneh B. Physical activity, sedentary behaviors and dietary patterns as risk factors of obesity among Jordanian schoolchildren. *Diabetes & Metabolic Syndrome: Clin Res Rev* 2019;13:189–94.
- [24] Waleh MQ. Impacts of physical activity on the obese. *Prim Care Clin Off Pract* 2016;43:97–107.
- [25] Koplan JP, Liverman CT, Kraak VI. Preventing childhood obesity: health in the balance: executive summary. *J Am Diet Assoc* 2005;105:131–8.
- [26] Keim NL, Blanton CA, Kretsch MJ. America's obesity epidemic: measuring physical activity to promote an active lifestyle. *J Am Diet Assoc* 2004;104:1398–409.
- [27] Singh GK, Kogan MD, Siahpush M, Van Dyck PC. Independent and joint effects of socioeconomic, behavioral, and neighborhood characteristics on physical inactivity and activity levels among US children and adolescents. *J Commun Health* 2008;33:206–16.
- [28] Markwald RR, Melanson EL, Smith MR, Higgins J, Perreault L, Eckel RH, et al. Impact of insufficient sleep on total daily energy expenditure, food intake, and weight gain. *Proc Natl Acad Sci Unit States Am* 2013;110:5695–700.
- [29] Hills AP, Andersen LB, Byrne NM. Physical activity and obesity in children. *Br J Sports Med* 2011;45:866–70.
- [30] Lau XC, Chong KH, Poh BK, Ismail MN. Physical activity, fitness and the energy cost of activities: implications for obesity in children and adolescents in the tropics. In: *Advances in food and nutrition research*. Elsevier; 2013. p. 49–101.
- [31] Hill JO, Melanson EL. Overview of the determinants of overweight and obesity: current evidence and research issues. *Med Sci Sports Exerc* 1999;31: S515–21.
- [32] Mekhancha-Dahel C, Mekhancha D, Bahchachi N, Benatallah L, Nezzal L. Surpoids, obésité: signes de la transition nutritionnelle chez des enfants et des adolescents scolarisés au Khroub, Algérie. Elsevier Masson; 2005.
- [33] Descatha A, Geoffroy-Perez B, Leclerc A, Goldberg M. Enquêtes épidémiologiques en milieu de travail: quelques bases pour le médecin du travail. *Arch Maladies Prof Environnement* 2005;66:343–51.
- [34] Bousquet PJ, Bousquet J, Daurès JP, Demoly P. Les principales études épidémiologiques d'observation. *Rev Fr Allergol Immunol Clin* 2004;44: 509–15.
- [35] Garriguet D. Sous-déclaration de l'apport énergétique dans l'Enquête sur la santé dans les collectivités canadiennes. *Rapports sur la santé* 2008;19:1–10.
- [36] National Heart L, Institute B. National institute of diabetes and digestive and kidney diseases. In: *Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults the evidence report Bethesda*. National Institutes of Health; 1998. p. 1–228.
- [37] Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *Br Med J* 2000;320:1240.
- [38] Martinez-Millana A, Hulst JM, Boon M, Witters P, Fernandez-Llatas C, Asseiceira I, et al. Optimisation of children z-score calculation based on new statistical techniques. *PLoS One* 2018;13.
- [39] Bonnefoy M. Besoins énergétiques de la personne âgée. *Les cahiers de l'année gériatrique* 2013;5:303–7.
- [40] Tounian PL. 'obésité de l'enfant. John Libbey Eurotext; 2006.
- [41] Boisseau N. Nutrition et bioénergétique du sportif: bases fondamentales. Masson; 2005.
- [42] Belounis R. Le niveau d'Activité physique chez les Lycéens obèses. *Majallat 'Ulum wa-Taqniyat al-Nashāt al-Badani al-Riyaḍi* 2014;348:1–8.
- [43] Kleiber M. The fire of life. An introduction to animal energetics. The fire of life an introduction to animal energetics. 1961.
- [44] Bergouignan A, Blanc S. Énergétique de l'obésité. *J Soc Biol* 2006;200:29–35.
- [45] Ekelund U, Åman J, Yngve A, Renman C, Westerterp K, Sjöström M. Physical activity but not energy expenditure is reduced in obese adolescents: a case-control study. *Am J Clin Nutr* 2002;76:935–41.
- [46] Salbe AD, Fontvieille AM, Harper IT, Ravussin E. Low levels of physical activity in 5-year-old children. *J Pediatr* 1997;131:423–9.
- [47] Hunter GR, Kekes-Szabo T, Snyder SW, Nicholson C, Nyikos I, Berland L. Fat distribution, physical activity, and cardiovascular risk factors. *Med Sci Sports Exerc* 1997;29:362–9.
- [48] Castell GS, Serra-Majem L, Ribas-Barba L. What and how much do we eat? 24-hour dietary recall method. *Nutr Hosp* 2015;31:46–8.
- [49] Oulamara H, Allam O, Tebbani F, Agli A-N. Prevalence of overweight and underweight in schoolchildren in Constantine, Algeria: comparison of four reference cut-off points for body mass index. *East Mediterr Health J* 2020;26.
- [50] Addor Véronique, Wietlisbach V, Narring F, Michaud P-A. Cardiovascular risk factor profiles and their social gradient from adolescence to age 74 in a Swiss region. *Prev Med* 2003;36:217–28.
- [51] Regaieg S, Charfi N, Trabelsi L, Kamoun M, Feki H, Yaich S, et al. Prévalence et facteurs de risque du surpoids et de l'obésité dans une population d'enfants scolarisés en milieu urbain à Sfax, Tunisie. *Pan Afr Med J* 2014;17.
- [52] El Kabbaoi M, Chda A, Bousfiha A, Aarab L, Bencheikh R, Tazi A. Prevalence of and risk factors for overweight and obesity among adolescents in Morocco. *East Mediterr Health J* 2018;24:512–21.
- [53] Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014;384:766–81.
- [54] Cole TJ, Faith MS, Pietrobelli A, Heo M. What is the best measure of adiposity change in growing children: BMI, BMI%, BMI z-score or BMI centile? *Eur J Clin Nutr* 2005;59:419–25.
- [55] Martinez-Gomez D, Ruiz JR, Ortega FB, Veiga OL, Moliner-Urdiales D, Mauro B, et al. Recommended levels of physical activity to avoid an excess of body fat in European adolescents: the HELENA Study. *Am J Prev Med* 2010;39:203–11.
- [56] Sato M, Ishii K, Shibata A, Oka K. Promotion of school recess physical activity among elementary school children: a literature review. *Jpn J Phys Fit Sports Med* 2012;61:157–67.
- [57] Cureau FV, da Silva TLN, Bloch KV, Fujimori E, Belfort DR, de Carvalho KMB, et al. ERICA: inatividade física no lazer em adolescentes brasileiros. *Rev Saude Publica* 2016;50:4s [s].
- [58] de Lima TR, Silva DAS. Prevalence of physical activity among adolescents in southern Brazil. *J Bodyw Mov Ther* 2018;22:57–63.
- [59] Health USDo. Healthy people 2010: understanding and improving health. Government Printing Office; 2000.
- [60] Gordon-Larsen P, McMurray RG, Popkin BM. Determinants of adolescent physical activity and inactivity patterns. *Pediatrics* 2000;105:E83.
- [61] Strauss RS, Rodzilsky D, Burack G, Colin M. Psychosocial correlates of physical activity in healthy children. *Arch Pediatr Adolesc Med* 2001;155:897–902.
- [62] Kimm SY, Glynn NW, Obarzanek E, Kriska AM, Daniels SR, Barton BA, et al. Relation between the changes in physical activity and body-mass index during adolescence: a multicentre longitudinal study. *Lancet* 2005;366: 301–7.

- [63] Meininger JC, Brosnan CA, Eissa MA, Nguyen TQ, Reyes LR, Upchurch SL, et al. Overweight and central adiposity in school-age children and links with hypertension. *J Pediatr Nurs* 2010;25:119–25.
- [64] Bandini LG, Schoeller DA, Dietz WH. Energy expenditure in obese and non-obese adolescents. *Pediatr Res* 1990;27:198.
- [65] Drewnowski A. Obesity and the food environment: dietary energy density and diet costs. *Am J Prev Med* 2004;27:154–62.
- [66] French SA, Harnack L, Jeffery RW. Fast food restaurant use among women in the Pound of Prevention study: dietary, behavioral and demographic correlates. *Int J Obes* 2000;24:1353.
- [67] French S, Jeffery R, Forster J, McGovern P, Kelder S, Baxter J. Predictors of weight change over two years among a population of working adults: the Healthy Worker Project. *Int J Obes Relat Metab Disord* 1994;18:145–54. *Journal of the International Association for the Study of Obesity*.
- [68] Schmitz K, Jacobs Jr D, Leon A, Schreiner P, Sternfeld B. Physical activity and body weight: associations over ten years in the CARDIA study. *Int J Obes* 2000;24:1475.
- [69] Levine JA, Kotz C. NEAT—non-exercise activity thermogenesis—egocentric & geocentric environmental factors vs. biological regulation. *Acta Physiol Scand* 2005;184:309–18.
- [70] Bowman SA, Gortmaker SL, Ebbeling CB, Pereira MA, Ludwig DS. Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. *Peds* 2004;113.
- [71] Nielsen SJ, Siega-Riz AM, Popkin BM. Trends in food locations and sources among adolescents and young adults. *Prev Med* 2002;35:107–13.
- [72] Tappy L, Binnert C, Schneiter P. Energy expenditure, physical activity and body-weight control. *Proc Nutr Soc* 2003;62:663–6.
- [73] Jéquier E, Tappy L. Regulation of body weight in humans. *Physiol Rev* 1999;79:451–80.
- [74] Fonseca DC, Sala P, Ferreira BdAM, Reis J, Torrinhas RS, Bendavid I, et al. Body weight control and energy expenditure. *Clin Nutr Exp* 2018;20:55–9.