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Nutritional Status, Oxidant/Antioxidant and Inflammatory Markers in Scholar Athletes Adolescents

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Abstract In the last two or three decades, physical activity (PA) has gained increasing recognition as being essential for maintaining good health and improving quality of life for all ages. To evaluate the nutritional status, oxidant/antioxidant, and inflammatory markers, in sports adolescents, a cross sectional study has done in west Algeria. A total of 110 athletes adolescents from special sport classes, aged 11-17 years, were compared to a non athletes group (n=60). Blood pressure, anthropometric and serum parameters were measured. Daily energy intake (DEI) was estimated using 24 hours recall, followed by a 3-days record. Energy expenditure (EE) was evaluated by the International Physical Activity Questionnaire-short form (IPAQ-S). Oxidant/antioxidant and inflammatory markers were determined. An increase in body weight and height (p<0.001) was noted in athletes compared to non athletes. DEI was similar in both groups, whereas EE was higher in athletes than non athletes (p<0.001). Serum triacylglycerol (TG) values were lower in athletes group than in non athletes (p<0.05). Enhanced values were observed in glutathione peroxidase (GPx) (p<0.001), and superoxide dismutase (SOD) (p<0.05) activity, and tumor necrosis factor-α (TNF-α) (p<0.01) in athletes compared to non athletes. Significant relationships were found between height, weight, albumin, GPx, TNF-α, IL-1, and EE. Significant associations were noted between GPx (OR=0.14; 95% CI 0.03, 1.05), inflammatory markers TNF-α (OR=0.47; 95% CI 0.28, 0.80), IL-1 (OR=1.17; 95% CI 0.28, 0.80) and physical activity. Significant relationships were found between weight (P < 0.001), height (P < 0.01), albumin, GPx, IL-1, TNFα (P < 0.05) and EE. In spite of inadequate DEI in athletes adolescents, beneficial effect of sport is observed by lowering serum TG concentrations. However, more research in this area is warranted to clarify sport nutrition needs to provide better and healthy nutritional guidance to young athletes.

Keywords: *athlete adolescent, energy expenditure, daily energy intake, oxidant/antioxidant status, inflammatory markers*

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1. Introduction

In order to improve health, World Health Organization recommends that adolescents should accumulate, at least, 60 minutes of daily physical activity (PA), that is of moderate - to vigorous – intensity [1]. This includes activities such as brisk walking, bicycling, and soccer [2]. Childhood and adolescence represent a period of rapid growth and development. Both are influenced by nutrition and PA, which therefore play a particularly important role during this phase of life [3]. Appropriate nutrition during this period is a basic requirement to express genetic potential that, together with PA, will influence later adult and elderly health outcomes [4]. The protective role of PA on cardiometabolic risk, in children and adolescents, has been described in the literature. Indeed, studies have demonstrated that vigorous PA ameliorates levels of total cholesterol (TC), triglycerides (TG), and blood pressure (BP), and decreases waist circumference (WC) in this population [5]. Nutrition is an important part of sport performance for young athletes, in addition to allowing for optimal growth and development, macronutrients, micronutrients and fluids, in the proper amounts, are essential to provide energy for growth and activity [6].

Furthermore, good nutritional practices are important for exercise performance, and health during all ages. Athletes, and especially growing children, engaged in heavy training, have higher energy and nutrient requirements, compared to their non-active counterparts. Most of the sports nutrition recommendations given to athletic children and adolescents are based on adult findings due to the deficiency in age specific information in young athletes [7]. During sports training, athletes are continuously exposed to various kind of stress [8]. However, it has been reported that acute aerobic exercise induces oxidative stress (OS), whereas regular aerobic exercise decreases oxidant markers, and increases anti-oxidant enzyme activities [9].

PA and fitness may be important protective factors for low-grade inflammation [10]. Therefore, evidence is scarce and results are mixed regarding the association of PA and fitness with inflammation in adolescents. In

addition, previous studies on inflammation in this age group had some critical methodological limitations [11].

Therefore, the objective of this study was to evaluate the nutritional status, oxidant/antioxidant, and inflammatory markers, in athletes compared to non athletes adolescents.

2. Methods

2.1. Study Design

A cross sectional study was done on adolescents, aged 11–17 years, recruited between March 2011 and May 2012, in Oran city (West Algeria) college, from 1st to 4th secondary classes. An athlete group was composed of 110 adolescents (sex ratio G/B= 28/82), from special sport classes, practicing in average 7 hours of sport per week in school (60% handball and 40% athletic sport), and 50% of them practiced between 2 and 9h/week of sport after school (football, swimming, judo, kick-boxing, athletic sport, tennis). This group was compared to non athletes which were composed of 60 students (sex ratio G/B= 27/33), practicing 2 hours of sport per week in school. All adolescents were healthy, using no medications or supplements, and were no-smokers.

The characteristics of the adolescents are shown in Table 1.

Table 1. Characteristics and family SES of adolescents

	Athletes (n=110)	Non athletes (n=60)
Gender (Girls/Boys)	28/82	27/33
Age (years)	13±2	13±1
Weight (kg)	46.36±12.79***	40.74±10.79
Height (m)	1.56±0.12***	1.50±0.08
BMI (kg/m^2)	18.63±3.18	17.85±3.17
Pubertal status I/II/III/IV/V (%)	2/18/41/31/8	3/21/38/28/10
Family SES (%)		
Low	14.41	12.72
Intermediate	69.36	74.54
High	16.21	12.72
Waist circumference (cm)	75.47±11.89	76.65±8.07
Systolic BP (mmHg)	105.0±8.1	110.5±10.5
Diastolic BP (mmHg)	55.0±5.1	58.0±6.1
Glucose (mmol/L)	5.00±0.85	5.16±0.92
Cholesterol (mmol/L)	4.03±0.86	4.05±0.70
Triacylglycerols (mmol/L)	1.12±0.27*	1.27±0.30
Urea (mmol/L)	4.86±0.99	4.70±1.01
Total proteins (mmol/L)	0.12±0.02	0.13±0.02
Hemoglobin (mmol/L)	0.39±0.07	0.36±0.08

Values are means ± SD, SES: socio-economic status; BP: blood pressure; Low SES: children of mothers with a low educational level; Intermediate SES: children of mothers with an intermediate educational level; High SES: children of mothers with a high educational level. Differences were determined by the Student 't' test. *p<0.05, **p<0.01 and ***p<0.001.

2.2. Ethic Statement

The Ethic approval was obtained from the Committee of the Thematic Agency on Health Sciences Research, after receiving the institutional approval from the both Directories of Health and Education. An informed written consent was obtained from the parents or tutors, and verbal consent was provided by each adolescent.

2.3. Anthropometric and Blood Pressure (BP) Measurements

Anthropometric parameters were measured at school by trained operators, using standard equipments. Waist circumference (WC) was measured to the nearest 0.1 cm in standing position at the midpoint between the lowest rib and the iliac crest and at the end of normal expiration, using a measuring tape. Body weight (BW) was measured to the nearest 0.1 kg using portable scale (Seca, Germany), with minimal clothing and no shoes. Height was measured to the nearest 0.1 cm using a height bar (2 meters, dismantling) without shoes. Body mass index (BMI) was calculated as weight in kilogram divided by the square of height in meter (kg/m^2).

BP was measured in a sitting position, after 10 min rest period. The averages of two systolic (SBP) and diastolic blood pressure (DBP) measures were recorded at 5 min intervals.

2.4. Socioeconomic Status (SES)

In the present study, we used maternal educational level as an indicator of SES, as it is one of the three commonest indicators of SES and has been found to be the strongest and most consistent SES indicator for predicting health-related behavior [12]. Maternal educational level was classified into three groups: 'low educational level' (primary school and lower secondary education); 'intermediate educational level' (intermediate vocational level, higher secondary school); 'high educational level' (higher vocational education and university). In the remainder of this article, we refer to these groups as 'low SES' (children of mothers with a low educational level), 'intermediate SES' (children of mothers with an intermediate educational level) and 'high SES' (children of mothers with a high educational level).

2.5. Energy Expenditure

The physical activity was measured using a French version of the International Physical Activity Questionnaire-short form (IPAQ-S) [13]. The IPAQ-S asks students to self-recall different types of activities (moderate, vigorous) they performed during the past 7 days. The students were provided with descriptions and examples of each activity types and were asked to record the number of days and the lasting time (in minutes) for each day of the types of activity they participated. Each day's moderate or vigorous PA time was added up. The total weekly MVPA time was calculated by the weekly sum of both moderate and vigorous PA time. The reliability and validity of IPAQ-S across 12 countries have been established before [13].

The physical activity questionnaire collects complete information on frequency, duration and intensity of light-moderate- and vigorous-intensity physical activities during a typical week and includes domains such as transport, household, fitness and sports activities.

Moderate-intensity activities were assigned MET (metabolic equivalent of task) values based on the compendium of physical activities [14], and the compendium of physical activities for youth [2].

Moderate-intensity recreational sports were assigned an average MET value equivalent to 4 MET. Slow walking, normal-pace walking and brisk walking were assigned MET values of 2·8, 3·5 and 4·5 MET, respectively, based on modified MET values from the compendium for youth [2]. Vigorous-intensity physical activity and sports included jogging, running, bicycling, self defense, athletic sport, basket ball, handball and singles tennis. Such sports were assigned an average value of 8 MET.

2.6. Daily Energy Intake

Food consumption was estimated using 24 hours recall, followed by a 3-days record. Adolescents were interviewed by trained interviewers, using an adapted and structured questionnaire. Each subject was asked to recall everything they had eaten or drunk during the 24 hours preceding the interview. The day was chronologically organized into breakfast, collation, lunch, snack, and dinner. The meals were structured by entry, principal dish accompaniments, bread, and drinks. The interview was organized with specific questions about ingredients, and methods of preparation. Serving sizes were estimated by the use of food portion model handbook. The 3-days record was completed by the adolescents. The quantitative assessment of nutrient foods (daily energy intake (DEI), proteins, fats, carbohydrates, vitamins and minerals) was achieved by GENI software [15].

2.7. Blood Sampling

Blood samples were collected after 12 hours fasting from antecubital venipuncture, between 8:00 and 9:00 am. Serum was collected by low speed centrifugation at 3000 × *g* at 4°C, for 15 min. The samples were separated in aliquots and frozen immediately at -75°C until determination could be performed.

2.8. Assays

Glucose, uric acid, urea, TC and albumin were measured by enzymatic colorimetric methods (kits Spinreact, Spain). Triacylglycerols, hemoglobin, and total proteins were determined by enzymatic colorimetric methods (kits Chronolab, Spain).

Serum lipid peroxidation was estimated by measuring thiobarbituric acid reactive substances (TBARS) according to the method of [16]. The colored complex formed between malondialdehyde (MDA) and thiobarbituric acid (TBA) had maximum absorbance at 532 nm. Superoxide dismutase (SOD) activity was measured by nicotinamide adenine dinucleotide (NADH) oxydation procedure (Fluka/Sigma-Aldrich, Buchs, Switzeland). Briefly, the method uses xanthine and xanthine oxydase to generate superoxide radicals, which react with 2-(4-iodophenyl)-3-(4-netrophenyl)-5-phenyltetrazoluim chloride to form a formazan dye. The SOD activity was measured by the inhibition degree of the reaction at 440nm. Glutathione peroxidase (GPx), and glutathione reductase (GRed) activities were determined by using assay kits (Sigma, Missouri, USA). GPx activity was measured indirectly through a couple with glutathione reductase. Oxidized glutathione produced upon reduction of an organic hydroperoxide by GPx was recycled to its reduced state by GSH-Red and nicotinamide adenine dinucleotide phosphate (NADPH). The oxidation of NADPH to oxidized forms (NADP+) was accompanied by a decrease in absorbance at 340nm. One unit of enzyme was defined as 1µmol of NADPH oxidized/mg protein/min. GRed activity was determined by either the decrease in absorbance caused by the oxidation of NADPH at 340 nm.

TNF-α, and interleukin-1 (IL-1) were assayed in duplicate samples by commercial enzyme-linked immunosorbent assay kits (ELISA) (Cayman Chemical's ACE™ EIA kit, USA) with a range of 0-250 pg/ml. The lower limit of detection was 3.9 pg/ml for TNF-α and IL-1. C-reactive protein (CRP) value was measured in duplicate samples with an immunometric assay kit (ELISA) (Cayman Chemical's ACE™ EIA kit, USA) with a range of 0-3000 pg/mL and with a limit of detection of approximately 50pg/mL.

2.9. Statistical Analysis

Statistical analysis of the data was performed using IBM SPSS statistics version 20. Values were expressed as means ± SD and percentages. The Shapiro-Wilk test was used to verify whether variable distribution was normal. The Student *t*-test was used to compare different variables in athletes group with those of non athletes. Correlations between energy expenditure and different variables were calculated using Pearson's coefficient. The Odds Ratio (OR) was estimated for each factor separately to evaluate its influence on PA. A *p*-value = 0.05 was considered statistically significant with the confidence interval (CI) 95%. OR was estimated using logistic regression analysis.

3. Results

3.1. Anthropometric and Metabolic Characteristics

There was no significant difference according to age and gender, between athletes and non athletes groups. However, body weight was 1.13-fold higher in athletes group (46.36±12.79 kg), than in non athletes (40.74±10.79 kg) ($p < 0.01$). Height was 1.05-fold higher in athletes (1.56±0.12 m) than in non athletes (1.50±0.08 m) ($p < 0.001$). Nevertheless, there was no significant difference in BMI, and WC *between* the both groups. SBP and DBP values were similar in all adolescents. Moreover, serum concentrations of glucose, TC, urea, total proteins, and hemoglobin were similar in both groups, excepted serum TG values which were lower in athletes group (1.12±0.27mmol/L) than in non athletes group (1.27±0.30 mmol/L) ($p < 0.05$) (Table 1).

3.2. Socioeconomic Status

Analysis of family socioeconomic status according to maternal educational level, showed that low SES was noted in 14% and 12% of athletes and non athletes groups, respectively. Intermediate SES was observed in 69% and 74% of athletes and non athletes adolescents, respectively, and high SES in 16% and 12% of athletes and non athletes groups (Table 1).

3.3. Lifestyle of Adolescents

The adolescent lifestyle (Table 2) showed that 28% of athletes, and 52% of non athletes groups spent ≥2h/day watching television. The sleep duration was similar in the both groups. The time of sport in school was 2.82-fold higher in athletes than in non athletes adolescents. The daily breakfast consumption was noted in 74% and 71% of athletes and non athletes groups, respectively. The sugary drinks intake was 12% high in non athletes adolescents, compared to athletes group. Moreover, 46% of athletes consumed fast-foods compared to 74% of non athletes adolescents. Nibbling was noted in 41% and 33% of athletes and non athletes groups, respectively.

Table 2. Daily Food Intake (DEI), Energy Expenditure (EE) and life style of athletes compared to non athletes

	Athletes n=110		Non athletes n=60	
Daily energy intake (MJ/d)	8.46±1.99		8.47±1.88	
Proteins (%, g/d)	16	80±18***	14	69±15
Animal Proteins (%, g/d)	52	41±14***	45	30±13
Vegetable Proteins (%, g/d)	48	25±8	55	27±7
Total lipids (%, g/d)	27	61±20*	29	66±21
SFAs (%, g/d)	37	21±8	30	20±7
MUFAs (%, g/d)	32	19±7	28	18±7
PUFAs (%, g/d)	10	6±3***	15	10±6
Cholesterol (mg/d)	265±108		262±123	
Carbohydrates (%, g/d)	57	287±69	57	286±73
Complex carbohydrates (%, g/d)	68	193±46	65	184±41
Simple carbohydrates (%, g/d)	32	97±37	35	99±34
Fiber (g/d)	19±6		21±5	
Bread, Cereals, rice, Pasta, Starchy (g/d)	388±173		377±91	
Vegetables, Fruits (g/d)	147±103		123±77	
Milk &Dairy (g/d)	292±135		253±99	
Meat, fish, eggs (g/d)	223±86**		156±80	
Butter, cream, oils, margarine, oleaginous (g/d)	7±6*		13±11	
Sugars and sugary products (g/d)	239±145		275±99	
Breakfast (%)				
Several times per week	19		13	
Every day	74		71	
Never	7		16	
Consumption of sugary drinks (%)	52		40	
Consumption of fast food (%)	46*		74	
Nibbling (%)	41		33	
Watching Television ≥2h/ day (%)	28*		52	
Total sleep time (h/d)	9.26±0.99		9.38±0.81	
Time school sport/wk (h)	5.32±2.80***		1.88±0.46	
Time sport outside school /wk (h)	4.26±2.16		0	
Energy expenditure (MET-min/week)				
Total physical activity (min-max)	5235-14320***		3860-7285	
Moderate physical activity (min-max)	1000-4150**		1200-4300	
Vigorous physical activity (min-max)	600-9720***		0	

Values are means ± SD, SFAs: Saturated fatty acids; MUFAs: Monounsaturated fatty acids; PUFAs: polyunsaturated fatty acids, MET: metabolic equivalent of task. Differences were determined by Student't' test, *p<0.05; **p<0.01; ***p<0.001.

3.4. Daily Energy Intake and Energy Expenditure

The DEI of the adolescents, presented in Table 2, showed no significant difference in the both athletes and non athletes groups, and the values were respectively, 8.46±1.99 and 8.47±1.88 MJ/day. Qualitatively, total protein intake, and animal proteins were elevated in athletes compared to non athletes (80±18 and 41±14 g/day *vs* 69±15 and 30±13 g/day) ($p < 0.001$).

Carbohydrates consumption was similar in both groups, whereas, lower intake was noted in total lipids ($p < 0.05$), and in polyunsaturated fatty acids ($p < 0.001$), in athletes compared to non athletes group. Moreover, there was no significant difference in cholesterol, and fibers feeding between both groups. More consumption of meat/fish/eggs ($p < 0.01$), and less feeding butter, cream, oils, margarine, and oleaginous were observed in athletes adolescents compared to non athletes group.

Physical activity patterns and intensity differed between the both groups. As anticipated, athletes adolescents were more active than non athletes across a typical week and engaged in more vigorous-intensity physical activity than non athletes adolescents, who spent more time in moderate intensity physical activity.

3.5. Oxidative Stress and Inflammatory Markers

Lipid peroxidation, determined by TBARS concentrations, was similar in both athletes and non athletes groups (Table 3). Moreover, there was no significant difference in GRed, albumin and uric acid, whereas, in athletes adolescents, GPx and SOD activities were 1.32-fold and 1.09-fold higher than in non athletes group.

The inflammatory biomarkers (Table 3) showed that TNF-α value was 1.20-fold higher in athletes than non athletes adolescents (p<0.01). Nevertheless, CRP and IL-1 concentrations were similar between the both groups.

Table 3. Redox and inflammatory status of athletes adolescents compared to non athletes

	Athletes (n=110)	Non athletes (n=60)
TBARS (nmol/L)	7.08±0.95	6.93±0.85
GPx (U/g Hb)	2.18±0.73***	1.65±0.38
GRed (U/g Hb)	5.20±1.80	5.70±1.80
SOD (U/g Hb)	8.99±1.43*	8.21±0.89
Albumin (mmol/L)	0.67±0.13	0.65±0.96
Uric acid (µmol/L)	0.18±0.56	0.17±0.63
CRP (ng/mL)	0.30±0.05	0.32±0.08
TNF-α (pg/mL)	4.36±0.92**	3.61±0.92
IL1 (pg/mL)	13.85±3.54	13.87±3.22

Values are means ± SD. TBARS: Thiobarbituric acid reactive substances; GPx: Glutathion peroxidase; GRed: Glutathion reductase; SOD: Superoxide dismutase; CRP: C-reactive protein; TNFα: Tumor necrosis factor α; IL-1: Interleukin 1. Differences were determined by Student't' test, *p<0.05; **p<0.01; ***p<0.001.

Table 4. Correlations between variables and energy expenditure

Variables	*R*	*P*
Height	0.280	<0.001
Weight	0.219	<0.01
BMI	0.177	0.068
Waist circumference	0.054	NS
Glucose	0.298	NS
Cholesterol	0.096	NS
Triacylglycerols	0.035	NS
Urea	- 0.101	NS
Uric acid	0.325	NS
Total proteins	0.069	NS
Hemoglobin	0.007	NS
DEI	0.229	NS
Proteins	-0.171	NS
Animal proteins	0.163	NS
Vegetable Proteins	0.169	NS
Lipids	0.213	NS
Carbohydrates	0.132	NS
Simple carbohydrates	0.114	NS
Complex carbohydrates	0.157	NS
TBARS	-0.024	NS
Albumin	0.459	<0.05
GPx	0.411	<0.05
GRed	0.223	NS
SOD	-0.263	NS
IL-1	0.381	<0.05
CRP	0.065	NS
TNF-α	0.436	<0.05

BMI: body mass index, DEI: daily energy intake, TBARS: Thiobarbituric acid reactive substances, GPx: Glutathion peroxidase; GRed: Glutathion reductase; SOD: Superoxide dismutase; CRP: C-reactive protein; TNFα: Tumor necrosis factor α; IL-1: Interleukin 1. NS: not statically significant.

Table 5. Multiple logistic regression analysis: association between energy expenditure and variables

	OR	95% CI	*P*
Gender	0.37	0.13-1.05	0.062
Pubertal status	0.88	0.61-1.28	NS
Waist circumference	1.01	0.98-1.05	NS
BMI	1.05	0.95-1.15	NS
Glucose	1.37	0.78-2.38	NS
Total cholesterol	1.01	0.56-1.94	NS
Triacylglycerols	3.40	0.62-8.66	0.12
Urea	0.78	0.53-1.15	NS
Uric acid	1.00	0.99-1.00	NS
Hemoglobin	0.99	0.98-1.00	0.13
Total proteins	1.01	0.99-1.04	0.16
GPx	0.14	0.03-0.52	0.004
GRed	1.11	0.86-1.43	NS
Albumin	0.99	0.99-1.00	0.03
TBARS	1.06	0.76-1.47	NS
SOD	0.93	0.66-1.30	NS
TNFα	0.47	0.28-0.80	0.005
CRP	0.74	1.14-1.30	NS
IL-1	1.17	0.28-0.80	0.005

BMI: body mass index, GPx: Glutathion peroxidase, GRed: Glutathion reductase, TBARS: Thiobarbituric acid reactive substances, SOD: Superoxide dismutase, TNF-α-tumor necrosis α, CRP: C-reactive protein, IL-1: Interleukin. OR: odds ratio, CI: confidence interval, NS: not statistically significant.

3.6. Correlations and Associations between EE and Different Variables

Significant relationships were found between weight ($P < 0.001$), height ($P < 0.01$), Albumin, GPx, IL-1, TNFα ($P < 0.05$) and EE (Table 4). Multiple logistic regression analysis of EE (athletes and non athletes groups) and variables (sex, BMI, pubertal status, waist circumference, glucose, total cholesterol, TG, urea, uric acid, hemoglobin, total proteins, GPx, GRed, albumin, TBARS, SOD, TNFα, CRP, IL-1) is shown in Table 5.

4. Discussion

The aim of this study was to evaluate nutritional status, oxidant/antioxidant and inflammatory markers, in athletes adolescents compared to non athletes.

Anthropometric parameters showed that athletes group had high weight and height compared to non athletes, whereas, there was no significant difference in BMI and WC in the both groups. These results were not in accordance with those found in young male handball players [8], and those in athletic adolescents [17], for weight and height, but the same results were noted for BMI.

In the current study, PA levels had no effect on serum concentrations of glucose, TC, urea, total proteins, and hemoglobin. However, vigorous PA reduced significantly serum TG in adolescents. Indeed, aerobic exercise decreased TG level in 18 years and older men [18].

During adolescence, adequate energy was required to meet both growth and development needs of the individual, as well as, the substrate demands associated with general physical activity, training and competition [19].

The present study showed that in athletes group, DEI was less than recommended intake of 9 to 12 MJ/day [6]. These findings were also reported in female adolescents athletes, with low DEI compared to EE [20].

Otherwise, our athletes had a negative energy balance but their body weight was on average 6 kg heavier than that of non athletes, in spite of the same DEI but with a high proteins intake. Evidence points indicated that in a dietary energy restriction with a higher protein intake, in combination with a regular practice, resistance exercise can lead to gains in skeletal muscle mass [21].

The protein needs for the athletes are slightly higher than those for the general population [22]. In our study, total protein intake in athletes group was 1.64 g/kg/day. This intake was explained by the high frequency of animal protein rich foods, such as meat, fish and eggs. A typical intake of protein for most athletes should be 1.2–2.0 g/kg of body weight per day [23], which representing 10 to 30% of total energy intake for 4- to 18-years-old [24]. On the other hand, lipid intake in athletes adolescents (27%) was less than that of non athletes group (29%), and recommendations, knowing that adequate dietary fat is important to ensure an appropriate supply of fat soluble vitamins, and essential fatty acids, as well as, to provide adequate energy to support growth, and maturation of adolescent athlete [17]. Dietary surveys of adolescent athletes suggested that current dietary practices typically provide a fat intake of at least 30% of DEI [25,26].

In our study, athletes adolescents consumed 57% of carbohydrates (a mean of 6.23 g/kg/day). This proportion was lower than that recommended for athletes under growing process and daily practice, to maximize muscular glycogen storage, carbohydrates should comprise 45% to 65% of total energy intake for 4- to 18-year-olds [27], in average of 6 to 10g/kg/day [28]. So, Anderson et al [29] suggested that although professional Soccer players readily achieve current guidelines for daily protein and fat intake, carbohydrates intake on the day before and in recovery from match play was not in accordance with guidelines to promote muscle glycogen storage.

More than 70% of our adolescents consumed breakfast every day, and 30% occasionally, knowing that skipping breakfast has been associated with overweight [30].

Our results showed that non athletes group spent more time watching TV, than athletes group. A Brazilian study [31], in children and adolescents, reported that screen time was inversely related with PA. Similarly, Ferrari et al [32], found a higher prevalence of children meeting vigorous PA guidelines among children who watched ≤2h/day television. There was no significant difference in total sleep between the both athletes and non athletes groups, suggesting that sleep time was not affected by the sport duration, in school or outside. These results were similar to those observed by Ribeyre et al [17], in athletic adolescents.

The regular exercise training is associated with numerous physiological adaptations of the body. One of the objectives of our study was to evaluate some oxidant-antioxidant and inflammation markers, in athletes compared to non athletes adolescents.

No significant difference was noted in TBARS concentrations, and GRed activity between the both groups. However, athletes group had higher SOD and GPx. Studies reported that these enzymes provide the primary defense against reactive oxygen species (ROS) generated during exercise, and their activities are known to increase, in response to exercise, in both animal and human studies [33,34]. Compared with non-athletes, higher SOD activity was noted in athletes, including handball players [8], karate athletes [35], footballers [36], and soccer players [37]. Indeed, high level of GPx, found in fit populations, and the positive relationship between GPx and fitness variables, support the paradigm that regular exercise upregulates the antioxidant defense, in response to the acute increase in ROS generation, during a single bout of exercise [38].

Our results showed no change in CRP and IL-1, whereas TNF-α concentration was significantly higher in athletes group. Said et al [39] have shown that circulating leukocyte, induced by maximum muscular exercise intensity, is superimposed a significant release of TNF-α, in the blood compartment. However, Drenth et al [40] reported that the race endurance does not affect TNF-α concentration. The same authors have shown, few years after, that a run of 5 km is likely to decrease TNF-α. Suzuki et al [41] have noted that TNF-α remained unchanged by a short-lived very intense muscular exercise, but increased significantly two hours later.

The multiple logistic regression analysis showed no significant association between sex, pubertal status, waist circumference, BMI, glucose, TG, total cholesterol, urea, uric acid, hemoglobin, total proteins, GRed, TBARS, SOD, CRP and EE. However, GPx, albumin, TNF-α, IL-1 showed a positive and significant association with EE.

In summary, a negative energy balance due to inadequate DEI is observed in athletes adolescents. Slightly decrease of serum TG concentrations, and enhanced GPx and SOD activities are noted in athletes, compared with non athletes. However, significant associations are found between GPx, inflammatory markers and EE. Indeed, these results contribute to the recognition that adequate level of physical activity in adolescents leads to better health, while increasing PA should still be a public health priority. Longitudinal and intervention studies are warranted to give future recommendations.

Statement of Competing Interests

None.

Abbreviations

PA: Physical activity; DEI: Daily energy intake; EE: Energy expenditure; IPAQ-S: International Physical Activity Questionnaire-short form; MET: metabolic equivalent of task; BMI: Body mass index; BW: Body weight; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; TG: triacylglycerol; SES: Socioeconomic status; OS: Oxidative stress; CRP: C-Reactive protein; TNF-α: Tumor necrosis factor-α; IL-1: Interleukin-1; TBARS: Thiobarbituric acid reactive substances; SOD: Superoxide dismutase; GPx: Glutathione peroxidase; GRed: Glutathione Reductase; CI: Confidence Interval; OR: Odds Ratio. NS: not statistically significant.

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