ORIGINAL ARTICLE

NUTRITION PECULIARITIES OF UKRAINIAN ADOLESCENTS WITH METABOLIC SYNDROME

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ABSTRACT

The aim: To study the dietary peculiarities of Ukrainian adolescents with obesity and to identify the eating disorders on the background of metabolic syndrome.

Materials and methods: A survey on the nutrition of Ukrainian adolescents was conducted at O. Yaremenko Ukrainian Institute for Social Research within the framework of the international project Health and Behavioral Orientations of Student Youth (HBSC), 2018. As a result, a sample of 200 adolescents with obesity (age 14-18 years: 100 boys and 100 girls) was formed, with the following examination by the Institute of Children and Adolescents Health Care of the National Academy of Medical Sciences of Ukraine.

Results: A survey conducted revealed the problem of irrational and unbalanced diet in Ukrainian adolescents. Thus, irregular and unbalanced diet naturally causes digestive disorders and contributes to the formation of comorbid pathologies such as obesity and metabolic syndrome. The general analysis of the DEBQ survey results revealed that patients with metabolic syndrome were twice as likely to have abnormalities in eating behavior (71.8 ± 3.7)% than in patients without them (39.4 ± 4.1)%, ($\varphi < 0.05$). Adolescents with obesity experienced significant zinc and magnesium deficiency in the body ($\varphi < 0.05$).

Conclusions: Modification of eating behaviour through healthy balanced nutrition and psychological support is one of the most important tasks in the treatment of patients with obesity and metabolic syndrome.

KEY WORDS: adolescents, metabolic syndrome, eating disorders

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INTRODUCTION

According to WHO definition, nutrition is an organized and timely supply of nutritious and tasty food to the human body, which contains the optimal amount of nutrients needed to support life, develop and increase productivity. Nutrition is a leading fact in preserving the body, especially when it concerns a growing organism. Such a demand in childhood and adolescence is caused by the increase of the basic metabolism rate (1.5 times higher than in adults), high neuropsychiatric loads, puberty, acceleration, sports activities, etc. [1]. A teenager's daily nutritional diet depends on many reasons: family well-being, state of health, school training and other pressures, the time of year. Individual advice in this case can be provided by a nutritionist. Unfortunately, the diet of today's Ukrainian youth remains unbalanced, with high-calorie foods, sometimes harmful to health, which over time leads to overweight and obesity.

Childhood obesity is a pressing medical and social problem in Ukraine and beyond, due to the progressive increase in its prevalence, a significant spectrum of comorbid disorders [2, 3, 4], the risks of metabolic syndrome (MS), the main criteria of which in childhood are abdominal obesity, insulin resistance (IR), dyslipidemia, increased blood pressure (IDF, 2007) [5, 6]. It is wrongly believed that MS is the problem of middle aged and elderly people, as evidenced by recent studies on its prevalence in adolescents [7, 8]. Childhood obesity is rooted in genetic susceptibility, which is influenced by the environmental factors, primarily irrational nutrition during infancy and adolescence. According to Fonseca H, 2009, particular attention should be paid to overweight young people who are at most risk of disordered eating, since overweight (or just the idea of being overweight) can be a motivation to adhere to rigid diets and other eating disorders [9, 10]. In addition, such unbalanced diets lead to the imbalance of microelements in the body, which are essential and perform many functions. These microelements, at low concentrations, are involved in all metabolic processes, including intracellular, the provision of reproductive function and immunity, the development of the cognitive sphere and behavioral responses [11]. There is evidence of zinc (Zn) involvement in energy metabolism, pancreatic insulin synthesis, antioxidant protection, cell membrane stabilization, etc. Therefore, zinc deficiency is likely to affect carbohydrate and lipid metabolism, as it is an integral part of insulin, which substantiates its role in the development of IR. In particular, magnesium deficiency (Mg) leads to disorders of the nervous system in the form of a syndrome

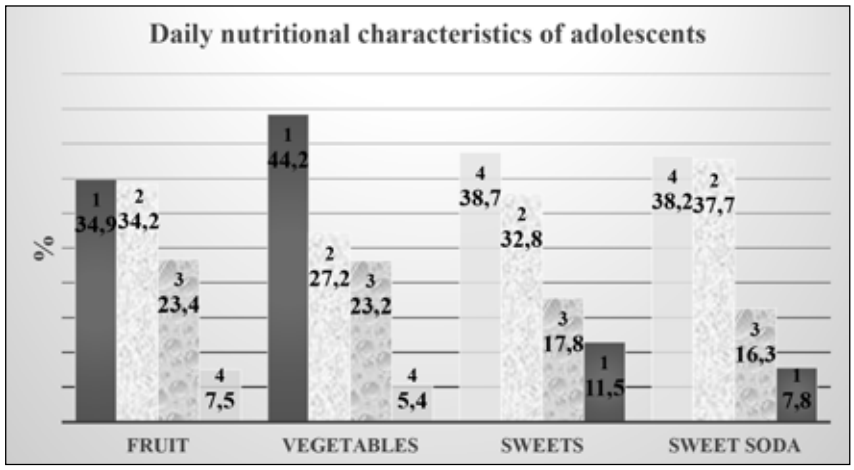

Fig. 1. O. Yaremenko Ukrainian Institute for Social Research within the framework of the international project Health and Behavioral Orientations of Student Youth (HBSC), 2018
1 – never, less than once a week; 2 – once a week, 2-4 times a week; 3 – 5-6 times a week; 4 – daily, more than once a day.

of 'chronic fatigue', cardiovascular system (increased blood pressure, impaired cardiac rhythm) and metabolism. Most often, the deficiency or imbalance of these microelements may be due to an unbalanced diet [12, 13]. Unfortunately, the studies of nutrition of Ukrainian children and adolescents, psychological predictors of childhood obesity, their relation to metabolic disorders, imbalances of biological substances that regulate eating behavior (EB) did not clarify the essence of the problem [14]. Therefore, a survey conducted by *O. Yaremenko Ukrainian Institute for Social Research* within the framework of the international project *Health and Behavioral Orientations of Student Youth* (HBSC), 2018, which aimed to study the daily nutrition of Ukrainian adolescents with subsequent identification of EB disorders and metabolic disorders like metabolic syndrome in adolescents with obesity and possibilities of modifying them to improve the effectiveness of treatment and prevention has undoubtedly become relevant.

THE AIM

To study the dietary peculiarities of Ukrainian adolescents with obesity and to identify the eating disorders on the background of metabolic syndrome.

MATERIALS AND METHODS

A survey on the nutrition of Ukrainian adolescents was conducted at *O. Yaremenko Ukrainian Institute for Social Research* within the framework of the international project *Health and Behavioral Orientations of Student Youth* (HBSC), 2018. As a result, a sample of 200 adolescents with obesity (age 14-18 years: 100 boys and 100 girls) was formed, with the following examination by the *Institute of Children and Adolescents Health Care of the National Academy of Medical Sciences of Ukraine*. To confirm the diagnosis of obesity in all patients, the body mass index (BMI) was calculated according to the formula (body weight (kg)/height^2 (m^2)) with the estimation of data on the percentile tables recommended by WHO. All BMIs surveyed exceeded 95 percentiles. The type of obesity was analyzed by the waist-to-growth ratio (WC/height); waist circumference to hip circumference ratio (WC/HC). The abdominal type of obesity in adolescents was diagnosed at the value of ≥ 0.9 for boys, ≥ 0.8 for girls [15]. The control group consisted of 30 healthy children of the same age category. All patients underwent a comprehensive clinical and laboratory examination: anthropometric measurements, biochemical blood testing with the determination of lipid and protein metabolism, liver enzyme levels and bilirubin. The criterion for IR was the homeostatic model HOMA – IR (Homeostasis model assessment of Insulin Resistance, Matthews D.R., 1985). The calculation was carried out according to the formula: HOMA = (G_0 • Ins_0) / 22.5; (G_0 – fasting glucose level of the blood serum, mmol/l; Ins_0 – the content of insulin in blood serum, mkU/ml. The result of more than 3.5 units testified to IR presence. On the basis of the studies conducted, the obese subjects were divided into the main and the control groups. The main consisted of two subgroups: 1 – with signs of MS and 2 – without signs of MS, each of which included 100 patients. Criteria used for diagnosing MS in children were presented by the International Diabetes Federation. The main ones in childhood are abdominal obesity, IR, dyslipidemia, high blood pressure [International Diabetes Federation, 2007]. A study of EB in obese adolescents was conducted using a Dutch questionnaire (DEBQ, The Dutch Eating Behaviour Questionnaire). The Dutch questionnaire allows you to identify the causes of overeating and, accordingly, to establish the type of eating behaviour (restrictive, emotional, external). It should be noted that according to this test, it is possible to have several EB disorders in one patient at a time. Also, the levels of zinc and magnesium trace elements indispensable for the life of the organism were analyzed using *Cormay* standard apparatus and kits.

Table 1. Characteristics of complaints in patients with obesity, (%)

Complaints	MS + (n= 100)	MS - (n= 100)	Total (n= 200)
increased fatigue	62.8 ± 4.5	61.1 ± 4.5	61.9 ± 3,2
irritability	27.4 ± 4.2	25.7 ± 4.1	26.5 ± 2.9
weakness	17.7 ± 3.6	17.7 ± 3.6	17.7 ± 2.5
headache	85.0 ± 3.3	80.5 ± 3.7	82.7 ± 2.5
epigastric pain	55.8 ± 4.6*	45.1 ± 4.7	50.4 ± 3.3
pain in the region of liver	62.8 ± 4.5*	18.6 ± 3.6	40,7 ± 3.2
pain in the pyloric duodenal area	61.1 ± 4.6*	32.7 ± 4.4	46.9 ± 3.3
increased appetite	76.1 ± 4.0*	55.8 ± 4.6	65.9 ± 3.1
heartburn	61.9 ± 4.5*	38.9 ± 4.6	50.44 ± 3.3
nausea	52.2 ± 4.7*	31 ± 4.3	41.6 ± 3.2

* - Difference between patients from group 1 (MS +) and 2 (MS -) ($p < 0.05$)

The database creation and the statistical processing of the results were performed on IBM-Pentium III using application packages 'Stadia-6' (serial number of license certificate 1218 May 24, 2000, version 'Prof'), Microsoft 'Access', 'Excel'. The t-criterion of the Student (p), Fisher (φ), Mann-Whitney test were used to assess the likelihood of differences, as well as the correlation analysis. The critical significance level for checking statistical hypotheses when comparing groups was assumed to be 0.05. Ethical norms at all stages of the survey were observed. The work was conducted taking into account the requirements of the European Convention (Strasbourg, 1986), the provisions of the ICH GCP (2008), GLP (2002). The studies did not cause psychological discomfort in patients. Patients and their parents were provided with the information on the methods and scope of the research, signed informed consent to participate in the study.

RESULTS

A survey conducted by *O. Yaremenko Ukrainian Institute for Social Research* within the framework of the international project *Health and Behavioral Orientations of Student Youth* (HBSC), 2018 demonstrated the adolescent consumption of fruit, vegetables, sweets and sodas, containing sugar by time: daily, more than once a day, once a week, 2-4 days a week, never (Figure 1).

It was also found that about 7.8% of 14-years and 15.6% of 16-years do not have breakfast on weekdays. Every day, only half of adolescents consume fruit and vegetables 42.2% (boys) and 51.2% (girls). 17% of adolescents in all sex-age groups regularly ('daily') consume drinks (soda and sweets). One third (27.9%) consume food daily or 5-6 days a week while watching TV.

It should be recognized that the proportion of students who regularly ('daily') consume both healthy (vegetables, fruit) and potentially harmful food (carbonated drinks and sweets) remains stable across all age groups, indicating that food preferences and eating behaviour are formed in adolescence. In addition, the sugary beverage intake is high, more than once a week (42.4% of respondents), especially among boys (48.7% versus 37.5% among girls).

A comprehensive clinical and laboratory-instrumental study of 200 adolescents with obesity allowed dividing patients into 2 groups: I – with the main features of MS (50.0% of patients with the presence of IR, abdominal type of obesity, dyslipidemia), II – patients with obesity and without IR, borderline changes in lipidogram (also 50.0%). In patients of group I, when determining BMI, its values were statistically significantly higher than those of group II (36.25 ± 4.45 kg/m^2 and 28.0 ± 3.73 kg/m^2, respectively, $p < 0.01$). Group I was characterized by statistically significantly higher WC/height ratios compared with patients in group II (0.69 ± 0.07 U and 0.59 ± 0.04 U, respectively, $p < 0.05$). The WC/HC ratio in obese adolescents also indicated an abdominal type of obesity, but did not differ significantly in the groups ($p > 0.05$). Thus, the WC/height index was more sensitive to establishing the type of adipose tissue distribution, which is consistent with the world literature [15]. That is, half of the patients surveyed had MS by the main criteria. A comparative analysis of the degree of obesity in adolescents was also performed depending on the presence of MS signs by use of the Mann-Whitney U test. As shown in the analysis, patients in group 1 had, on average, a higher degree of obesity than patients in group 2 ($p = 0.009$). Moreover, this trend persisted regardless of gender and age.

In patients with obesity the following complaints were noted (Table 1). Most often, children complained of headaches – (82.7 ± 2.5)% and fatigue – (61.9 ± 3.2)%. There were less frequent complaints of being irritable (26.5 ± 2.9)% and feeling weak (17.7 ± 2.5)%. Patients also complained of abdominal pain and had manifestations of dyspeptic syndrome.

Thus, the signs of asthenovegetative syndrome were almost identical in both groups of patients ($p > 0.05$). As to the digestive system, about half of adolescents complained of epigastric pain (50.4 ± 3.3%), pyloric duodenal (46.9 ± 3.3%) and liver projection (40.7 ± 3.2), and it occurred significantly more frequently in the group of patients with

Table 2. Deviant forms of eating behavior in adolescents with obesity according to the data DEBQ, (%)

Type of EB	MS +		MS -		Total	Control group
	Boys	Girls	Boys	Girls		
Restrictive	44.18 ± 2.3 **	52.5 ± 2.8**	24.0 ± 2.0	28.8 ± 3.0	73.9 ± 3.2 *	16.73 ± 2.4
External	17.0 ± 2.0	28.8 ± 3.0	19.3 ± 2.1	24.7 ± 2.7	43.8 ± 3.1 *	13.67 ± 2.1
Emotional	14.7 ± 1.9	17.5± 2.9	11.6 ± 1.9	24.7 ± 2.7	32.3 ± 3.1 *	10.86 ± 1.9

* Difference between the patients from the main group and the control group ($\varphi < 0.05$)
** Difference between the patients from group1 (MS +) and 2 (MS -) ($\varphi < 0.05$)

Table 3. Zinc and magnesium levels in adolescents with obesity, depending on the type of EB, (M ± m)

Type of EB	Zinc, mkmol/l (N – 10-15)	Magnesium, mmol/l (N – 0,7-1,1)
Restrictive	7.31 ± 0.5 *, **	0.34 ± 0.4 *, **
External	8.87 ± 0.3 *	0.67 ± 0.2 *
Emotional	8.92 ± 0.7 *	0.73± 0.2 *
Control group	12.7 ± 0.3	0.93 ± 0.03

* Difference between the patients from the main group and the control group ($\varphi < 0.05$)
** Difference between the patients from group 1 (MS +) and 2 (MS -) ($\varphi < 0.05$)

obesity and signs of MS ($p < 0.05$). The characteristics of dyspeptic syndrome complaints also indicate their high prevalence in the patients surveyed, with a likely predominance of complaints of increased appetite, heartburn, nausea in group1of patients compared with group 2 of adolescents ($p < 0.05$).

On objective examination, an increase in liver size was found in (37.8 ± 3.2)% of adolescents with obesity, which was more commonly reported in individuals with MS (50.4 ± 4.7)%, compared with individuals without MS (24.8 ± 4.0)%, ($p < 0.001$). According to ultrasound, an increase in liver size was found in (38.0 ± 4.0)% of patients, statistically significantly more often in individuals with MS (49.4 ± 5.4)%, in contrast to individuals without MS (23.5 ± 5.1)%, ($p < 0.01$). Increased liver echogenicity was also more prevalent in patients with MS (24.7 ± 4.6)% than in patients without MS (13.2 ± 4.1)%, ($p < 0.01$), which indicated unfavorable dynamics of pathological liver changes against the background of IR. Sealing of liver vessels was observed at almost the same frequency in the groups compared (36.5 ± 5.2)% and (33.8 ± 5.7)%, respectively ($p > 0.05$).

The relationship between MS and IR as a leading symptom of this syndrome and the eating behaviours of the main groups examined were further analyzed by correlation analysis. Therefore, correlation analysis revealed a weak, statistically significant correlation between EB and HOMA index ($r = 0.31$; $p < 0.001$). That is, it confirms the possible pathogenetic role of IR in the progression of obesity and the development of EB abnormalities.

The analysis of the Dutch questionnaire data (Table 2) showed that most adolescents with obesity had a restrictive type of EB – (73.9 ± 3.2)%, whereas in the control group only (16.73 ± 2.4) % of children have a specified EB disorder ($\varphi < 0.05$). This disorder of EB is characterized by excess food self-restraint and rigid diets that alternate with the episodes of overeating. In the presence of signs of MS, a statistically significant difference was found in both groups boys and girls ($\varphi < 0.05$).

A fairly common variant of eating disorders was the external one – in (43.8 ± 3.1)% of children with obesity, against (13.67 ± 2.1)% in the control group ($\varphi < 0,05$), characterized by the increased reaction to external stimuli (food advertising, etc.) rather than the internal stimuli for eating, such as hunger. No significant difference by gender and in the MS + and MS – groups was found ($\varphi > 0.05$).

More than a third of patients with obesity had an emotional type of EB – (32.3 ± 3.1)%, against (10.86 ± 1.9)% in children in the control group ($\varphi < 0,05$), without significant difference by gender and MS ($\varphi > 0.05$). In case of emotional type of EB, the stimulus for eating becomes not hunger but emotional discomfort: a person eats not because of being hungry, but because of feeling anxious, insulted, irritated, and so on.

It was also found that in general, patients with MS + group had statistically significantly more frequent disorders of EB (71.8 ± 3.7%) than patients without signs of MS (39.4 ± 4.1%), ($p < 0.05$). That is, disorders of EB, as a clinical feature, are more common in individuals with metabolic disorders in the background of IR.

The next step was the study of serum magnesium and zinc levels with an assessment of these indicators depending on the type of EB disorder (Table 3).

According to the results of studies, in adolescents with obesity there was a significant deficiency of zinc and magnesium in the body, in contrast to the control group surveyed ($\varphi < 0.05$). It was observed that the lack of these trace elements was most pronounced and statistically significant ($\varphi < 0.05$) in the group of patients with restrictive type of EB. Thus, haphazard, rigid and unbalanced self-prescribed diets are very harmful and, at times, dangerous.

DISCUSSION

Eating disorders lead to somatic disorders, psychological discomfort of the patient, even to depressive states [4]. The lack of trace elements in the blood of adolescents with obesity and metabolic syndrome may be important in the formation of these conditions due to the huge range of their physiological functions, perhaps closing the wrong circle of these metabolic disorders [3, 6]. Therefore, drugs containing zinc and magnesium may be recommended to these patients in rehabilitation programs. It is also advisable to modify eating behaviours through healthy balanced eating and psychological counseling to improve the effectiveness of the treatment of obesity and the prevention of metabolic syndrome. The daily requirement of zinc for adolescents 14-17 years is 15 mg (boys) and 13 mg (girls), magnesium – 300 mg [1, 10].

These results confirm the current ideas about obesity as a psychosomatic disease, in the origin of which both psychological and somatic factors play a role [16, 17, 18]. The psychological effects of childhood obesity on the patient and his or her family require screening for mental health and counseling if needed. The prevention of childhood obesity by promoting healthy eating habits appropriate to the age of physical activity and a healthy environment should be the primary goal of pediatricians and general practitioners. Unfortunately, there are few studies of psychological predictors of childhood obesity, including EB, their connection with metabolic disorders, and trace element imbalances caused by unbalanced nutrition [3, 4, 19, 21]. Therefore, a research with a detailed study of the nature of the daily diet of Ukrainian adolescents, namely children with obesity and signs of metabolic syndrome, eating disorders, levels of essential trace elements, is certainly relevant. In the long run, this will make possible to correct at early stages eating behaviour by lifestyle modification, to prevent obesity and metabolic syndrome progression, as well as to correct the microelement imbalances.

CONCLUSIONS

1. A survey conducted revealed the problem of irrational and unbalanced diet in Ukrainian adolescents. Thus, irregular and unbalanced diet naturally causes digestive disorders and contributes to the formation of comorbid pathologies such as obesity and MS.
2. A comprehensive clinical and laboratory-instrumental study proved that 50% of patients with obesity have classic signs of metabolic syndrome (abdominal obesity, insulin resistance, dyslipidemia, etc.).
3. The general analysis of the DEBQ survey results revealed that patients with MS were twice as likely to have abnormalities in EB (71.8 ± 3.7)% than in patients without them (39.4 ± 4.1)%, ($\varphi < 0.05$). Among the eating disorders, the most widespread was the restrictive type – 73.9% of all surveyed, with less frequent occurrence external (43.8%) and emotional (32.3%).
4. Restrictive type of EB was twice as common in patients with metabolic syndrome, correlation analysis determined a positive association of these disorders with the index HOMA ($r = 0{,}311$; $p < 0{,}001$).
5. Adolescents with obesity experienced significant zinc and magnesium deficiency in the body ($\varphi < 0.05$). The most pronounced, statistically significant ($\varphi < 0.05$) deficiency of these trace elements was observed in the group of patients with restrictive type of EB, that is, haphazard, rigid and unbalanced diets are harmful and, at times, dangerous.

Thus, the modification of eating behaviour through healthy balanced nutrition and psychological support is one of the most important tasks in the treatment of patients with obesity, which will make possible to normalize body weight, psychological and general health, improve the quality of life and take preventive measures to avoid metabolic syndrome and the development of trace elements imbalance.

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The Authors declare no conflict of interest.

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