



**ORIGINAL RESEARCH PAPER**

**Medicine**

**WEIGHT STATUS AND NUTRITION IN SIBERIAN ADOLESCENTS**

**KEY WORDS:** Adolescents 14-18 Years Old; Nutrition; Underweight; Normal Weight; Overweight; Obesity; Under-reporting Of Energy Intake

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**ABSTRACT**

The purpose of the study was to evaluate the nutrition in adolescents with different weight status. **Material and methods.** In April-May 2019, a cross-sectional population survey was conducted on a random representative sample of schoolchildren aged 14-18 years of both sexes, 612 people were examined: 249 boys (40.9%), 360 girls (59.1%). Diet recall was taken in 537 persons. The survey program included a standard questionnaire, anthropometry, and assessment of diet using 24-hour dietary recall (537 persons). **Results.** Based on IOTF criteria, 5 body mass index categories were identified: underweight, normal weight, overweight, obesity, extreme obesity. Because of low prevalence of obesity and extreme obesity in the study these groups were combined with the overweight group and further 3 groups were analyzed: underweight, normal weight and overweight. The prevalence of overweight and obesity among adolescents in Novosibirsk was 22.1% in boys and 14.4% in girls. Disturbances in the structure of nutrition were revealed both in the studied sample of adolescents in general, and in the group of boys and girls with overweight and obesity. Quotas of fat energy in general, saturated fatty acids, easily digestible sugars exceed recommended levels. The fiber content was below the recommended level by more than 2 times. Above 80% of overweight adolescents underestimate energy intake. Percent of under-reporting of energy intake in boys was 45,8% in underweight group; 48,6% in normal weight group; 80,6% in overweight group. In girls – 26,8%, 54,1% and 85,1%, respectively. **Conclusions.** The results show that both adolescents with overweight and obesity, as well as with normal indicators of physical development, need to optimize nutrition.

**INTRODUCTION**

The increase in the prevalence of overweight, one of the leading risk factors for noncommunicable chronic diseases, is a major problem in modern society, not only in adults but also in adolescents. Adolescence is a period of formation of the base for future health, social life. Negative habits, fixed at this stage of development, are a subsequent platform for increasing the health risks [1]. Nutrition is considered one of the most modifiable factors affecting the levels of predictors of atherosclerosis (lipid profile disorders, overweight, high blood pressure, hyperglycemia, etc.), therefore, the efforts of both medical science and public health are directed to its study and correction. The features of nutrition of the young generation are fast food, an increase in food outside the home to a greater extent in fast food enterprises. Improper eating habits, leading to a decrease in the intake of vitamins, minerals, dietary fiber, an increase in the contribution of fats and easily digestible carbohydrates to the total energy of the diet, contribute to the increase in the prevalence of overweight and obesity among adolescents [2]. According to some epidemiological studies, in the Russian Federation the prevalence of overweight in children in different regions of Russia is from 5.5 to 11.8% [3].

In connection with the above, the study of dietary patterns in adolescents in general, as well as in groups of overweight and obesity, is relevant for determining the direction of prevention activities among the younger generation.

The purpose of this study was to evaluate the nutrition of adolescents with different weight status.

**MATERIALS AND METHODS**

The study design was a cross-sectional survey of cardiovascular risk factors and some other health indicators in adolescents of Novosibirsk. Out of 20 schools in one of the city districts, 6 secondary schools were selected by random numbers, in which students of grades 8-11 were examined. In 2019, screening of a representative sample of adolescents aged 14-18 (612 students, 40.9% of boys) was conducted, the response rate was 78%. Dietary questionnaires were received from 537 adolescents. During the screening, all children signed an informed consent for the examination, the same informed consent was obtained from their parents. Study approved by Local Ethics Committee.

For each student anthropometric, lifestyle and dietary data were collected. Height and weight were measured in the school setting, in the morning. Weight was measured in underwear by a regularly calibrated scale to the nearest 0.1 kg. Height was measured using a stadiometer in a standing position without shoes with an accuracy of 0.5 cm. For analysis, we used the body mass index (BMI) = body mass (kg) / height (m<sup>2</sup>). To assess levels of overweight and obesity International Obesity Task Force (IOTF) cut offs were used [4]. The collection of dietary data was carried out using 24-h dietary recall method with the standard questionnaire "Daily dietary form", developed by specialists of the nutrition laboratory of the State Research Center for Preventive Medicine of the Ministry of Health of the Russian Federation for population studies of actual nutrition in Russia [6]. In daily diets, the protein (animal and vegetable) content, total fat (including saturated (NFA), monounsaturated (MFA) and

polyunsaturated fatty acids (PUFA)), carbohydrates (including sugar), as well as the energy value of the diet with a percentage contribution to the energy of these nutrients were calculated.

To obtain these data, we used our own original program (Ph.D. Verevkin E.G.) and tables of the chemical composition of food products [7].

The basal metabolic rate (BMR) was calculated using formulas proposed by FAO/WHO/ONU according to the adolescent's age, gender, weight, and height [8-10]. For evaluation of misreporting of energy intake (EI) in the studied population the following equations were applied to derive cut-offs:

$$EI.BMR > PAL \times \exp \left[ SDmin \times \frac{S/100}{\sqrt{n}} \right]$$

$$EI.BMR < PAL \times \exp \left[ SDmax \times \frac{S/100}{\sqrt{n}} \right]$$

The first and second equations are used to calculate the specific lower cut-off and upper cut-off values to identify under- and over-reporters in a population.

**In the equations:**

SDmin: is -2 for the 95% lower confidence limit, SDmax is +2 for the 95% upper confidence limit,

n is the number of subjects included in each defined group. Reported Energy Intake (EIrep) should be calculated as average value on the basis of energy intakes estimated for each of non-consecutive days applying 24-h dietary recall.

PAL: Physical activity level.

Age specific PAL values for low, moderate and active (vigorous) physical activity adopted by EFSA NDA Panel in the scientific opinion on DRV for energy (2013) should be applied in the equations to establish misreporting of EI for individuals of age 15- 69 years. Mean Physical Activity Level (PAL) for adolescents and adults of age 15-69 years: low - 1,6; moderate 1,8; vigorous -2.0 [10].

To recognize misreporting a comparison between total energy intake and basal metabolic rate (BMR) was performed for each participant. Under-reporters energy intake estimate if EI/BMR < 0,97 for boys and <0,95 for girls.

Statistical analysis was carried out with the calculation of mean value (M) and 95% confidence intervals. The differences between mean values of the quantitative variables were evaluated using one-way ANOVA. For multiple comparisons of variables, posterior tests were used (Fisher test of least significant difference, Bonferroni correction). Hypothesis testing was performed for a probability level of 95% (p <0.05).

**RESULTS AND DISCUSSION**

**1. Weight status**

Based on IOTF criteria, 5 body mass index categories were identified: underweight, normal weight, overweight, obesity, extreme obesity. For analysis, given the very low prevalence of obesity and extreme obesity in the study these groups were combined with the overweight group and further 3 groups were analyzed: underweight, normal weight and overweight.

Overweight and obesity were found in 17.5% of adolescents, underweight - in 12.9%. The prevalence of overweight was 16.8% among boys and 11.9% among girls. Obesity was found in 3.6% boys and 1.9% girls. Extreme obesity was observed in 1.7% of boys and 0.6% of girls. In boys, the frequency of overweight was 1.5 times more often than in girls: 22.1% and 14.4%, respectively, p = 0.03. It is noteworthy that the percentage of adolescents with underweight was 12.9% (table 1).

**Table 1. Body mass index categories (%) among adolescents aged 14-18.**

Body mass index categories	Boys (249)		Girls (360)		p <sub>big</sub>
	n	%	n	%	
Underweight	28	11,3	50	13,9	0,338
Normal weight	168	66,6	258	71,7	0,267
Overweight	41	16,8	43	11,9	0,112
Obesity	9	3,6	7	1,9	0,205
Extreme obesity	3	1,7	2	0,6	0,383
Excessive weight (overweight+obesity+extreme obesity)	53	22,1	52	14,4	<b>0,03</b>

**2. Energy and nutrient intake**

The results of the daily intake of nutrients and energy by adolescents in Novosibirsk are presented in Table 2.

**Table 2. -Energy and nutrient intake by adolescents (M, 95% CI).**

Nutrients and energy	Boys, n=207		Girls, n=330	
	Actual intake	RDA*	Actual intake	RDA*
Protein, total, g/d	75,3 (69,3 -81,2)	87	53,5 (50,7 - 56,2)	75
-incl. animal proteins, g/d	52,4 (47,2 -57,6)			
-incl. vegetable proteins, g/d	22,4 (21,1 - 23,8)			
Fat, total, g/d	73,0 (66,3 -79,7)	97	51,6 (48,7 - 54,6)	83
SFA, g/d	26,7 (24,2 -29,2)		19,2 (18,0 - 20,4)	
MUFA, g/d	28,0 (25,1 -30,9)		18,8 (17,5 - 20,1)	
PUFA, g/d	10,5 (9,4 -11,6)		8,4 (7,5 - 9,2)	
Carbohydrates, total, g/d	219,3 (206,1- 232,5)	428	159,3 (151,7 -166,9)	363
Sugar, g/d	52,7 (46,5 -59,0)		38,7 (34,8 - 42,5)	
Dietary fiber, g/d	9,5 (8,7 -10,4)	20	7,8 (7,3 - 8,3)	20
Energy, kcal/d	1835,1 (1721,1 - 1949,1)	2900	1315,7 (1261,1 - 1369,4)	2500
Protein, % energy	16,6 (15,8 - 17,4)	12	16,6 (15,9 - 17,2)	12
Fat, % energy	34,6 (33,1 -36,1)	30	34,5 (33,4 - 35,7)	30
SFA, % energy	12,6 (11,9 -13,3)	<10	11,2 (10,2 - 12,2)	<10
MUFA, % energy	13,1 (12,3 -13,8)		12,8 (12,3 - 13,4)	
PUFA, % energy	5,1 (4,7 -5,4)		5,7 (5,2 - 6,2)	
Carbohydrates, % energy	48,8 (47,2 -50,5)		48,9 (47,6 - 50,1)	
Sugar, % energy	11,2 (10,0 -12,3)	<10	11,1 (10,2 - 12,2)	<10

\*RDA - recommended daily allowance for adolescents (14-18y) in Russian Federation [Norms of physiological needs for energy and food substances for various groups of the population of the Russian Federation. Methodical recommendations: — M.: MR 2.3.1/0253-21.- M.: Federal Service for Supervision in the sphere of consumer protection and human well-being, 2021.— 72 p.

The analysis of the dietary intakes of Novosibirsk adolescents showed reduced consumption of all nutrients, and, accordingly, low energy intake. For boys, the average energy consumed is 37% lower than recommended for a given age,

and for girls is 47%. It should be emphasized that the 24-hour diet recall method underestimates the total consumption of energy and nutrients, as recognized by experts [11].

Energy intake from macronutrients among Siberian adolescents was disbalanced: from fat - above 30%, from SFA - above 10%, from sugar - above 10%. Animal protein fraction in a total amount exceeds the recommended values for age - 60%. Energy intake from protein is also higher than recommended. However, the researchers show that exceeding the energy level of protein over 15% of the total energy of the diet during the growth and development period increases the risk of obesity [12].

Dietary fiber intake was less than recommended more than 2 times, both boys and girls. Such nutrition, even with a low energy intake, is the factor contributing to the development of cardiovascular and other chronic non-infectious diseases [13].

**3. Weight status and nutrition**

Table 3 shows anthropometric and diet characteristics in groups with underweight (UW), normal weight (NW), overweight and obese (OW) by gender.

**Table 3. Characteristics of boys and girls in different weight groups (M, 95% CI).**

	Boys			Girls		
	UW (n=24)	NW (n=144)	OW (n=36)	UW (n=41)	NW (n=242)	OW (n=47)
Age, y	16,2 (15,7-16,7)	15,7 (15,6-15,9)	15,4 (15,1-15,8)	16,3 (16,0-16,7)	15,9 (15,7-16,0)	15,7 (15,3-16,0)
Weight, kg	60,0 (48,4-53,5)	62,7 (61,5-64,0)	83,7 (79,6-87,8)	47,3 (46,0-48,6)	55,5 (54,6-56,3)	71,9 (68,6-75,1)
Waist, cm	65,4 (63,9-66,8)	73,7 (72,3-75,1)	89,3 (86,1-92,6)	62,4 (61,5-63,2)	68,2 (67,6-68,9)	82,3 (79,6-85,1)
BMI, kg/m <sup>2</sup>	16,4 (15,9-16,7)	20,2 (19,9-20,4)	27,2 (26,0-28,5)	17,1 (16,8-17,3)	20,6 (20,4-20,8)	27,0 (26,0-28,0)
Energy intake, kcal/d	1701 (1459-1943)	1941 (1792-2089)	1550 (1346-1754)	1468 (1293-1642)	1317 (1255-1378)	1179 (1038-1320)
Energy intake, kcal/kg/d	34,1 (29,3-38,9)	31,0 (28,6-33,4)	19,2 (16,6-21,8)	31,3 (27,8-35,1)	24,1 (22,9-25,3)	16,7 (14,5-18,8)
BMR, kcal/d	1560 (1515-1605)	1768 (1745-1790)	2138 (2066-2211)	633 (616-650)	742 (731-753)	962 (918-1005)
EI/BMR	1,09 (0,95-1,25)	1,09 (1,01-1,18)	0,74 (0,64-0,84)	1,11 (0,98-1,24)	0,92 (0,88-0,97)	0,71 (0,63-0,80)

**Table 4. Energy and nutrient intake by adolescents in groups with different weight status (M, 95% CI).**

Nutrients and energy	Weight status					
	UW		NW		OW	
	Boys, n=24	Girls, n=41	Boys, n=144	Girls, n=242	Boys, n=36	Girls, n=47
Protein, Total, g/d	69,2 (53,8-84,7)	59,6 (51,7-67,4)	78,1 (70,3-85,8)	53,0 (49,7-56,2)	68,7 (58,2-79,2)	50,7 (43,7-57,7)
-incl. animal proteins, g/d	47,9 (33,0-61,7)	43,2 (36,5-49,9)	53,5 (46,8-60,2)	38,4 (35,4-41,4)	51,4 (41,3-61,5)	37,1 (30,6-43,5)
-incl. vegetable proteins, g/d	22,0 (19,1-25,3)	17,1 (14,8-19,4)	23,5 (21,8-25,2)	16,2 (15,2-17,2)	13,2 (15,9-22,4)	14,8 (12,9-16,6)
Fat, total, g/d	64,8 (52,4-77,2)	62,3 (52,1-72,5)	78,1 (69,1-87,0)	51,3 (48,0-54,7)	61,1 (50,8-71,3)	43,8 * <sup>0,2</sup> (36,8-50,8)

SFA, g/d	23,4 (18,8-28,1)	23,2 (18,5-27,8)	28,2 (24,9-31,5)	19,3 (17,9-20,6)	23,6 (18,8-28,4)	43,8* <sup>0,2</sup> (36,8-50,8)
MUFA, g/d	24,0 (18,3-29,6)	22,8 (18,6-27,0)	30,5 (26,5-34,4)	18,8 (17,3-20,3)	22,1 (22,0-26,2)	15,3 (12,6-17,9)
PUFA, g/d	10,0 (7,7-12,3)	9,8 (7,8-11,8)	11,2 (9,8-12,6)	8,2 (7,1-9,3)	8,5 (6,9-10,2)	7,8 (5,6-9,9)
Carbohydrates, total, g/d	210,0 (178,5-241,6)	167,2 (145,0-189,5)	231,5 (215,3-247,7)	160,6 (151,7-169,5)	181,5* <sup>1,2</sup> (149,9-213,0)	145,5 (125,7-165,3)
Sugar, g/d	50,2 (35,1-65,3)	43,0 (32,6-53,4)	57,2 (49,3-65,1)	38,9 (34,5-43,4)	38,4 (24,6-52,1)	33,3 (21,5-45,1)
Dietary fiber, g/d	9,3 (6,7-11,6)	7,8 (6,5-9,1)	9,8 (8,8-10,9)	7,9 (7,3-8,4)	8,5 (6,2-10,7)	7,2 (6,1-8,4)
Energy, kcal/d	1700,6 (1458,8-1942,5)	1467,9 (1293,3-1642,5)	1940,9 (1792,4-2089,4)	1316,5 (1255,5-1377,6)	1550,1* <sup>1</sup> (1346,2-1754,1)	1179,1* <sup>0,2</sup> (1038,3-1319,8)
Protein, % energy	16,4 (14,1-18,7)	16,9 (15,1-18,8)	16,0 (15,2-16,9)	16,3 (15,6-17,1)	18,6* <sup>1,2</sup> (21,2)	17,6 (15,8-19,5)
Fat, % energy	33,6 (30,0-37,1)	37,1 (33,6-40,5)	34,7 (32,9-36,6)	34,5 (33,1-35,8)	35,3 (31,4-39,1)	33,6 (29,7-35,5)
SFA, % energy	12,1 (10,5-13,6)	13,3 (11,8-14,9)	12,5 (11,7-13,4)	12,9 (12,3-13,6)	13,3 (11,3-15,2)	11,8 (10,5-13,2)
MUFA, % energy	12,1 (10,3-13,6)	13,3 (11,7-14,9)	13,4 (12,5-14,3)	12,4 (11,8-13,0)	12,8 (11,0-14,5)	11,3 (10,1-12,4)
PUFA, % energy	5,5 (4,2-6,7)	6,3 (4,9-7,7)	5,1 (4,7-5,6)	5,6 (5,0-6,2)	5,2 (4,4-5,9)	5,7 (4,5-6,8)
Carbohydrates, % energy	50,0 (45,4-54,6)	45,9 (42,7-49,2)	49,2 (47,3-51,2)	49,2 (47,7-50,7)	46,1 (41,7-50,6)	49,8 (46,5-53,0)
Sugar, % energy	11,6 (8,5-14,7)	11,2 (8,8-13,6)	11,7 (10,3-13,2)	11,3 (10,2-12,5)	8,8 (6,2-11,5)	10,4 (7,7-13,1)

\*-p<0,05, Bonferroni test

Table 4 presents relative intakes of nutrients by boys and girls in the UW, NW and OW groups. According to the main indicators of the nutritional value of the diet, differences between groups of adolescents with underweight, normal weight and overweight (including obesity), both in boys and girls, have not been established. At the same time, the energy intake in the group of overweight and obesity is lower than in other groups. For boys, this decrease is due to lower carbohydrate intake, and for girls - fat, if comparing with adolescents with underweight and normal weight.

The fact of a decrease in energy consumption in adolescents with overweight and obesity, on the one hand, can be explained by the fact that they begin to adhere to dietary recommendations and limit their nutrition. On the other hand, one of the problems of nutrition analysis in epidemiological population studies is the underestimation of energy intake. Under-reporting of EI was found to be more common in subjects with higher body mass index (BMI), in adolescents as well as in adults. Adolescents are likely to under-report their EI. Female adolescents were found to under-report more often than male adolescents, and under-reporting of EI estimated with dietary records increased with age in preadolescent and adolescent girls. [14-18].

All the above positions regarding underestimation of energy intake in adolescence was obtained in our study. Percent of under-reporting of energy intake in boys was 45,8% in UW group; 48,6% in NW group; 80,6% in OW group. In girls - 26,8%, 54,1% and 85,1%, respectively. Energy intake in OW - normal-reporting groups is 1,84 times higher vs OW-under-reporting groups in boys, and in 1,94 - in girls respectively.

Adolescents with overweight and obesity, as well as all the other examined students, had high percent of fat energy intake, more than recommended 30% [7]. In 61.1% of boys and 51.1% of girls with overweight and obesity EI from fat exceeded this value. Energy intake from saturated fatty acids exceeded 10% in 61.1% boys and 59.6% girls. The energy from added sugar was > 10% for 33.6% boys, and 36.2% girls. High percent of animal protein consumption: 72.6% (64.8 - 80.3) and 69.8% (63.9 -75.8), for boys and girls, respectively. At the same time, protein intake per kilogram of body weight is below safe levels recommended by WHO: 0.85 (0.72-0.98) g /kg and 0.71 (0.61-0.80), for boys and girls, respectively.

**CONCLUSION**

The nutrition pattern of adolescents aged 14-18 is generally characterized by an imbalance in the basic nutrients and energy intake. Overweight adolescents exceeded the energy of fat, saturated fatty acids, added sugar, protein in the total energy intake. A low intake of total carbohydrates, vegetable protein, and dietary fiber was noted. Above 80% of overweight adolescents underestimate energy intake. The results presented that nutritional corrections requires both adolescents with overweight and obesity, as well as with normal weight.

**Competing Interests**

The authors declare that they have noncompeting interests.

**Authors' Contributions**

D. V.Denisova conceived, coordinated, participated in the study and drafted the manuscript.  
 I.P.Berezovikova participated in the design of the study and in the gathering of nutritional data, drafted the manuscript.  
 L.V.Shcherbakova performed the statistical analysis.  
 All authors read and approved the final version of the manuscript.

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