



Prevalence of Overweight and Obesity in School Children in Bosnia and Herzegovina: A Cross-Sectional Study

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Abstract Purpose: To identify the characteristics of age groups of children from 10 to 14 years old in terms of the ratio of body weight and length, in particular, the relative number of children with overweight and obesity, and to develop recommendations for reducing body weight for children 10-14 years old. **Material and Methods:** An observational cross-sectional survey of the health status (overweight and obesity) of school children was conducted on sample 500 school children from Bosnia and Herzegovina (Republic Srpska entity), which included 246 boys and 254 girls, aged 10 to 14 years. Anthropometric data including Body height (BH), Body weight (BW) and age were collected from all elementary school children. Body mass index (BMI) is an anthropometric index of weight and height that is calculated by dividing a person's weight (kg) by the square of their height (m^2). BMI participants was estimated with the Percentile BMI calculator for children and teens aged 2-19 years. The studied children were defined as underweight, normal (healthy)-weight, overweight and obese according to the Center for Disease Control and Prevention (CDC) child growth characteristics for age, sex, and BMI. Basic central and dispersion parameters (Mean, Min., Max., Range, SD, CI 95%, CV%, Skew., Kurt.) were calculated for each variable. To confirm normality, the Kolmogorov-Smirnov test was applied ($p>0.05$). The homogeneity of variance was tested with Levene's test. The nutritional status of the subjects was assessed using percentile values on the basis of which the percentile categories are calculated. Statistical procedures and analyzes were performed using the statistical package STATISTICA 10.0 for Windows. **Results:** The dynamics of changes in the relative number of children with overweight and obesity from 10 to 14 years old was revealed. The lowest number of overweight and obese students was recorded at the age of 14 (1% <). The results of malnutrition in boys point to the conclusion that it is present in a smaller percentage, from 1.96% (age 14) to 6.12% (age 12). The largest number of girls at the age of 13 were overweight, 10 (19.23%) and obese (2%<), and then at the age of 10 and 11 (overweight 15.68% vs. 13.72%, and obesity 1.96% vs 3.92%). Malnutrition as a category is in a slightly higher percentage than for boys, ranging from 3.92% (11 and 12 years) to 7.84% (10 years). **Conclusions:** If a child is overweight at any age, this should be an alarming signal, as it can provoke weight gain in adulthood or with the slightest decrease in self-control. Therefore, the best strategy would be to create conditions for a child's development in which he will receive joy from other sources, and not just from food and activities that do not require physical activity. Finding even a relatively small number of overweight and obese children is not a benign problem. It requires its own solution, helping such children understand their problem and overcome it.

Key Words boys, girls, overweight, obesity

1. Introduction

Currently, metabolic syndrome is considered one of the problems of civilization [1]–[4]. Metabolic syndrome is determined by a decrease in the sensitivity of peripheral tissues

to insulin, which, in turn, is associated primarily with an increase in visceral fat mass [5]–[8]. The increase in visceral fat mass also depends on the mass of total body fat, and, therefore, on the total body fat mass. Since visceral fat

has hormonal properties associated with the production of insulin-like growth hormone, in the body, with an increase in visceral fat, a decrease in insulin sensitivity occurs. At the initial stages, this leads to excessive production of insulin by the pancreas, and at subsequent stages, due to the depletion of the hormonal activity of the pancreas, a decrease in insulin production occurs and type 2 diabetes mellitus develops [9]–[11]. Thus, a violation of carbohydrate metabolism occurs. In addition to carbohydrate metabolism, lipid and purine metabolism are also disrupted, and arterial hypertension develops. Impaired lipid metabolism leads to an increase in low-density lipids in the blood and a decrease in high-density lipids. This is dangerous from the point of view of the development of atherosclerosis and increasing the risk of cardiovascular diseases. Violation of purine metabolism is dangerous from the point of view of the development of various diseases of the kidneys and joints [10]–[12].

Therefore, one of the main ways to reduce the risk of cardiovascular diseases, type 2 diabetes, kidney and joint disease is to combat metabolic syndrome, and, consequently, excess body fat, especially visceral fat mass. Modern scientific research has now accumulated a lot of materials that indicate the key role of lifestyle, mainly nutrition and the level of physical activity, in preventing and even getting rid of metabolic syndrome [13]–[16]. The main recommendation of modern scientists to avoid or get rid of metabolic syndrome is to reduce visceral fat mass, which is positively related to total body fat mass. To achieve this, a person needs to maintain a healthy body weight, which depends on the level of physical activity and dietary habits. Habits in nutrition and physical activity are formed in childhood [11], [12], [16]. Also, in childhood, an “ideal image” of oneself is formed, that is, an idea of what a healthy, beautiful body should be like. Habits in movement and nutrition are formed from early childhood [12], [16], [17], but this is especially characteristic of the puberty period [18]–[20]. Therefore, the purpose of physical education is to develop habits of movement and healthy eating, since these habits are key to preventing obesity and the development of metabolic syndrome as a result. To formulate strategies in the physical education of schoolchildren to prevent metabolic syndrome, it is first necessary to identify the number of children with overweight and obesity. Knowing the state of the issue about the number of children with overweight and obesity is the first step towards preventing such an unpleasant phenomenon as overweight and obesity in children, and, consequently, reducing the risk of developing metabolic syndrome both in the future and in the present [21]–[23]. It should also be noted that overweight children have a lower level of quality of life due to physical and psychological problems [24], [25]. Problems of a physical nature are associated with difficulties in movement, since controlling a body with a mass greater than the optimal value for a given age is much more difficult than controlling a body with normal body weight. People with excess body weight have reduced endurance, as well as relative strength indicators. This leads to difficulties in

coordination and mastering new movements. Thus, a vicious circle is formed: a lack of movement with an excess of calories leads to an increase in body fat mass, and an increase in body fat mass leads to a decrease in motor capabilities, and, accordingly, to a decrease in the level of physical activity and an even greater increase in body fat mass [26], [27]. Psychological difficulties are associated with a violation of the aesthetics of the body with excess fat mass. This can cause psychological frustration, a reluctance to communicate not only with their peers, but also with people of a different age. This also often leads to humiliation of overweight and obese children by their peers, which further strengthens the psychological problem and leads the child to a reclusive lifestyle. This, in turn, leads to an even greater decrease in physical activity, to “eating” stress, and, accordingly, to an even greater increase in body weight [24], [25].

Therefore, the problem of having even a small percentage of children with overweight and obesity is currently very relevant due to the need to preserve and strengthen the health of the population, reduce the risk of cardiovascular diseases, improve psychological state of people, and especially children. The first step to developing ways to solve this problem is to identify the number of children with excess body weight in prepubertal and pubertal age, as well as to identify the dynamics of changes in body weight in children of prepubertal and pubertal age, that is, ages from 10 to 14 years. The data obtained will serve as the basis for developing strategies to overcome and prevent overweight in children of each age group studied.

Purpose of the Work: to identify the characteristics of age groups of children from 10 to 14 years old in terms of the ratio of body weight and length, in particular, the relative number of children with overweight and obesity, and to develop recommendations for reducing body weight for children 10-14 years old.

2. Method

A. Participants

An observational cross-sectional survey of the health status (overweight and obesity) of school children was conducted on sample 500 school children from Bosnia and Herzegovina (Republic Srpska entity), which included 246 boys and 254 girls, aged 10 to 14 years. Data collection was carried out in the period from March to May 2019. Characteristics of study participation were included in Table 2.

B. Study Design

The study was conducted in elementary schools in the territory of the Municipality of Pale, which is part of the City of East Sarajevo. The municipality is located in the southeastern part BIH with an area of 493km², with 22,000 inhabitants and 820 m above sea level. It is mainly an area on the mountainous terrain between the mountains of Romanija, Jahorina, Trebević, Ozren (geographically defined as the Sarajevo-Romania region), with an altitude of 624m to 1916m. The

demography of the area is characterized by, among other things, faster population growth.

C. Anthropometry

Anthropometric data including Body height (BH), Body weight (BW) and age were collected from all elementary school children. The standard metric instruments were applied, Stadiometer - used for measuring body height (SECA 206, Germany) and body weight digital scale (BEURER Typ 35, Germany) and ASTRA SCALE with height meter – 200 kg (GIMA, ITALY). Body height was measured to the nearest 0.5cm according to the standard procedure, with the children standing upright without shoes, with hips and shoulders perpendicular to the central axis, feet and knees together, and the head in the Frankfurt plane. Body weight was measured to the nearest 0.1kg using a scale. Body mass index (BMI) is an anthropometric index of weight and height that is calculated by dividing a person's weight (kg) by the square of their height (m²). Because children and teenagers grow, height, weight, and BMI ranges vary by age and gender. As a result, BMI values must be expressed in relation to other children of the same sex and age. BMI participants was estimated with the Percentile BMI calculator for children and teens aged 2-19 years. (<https://www.cdc.gov/healthyweight/bmi/calculator.html>). The studied children were defined as underweight, normal (healthy)-weight, overweight and obese according to the CDC child growth characteristics for age, sex, and BMI (Table 1).

D. Ethical Consideration

The goals of the research were communicated to the children, and participation was completely voluntary. Informed consent forms were signed by the parents before the start of the study. Children for whom the written consent of the parents was not confirmed were excluded from the research (a total of 17 such children). The research was carried out in accordance with the professional and ethical standards of the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 2013)

E. Statical Software

Statical software (G*Power, v3.1.9.7, Heinrich-Heine-Universität, Düsseldorf, Germany) was used to calculate the sample 34. The combination of tests used in the statistical software to calculate the sample size was as follows: (a) x² tests, (b) goodness-of-fit tests: Contingency tables y (c) a priori: Compute required sample size – given α , power, and effect size. Tests considered two tails, effect size $w = 0.50$, α -error probability = 0.05, power ($1-\beta$ error probability) = 0.8.

F. Statistical Analysis

Basic central and dispersion parameters (Mean, Min., Max., Range, SD, CI 95%, CV%, Skew., Kurt.) were calculated for each variable. To confirm normality, the Kolmogorov-Smirnov test was applied ($p > 0.05$). The homogeneity of

variance was tested with Levene's test. The nutritional status of the subjects was assessed using percentile values on the basis of which the percentile categories are calculated. Statistical procedures and analyzes were performed using the statistical package STATISTICA 10.0 for Windows (StatSoft, Inc., Tulsa).

3. Results

Table 2 contains the basic central and dispersion parameters of the investigated cause of boys and girls in the segment of morphological characteristics (body height, body mass and BMI). On the basis of the obtained statistical parameters of the entire sample, a positive trend of growth in the average values of the height and mass of the respondents in both sexes is evident, and on the basis of which the BMI is also categorized.

This is confirmed by the fact that a positive growth trend was recorded in boys from 10 to 14 years old with an increase in height by 25 cm and an increase in body weight by 20 kg, and a slightly smaller trend in girls with an increase in height by 17 cm and an increase in weight of about 18 kg. This four-year period (10-14 years) of growth and development that defines the studied population includes the pre-puberty and puberty phase, so symmetric and often asymmetric numerical changes in the measured anthropometric parameters of both sexes are mostly evident. In our sample, at the age of 10, boys and girls recorded an almost identical average height, while body mass increased in favor of boys by about 4 kg. An almost identical trend defines the age of 11 years, where male students are on average taller by about 1.5 cm and heavier by about 4 kg compared to female students. This relationship at the age of 12 is mostly inverse, because girls are now on average about 1 cm taller and about 2 kg lighter than boys. The age of the respondents of 13 and 14 is determined by a higher numerical value, which allows for a significant advantage of boys in height and body mass compared to girls. In this regard, the average difference in height is about 2 cm at the age of 13 and even 8 cm at the age of 14 compared to girls. The present morphological changes in growth and development are inevitable and are a consequence of the acceleration of both sexes, especially males. An analysis of the range of minimum and maximum results within the same gender and age shows significantly higher quantitative indicators in the domain of body height, body mass and BMI. The boys' numerical differences in height ranged from 32-46cm and 31-48kg in body mass. The girls recorded a range in body height, 29-32cm and 30-39kg in body mass. All this gives one picture of the heterogeneity of the student population, the present acceleration of growth and development, which can be used for a deeper and clearer analysis of the physical and health status, in our case the state of normal nutrition or obesity of the students.

The discrepancy between body height and body mass gives a lower or higher BMI value, which is a good indicator of the nutritional status of the subjects and their health and nutritional habits. A growing global epidemic of childhood

Weight Status Category	Percentile range
Underweight	Less than the 5th percentile
Healthy Weight	5th percentile to less than the 85th percentile
Overweight	85th percentile to less than the 95th percentile
Obesity	95th percentile or greater
Severe Obesity	120% of the 95th percentile or greater OR 35 kg/m ² or greater

Table 1: Weight status category (Center for Disease Control and Prevention, 2000)

Age	Gender	Parameters	Mean ± SD	Min.	Max.	Rang	CI 95%		Skew	Kurt.
							Difference	CV%		
10	Male (n=49)	BH (cm)	150.04 ± 9.27	126.00	167.00	41.00	7.74 - 11.55	6.18	-0.62	0.45
		BW (kg)	41.65 ± 7.77	28.00	75.00	47.00	6.49 - 9.68	18.66	1.81	6.33
		BMI (kg/m ²)	18.51 ± 2.78	15.09	27.89	12.80	2.32 - 3.46	15.02	1.56	2.59
	Female (N=51)	BH (cm)	150.25 ± 7.94	132.00	165.00	33.00	6.64 - 9.87	5.28	-0.07	-0.52
		BW (kg)	37.94 ± 6.73	24.00	63.00	39.00	5.63 - 8.37	17.75	0.80	2.53
		BMI (kg/m ²)	16.80 ± 2.35	11.41	23.71	12.30	1.97 - 2.92	13.99	0.37	0.54
11	Male (n=49)	BH (cm)	157.71 ± 7.28	140.00	172.00	32.00	6.07 - 9.09	4.61	0.21	-0.28
		BW (kg)	47.68 ± 10.31	27.00	80.00	53.00	8.60 - 12.88	21.62	0.76	1.05
		BMI (kg/m ²)	19.12 ± 3.16	12.00	27.18	15.18	2.63 - 3.95	16.52	0.34	0.34
	Female (n=51)	BH (cm)	156.04 ± 7.67	141.00	170.00	29.00	6.42 - 9.54	4.92	-0.03	-0.91
		BW (kg)	43.37 ± 8.00	30.00	69.00	39.00	6.70 - 9.95	18.45	0.83	0.84
		BMI (kg/m ²)	17.71 ± 2.29	13.67	25.10	11.43	1.92 - 2.85	12.94	0.98	1.65
12	Male (n=49)	BH (cm)	162.33 ± 8.67	138.00	184.00	46.00	7.23 - 10.83	5.34	-0.31	0.65
		BW (kg)	49.39 ± 7.62	35.00	66.00	31.00	6.35 - 9.51	15.42	0.00	-0.36
		BMI (kg/m ²)	18.74 ± 2.74	13.75	25.46	11.71	2.29 - 3.42	14.63	0.45	-0.33
	Female (n=51)	BH (cm)	163.04 ± 7.09	148.00	180.00	32.00	5.93 - 8.81	4.35	0.03	-0.07
		BW (kg)	47.63 ± 7.24	33.00	67.00	34.00	6.05 - 8.99	15.19	0.59	0.27
		BMI (kg/m ²)	17.82 ± 2.09	14.20	22.38	8.18	1.75 - 2.60	11.74	0.40	-0.78
13	Male (n=48)	BH (cm)	171.83 ± 7.31	153.00	188.00	35.00	6.08 - 9.15	4.25	-0.14	0.83
		BW (kg)	58.77 ± 10.08	43.00	90.00	47.00	8.39 - 12.63	17.16	0.62	0.48
		BMI (kg/m ²)	19.84 ± 2.51	14.88	25.47	10.59	2.09 - 3.15	12.67	0.11	-0.40
	Female (n=52)	BH (cm)	169.22 ± 6.65	155.00	185.00	30.00	5.56 - 8.27	3.93	0.35	-0.37
		BW (kg)	55.66 ± 9.18	41.00	88.00	47.00	7.68 - 11.41	16.49	0.91	1.92
		BMI (kg/m ²)	19.35 ± 2.64	14.53	27.77	13.24	2.21 - 3.28	13.66	0.44	0.90
14	Male (n=51)	BH (cm)	175.14 ± 9.51	156.00	195.00	39.00	7.94 - 11.85	5.43	-0.16	-0.71
		BW (kg)	61.56 ± 10.73	37.00	85.00	48.00	8.97 - 13.38	17.44	0.07	-0.27
		BMI (kg/m ²)	19.93 ± 2.57	13.76	28.40	14.64	2.15 - 3.20	12.88	0.79	2.08
	Female (n=49)	BH (cm)	167.54 ± 6.72	155.00	182.00	27.00	5.62 - 8.38	4.01	0.40	-0.78
		BW (kg)	55.66 ± 7.46	40.00	72.00	32.00	6.23 - 9.30	13.41	0.23	-0.34
		BMI (kg/m ²)	19.80 ± 2.10	15.63	24.79	9.16	1.75 - 2.62	10.60	-0.07	-0.46

Table 2: Basic statistical parameters of school children

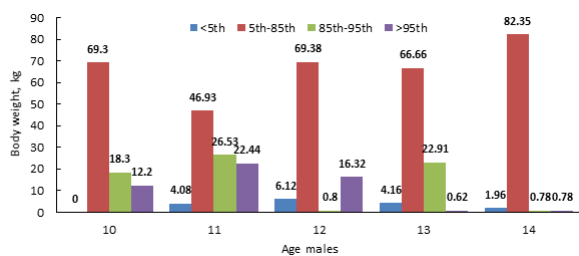


Figure 1: Distribution of weight status by age for males

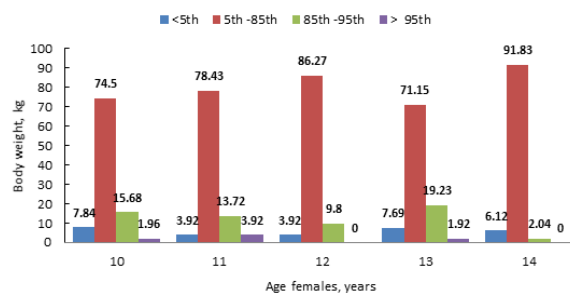


Figure 2: Distribution of weight status weight by age for females

obesity is evident, with large variations in secular trends across countries. Because of this, effective programs and policies are necessary at the global, regional and national level in order to limit the problem among children.

The increase in the number of children with increased body weight, both in developed and developing countries, causes concern for society as a whole. Primarily because of the direct and indirect impact on the health of the population, and then also because of significant economic consequences.

Changes in the lifestyle and functioning of modern families, as well as the positive increase in body mass values, and therefore the body mass index (BMI), have favored the increase in the frequency of obesity at school age.

Looking in general (Table 3, 4), in the Municipality of Pale (Sarajevo-Romania region) and based on the results of

the conducted research, in which a total of 500 students (10-14 years old) participated, 72 (14.4%) children with increased body mass were recorded, while 36 (7.29%) were obese, which is a total of 108 (21.6%) students. Looking at boys and girls separately, it can be noted that obesity is more prevalent in boys (13%) compared to girls (1.6%). More specifically, out of a total of 246 boys, 73 of them (29.67%) had an increased body weight or were obese, while out of a total of 254 girls, 35 (13.78%) had an increased body weight or were obese, which is twice less than boys. Of all study participants, as many as 74% (369) of students are in the healthy weight category, of which 67.07% (165) are boys and 80.31% (204) are girls, which is a good result, especially for female respondents. In addition, it is worth mentioning that 23 (4.58%) students in the category are malnourished, and that, when viewed separately, in this case, there are more malnourished girls than boys. Namely, 15 (5.90%) girls were malnourished, while for boys this number is slightly lower, and it amounts to 8 (3.26%).

The analysis of the results of boys by age (Table 3, Figure 1) recorded the most overweight boys, 13 (26.53%) and obese 11 (22.44%) at the age of 11, while 23 of them (46.93%) were in the healthy category (healthy weight). The lowest number of overweight and obese students was recorded at the age of 14 (1% <). Also, this age recorded the largest number of subjects characterized by a healthy weight, 42 (82.35%). In general, most males are characterized by a normal healthy weight (age 14 years), followed by ages 10, 12 and 13 (66% - 69%). The results of malnutrition in boys point to the conclusion that it is present in a smaller percentage, from 1.96% (age 14) to 6.12% (age 12). If we look at the number of respondents by age, then it is negligible.

The sample of girls (Table 4, Figure 2) is characterized by a somewhat different distribution of results that are "healthily" better than the results of boys. The largest number of girls at the age of 13 were overweight, 10 (19.23%) and obese (2% <), and then at the age of 10 and 11 (overweight 15.68% vs. 13.72%, and obesity 1.96% vs 3.92%). This population was also defined by an extremely high percentage of healthy weight (>80%), and girls aged 14 and 15 (91.83%) were in the lead. Then follow the ages of 12 years, 44 (86.27%), 11 years, 40 (78.43%) and 10 years, 38 (74.50%). Malnutrition as a category is in a slightly higher percentage than for boys, ranging from 3.92% (11 and 12 years) to 7.84% (10 years).

4. Discussion

The relevance of this study is reflected in the fact that this is the first study in Bosnia and Herzegovina (the entity Republic Srpska) on the population of respondents of school age 10-14 years, which was created as a result of the lack of research on the prevalence of overweight and obesity among school children. The purpose of our study was achieved: we identified the number of overweight children aged 10 to 14 years.

According to the results of this research, every 1.5 children (74%) have a healthy body weight, 22 children have

malnutrition (4.6%), every 7th child (14.4%) is overweight, and every 14th child is obese (7.2%) one could say, it is not worrying, it is even in the category of good average. Considering that obesity is said to have reached global proportions, and therefore its development is monitored, and in addition, for the sake of easier insight into the condition of primary school-age children of the Municipality of Pale, comparisons of the same with values abroad, the table below presents percentages values recorded in EU countries and the USA.

Our results on the percentage of overweight and obese female children in Bosnia and Herzegovina (13.77%) are almost identical to the results of Belgium (13.5%) and Norway (13.8%), which is a good parameter. All other countries (26) have a higher percentage of obese girls than our sample. The male sample recorded a lower percentage of overweight and obesity only than the sample of Albania (74%), Greece (44.4%), Italy (37.2%) and Spain (32.3%), which categorizes it in countries with increased overweight (Table 5).

It is important to know that, for the purpose of this research, as well as in all the results presented in the table below (Table 5), except in the USA, the percentage of obese and overweight children was determined based on the guidelines and limit values established by the World Health Organization. In the USA, due to the complexity of the population structure, the methodology established by the CDC (Center for Disease Control and Prevention) was used, which has minimal deviations from the one established by the WHO.

Age male, years	Underweight <5th		Healthy Weight 5th - 85th		Overweight 85th - 95th		Obesity >95th	
	N	%	N	%	N	%	n	%
10 (n=49)	-	-	34	69.3	9	18.3	6	12.2
11 (n=49)	2	4.08	23	46.93	13	26.53	11	22.44
12 (n=49)	3	6.12	34	69.38	4	0.8	8	16.32
13 (n=48)	2	4.16	32	66.66	11	22.91	3	0.62
14 (n=51)	1	1.96	42	82.35	4	0.78	4	0.78
Total n=246	8	3.26	165	67.07	41	16.66	32	13

Table 3: Weight Status category of males

Age female, years	Underweight <5th		Healthy Weight 5th-85th		Overweight 85th-95th		Obesity >95th	
	n	%	n	%	N	%	N	%
10 (n=51)	4	7.84	38	74.50	8	15.68	1	1.96
11 (n=51)	2	3.92	40	78.43	7	13.72	2	3.92
12 (n=51)	2	3.92	44	86.27	5	9.80	-	-
13 (n=52)	4	7.69	37	71.15	10	19.23	1	1.92
14 (n=49)	3	6.12	45	91.83	1	2.04	-	-
Total (n= 254)	15	5.90	204	80.31	31	12.20	4	1.57

Table 4: Weight status category of females

Country	Albania	Austria	Belgium	Bulgaria	Denmark	Finland	France	Greece	Holland	Ireland	Iceland	Italy	Norway	Germany	Portugal	Romania	Russia	USA	Slovenia	Serbia	Spain	Sweden	Switzerland	Turkey	UK-England	UK-North Ireland	UK-Scotland	UK-Wales
Girls body weight percentage of overweight	69.5	21.2	13.5	29	21.1	19.1	14.9	37.7	15.4	28.9	25.5	34.7	13.8	17.6	30.6	22.7	17	29.5	22.7	19.4	29.5	20.9	17.8	16.4	27	33	28.8	25.5
Boys body weight percentage of overweight	74	20.2	16.9	29.1	29.3	23.6	13.1	44.4	16.8	19.4	22	37.2	15.1	22.6	25.2	24.6	17.3	29.7	27.4	18.9	32.3	13.3	17.2	16	22.7	25	27.6	27.4

Table 5: Percentage of overweight children in different countries based on recommendations and limits set by the World Health Organization

Although the identified number of children with overweight and obesity, according to some authors [11], [12], [16], may not yet cause concern, it is still necessary to pay attention to the need to prevent and overcome weight gain and obesity in children. Even one child with such disabilities should cause concern, since the value of the life and health of every person is the most important value in the world. Therefore, identifying even a relatively small number of overweight and obese children is far from a benign problem. It requires its own solution, helping such children understand their problem and overcome it. The dynamics of changes in the percentage of children with overweight and obesity from the prepubertal period to the middle of the puberty period, that is, from 10 to 14 years, was revealed. In boys, the largest number of overweight children is observed at the age of 10 years (18.3%), 11 years (26.53%) and 13 years (22.91%). Slightly different indicators were found for obesity rates in boys: the largest number of obese boys was identified in the age groups of 10-12 years: 12.2%, 22.44% and 16.32%, respectively. Thus, at 14 years of age, there is a decrease in the relative number of obese boys (Table 3). We can explain this by the fact that at the age of 14, male sex hormones are activated due to the development of puberty, which accelerate metabolism. This may also be due to the accelerated increase in body length in boys. In addition, boys at this age begin to care about their appearance and their figure, so they begin to pay more attention to physical exercise. The number of overweight boys also decreases at age 12. This may be due to the onset of puberty, when the body experiences a certain amount of stress, which leads to a decrease in relative body weight. Then, by the age of 13, boys begin to temporarily adapt to changes in the body, and relative body weight increases again. However, by the age of 14, it returns to normal due to the unfolding of the hormonal system aimed at puberty, as well as with psychological attitudes changing at this age.

In girls, similar dynamics are observed: the largest relative number of girls with overweight was identified at 10 years of age (15.68%), 11 years of age (13.72%) and 13 years of age (19.23%) (Table 4). At the age of 12, the relative number of girls with excess body weight is slightly smaller compared to the ages of 10, 11 and 13 years, but this value is more pronounced than in boys of this age group (Tables 3, 4). A similar picture is observed for the dynamics of the relative number of girls with obesity. We can explain the decrease in the relative number of girls with excess body weight by the age of 14 for psychological reasons: girls begin to care more about their appearance, take great care of their figure (engage in different types of physical activity, monitor nutrition, and so on).

However, if a child is overweight at any age, this should be a warning sign, as it can provoke weight gain in adulthood or with the slightest decrease in self-control. Therefore, the best strategy would be to create conditions for a child's development in which he will receive joy from other sources, and not just from food and activities that do not require

physical activity. Recommendations that can be given to parents, teachers and children themselves with overweight and obesity:

- 1) Learn (teach a child) to enjoy movement, simple food (vegetables, fruits, whole grain cereals, nuts, fish, etc.), and eating food slowly. Pleasure is the most powerful motivator for changing habits. A child cannot change the habit of moving little and eating high-calorie foods, because he enjoys it. The way to change this habit is to learn to enjoy movement and other foods that are healthier and lower in calories.
- 2) Learn (teach a child) to enjoy movement by trying different types of physical activity, without striving for quick success, by performing movements simply for the sake of movement. Any exercise can be suitable for these purposes. If a child cannot himself determine the type of physical activity that suits him best, he can be helped by determining his psychophysiological characteristics and selecting the type of physical activity based on the identified psychophysiological characteristics of the child [28]. If the type of physical activity is chosen correctly, then there is a much greater chance that the child will enjoy the movement. This means that he will engage in physical exercise, which will lead to normal body weight and an increase in quality of life.

However, the developed recommendations require experimental verification, and, consequently, additional research.

5. Conclusions

This study is the first in Bosnia and Herzegovina (the entity Republic Srpska, Municipality of Pale, Sarajevo-Romanian region), on the prevalence of overweight and obesity among school children. The following conclusions were reached:

- 1) In the Municipality of Pale (Sarajevo-Romanian region), according to the results of a study in which 500 schoolchildren (10-14 years old) took part, 72 (14.4%) children were registered as overweight, and 36 (7.29%) were obese, that is, only 108 (21.6%) students. Obesity is more prevalent in boys (13%) compared to girls (1.6%). More specifically, out of a total of 246 boys, 73 of them (29.67%) had an increased body weight or were obese, while out of a total of 254 girls, 35 (13.78%) had an increased body weight or were obese, which is twice less than boys.
- 2) The dynamics of changes in the relative number of children with overweight and obesity from 10 to 14 years old was revealed. The lowest number of overweight and obese students was recorded at the age of 14 (1% <). The results of malnutrition in boys point to the conclusion that it is present in a smaller percentage, from 1.96% (age 14) to 6.12% (age 12). This is due to the fact that at the age of 14, male sex hormones are activated due to the development of puberty, which accelerate metabolism. This may also

be due to the accelerated increase in body length in boys. In addition, boys at this age begin to care about their appearance and their figure, so they begin to pay more attention to physical exercise.

- 3) The largest number of girls at the age of 13 were overweight, 10 (19.23%) and obese (2%<), and then at the age of 10 and 11 (overweight 15.68% vs. 13.72%, and obesity 1.96% vs 3.92%). Malnutrition as a category is in a slightly higher percentage than for boys, ranging from 3.92% (11 and 12 years) to 7.84% (10 years). The decrease in the relative number of girls with excess body weight by the age of 14 can be explained by psychological reasons: girls begin to care more about their appearance, take great care of their figure (engage in different types of physical activity, monitor nutrition, and so on).
- 4) If a child is overweight at any age, this should be an alarming signal, as it can provoke weight gain in adulthood or with the slightest decrease in self-control. Therefore, the best strategy would be to create conditions for a child's development in which he will receive joy from other sources, and not just from food and activities that do not require physical activity. Finding even a relatively small number of overweight and obese children is not a benign problem. It requires its own solution, helping such children understand their problem and overcome it.

Conflict of interest

The authors declare no conflict of interests. All authors read and approved final version of the paper.

Authors Contribution

All authors contributed equally in this paper.

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