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GLYCEMIC INDEX AND GLYCEMIC LOAD OF THIRTEEN YEAR OLD CHILDREN WHOSE WAIST CIRCUMFERENCE (WC) ≥ 90 PERCENTILE DEPENDENT ON BMI

Zuzanna Goluch-Koniuszy, Magdalena Bonczek
West Pomeranian University of Technology in Szczecin

Background. One of the reasons for the accumulation of fat tissue (including visceral fat tissue) in the body is an unbalanced diet in respect of the amount and the structure of carbohydrates and the value of the glycemic index (GI) and the glycemic load (GL). The research describing the dependence between the BMI (Body Mass Index), WC (Waist Circumference), WHtR (Waist-to-Height Ratio), and GI and GL indexes in adults exists but only a limited number of works discuss children during the pubertal spurt. Therefore the objective of this research is the evaluation of the state of nutrition of 13-year-old children with waist circumference ≥ 90 percentile with various BMI, taking into consideration GL and GL of their meals.
Material and methods. The state of nutrition (BMI, WC, WHtR) of 871 thirteen-year-old children of both sexes was evaluated and 230 children with WC ≥ 90 percentile were selected (26.4% of the total number examined) and divided into three groups regarding the BMI. In 71 children (30.9% of the selected group) the method of nutrition, energy and nutritive value of menus, structure of consumption of food groups and GI and GL value were evaluated, on the basis of the analysis of their three day menus, which had been documented.
Results. Significantly higher values of BMI and WC were ascertained in boys than in girls. No essential differences in values of WHtR index were ascertained between boys and girls. The analysis of children's menus, in both sexes with a waist circumference ≥ 90 percentile showed, regardless of BMI value, a low realisation of recommended energetic value of the diet and low realisation of recommended supply of: dietary fibre, fat, mineral components (K, Ca, P, Mg, Fe, Zn, Cu), vitamins (E, B_1, PP) and liquids with simultaneous occurrence of protein in general and animal protein, sodium and vitamins (A, B_2, B_6) supply. A significantly higher supply of the most of aforementioned ingredients was ascertained in the boys' diets. In the girls' diets distinctive differences have been noticed dependent on the value of BMI index, in realisation of the recommended supply: Fe, vitamins A, B_1, and for the boys in realization of recommended supply of dietary fibre, K,

Corresponding author – Adres do korespondencji: Dr inż. Zuzanna Goluch-Koniuszy, Department of Human Nutrition Physiology of West Pomeranian University of Technology in Szczecin, Papieża Pawła VI/3, 71-451 Szczecin, Poland, e-mail: Zuzanna.Goluch-Koniuszy@zut.edu.pl

Ca, vitamins A, B_2, C and liquids. The Glycemic Index and Glycemic Load of the basic meals – breakfasts, dinners and suppers – and an average GI and GL of meals from three days was significantly higher for the girls than for the boys. Depending on the BMI, the GI and GL value of basic meals and that of the average of three days were not statistically significant for the girls, although for obese boys they were significantly higher in breakfasts, dinners and suppers than for the boys with normal weight and overweight boys.
Conclusions. In thirteen-year-old children with abdominal obesity, regardless of their BMI Index values, numerous dietary mistakes were ascertained, for example: improper number of meals during the day, resignation from basic meals and frequent snacking, unbalanced diet, improper consumption of basic food groups and medium GI and high GL of meals. Children's diet might be the cause of the existing state of nourishment, including visceral obesity; it might predestine deeper disturbances in carbohydrate-lipid metabolism and that is why nutrition education in primary schools is necessary.

Key words: Glycemic Index, Glycemic Load, Waist Circumference, Body Mass Index, Waist-to-Height Ratio, children

INTRODUCTION

The presented results are a part of research constituting a unique three-year program, co-funded by the Department of Health and Social Policy of the City of Szczecin (WZiPS-IV/PiPZ – 1/07, CRU 2747/07; WZiPS-IV/.../08, CRU 4488/2008), which evaluates the state of nutrition, the nutrition methods in Szczecin secondary schools, nutrition education and the effects of this education by means of a questionnaire.

The state of nutrition, changing with age [Beaufrère and Morio 2000], is determined by nutrition, by the intake as well as the digestion of the nutritive ingredients, their absorption and utilization. The amount of energy coming from food and spent on growth and development processes should be balanced, because deficiencies and excesses of the nutritive components in a diet can lead to growth and development disturbances, immunity disturbances, weakening of cognitive functions as well as the development of lifestyle diseases. The period of pubertal spurt is connected to several somatic, physiological, social and psychological changes and during this period a proper diet should ensure a development consistent with the genetic potential [Steinberger et al. 2009]. Actually the age of 13 is the first moment when the changes which predetermine insulin immunity, as well as cardiovascular disorders in the future should be caught [Baker at al. 2007].

The problem of excessive weight and obesity among children, metabolic and health complications connected with it and its nutrition foundation have already been well researched [Garnett et al. 2005, Goluch-Koniuszy et al. 2009, Goluch-Koniuszy and Fugiel 2009, Goran and Grower 1999, Taskali et al. 2008]. However, there are only few studies in the aspect of nutrition concerning children with proper body mass but too much fat tissue concentrated around the abdomen, described as MONW (*metabolically obese normal weight*), whose characteristic feature is lower sensitivity of the tissue to insulin [Dvorak et al. 1999]. Children with proper BMI but visceral accumulation of fat tissue can have a changed body composition (increased percentage of fat tissue, decreased percentage of fat free body mass, decreased amount of water in the body), which predestinates carbohydrate-lipid metabolic disorder. One of the reasons of visceral fat tissue accumulation is an unbalanced diet in regard of the amount and structure of carbohydrates and glycemic index and glycemic load. Barclay et al. [2008] in his research confirmed that consumption of products which have a low Glycemic index (GI), and Glycemic load (GL) and are rich in dietary fiber lowers the risk of diabetes and heart diseases and confirmed the hypothesis that high postmeal glycaemia is a universal mechanism in the progress of these diseases.

That is why the target of this study was the evaluation of the nutrition of 13-year-olds with a waist circumference ≥ 90 percentile with various BMI, taking into consideration the GL and GL of meals.

MATERIAL AND METHODS

After obtaining the approval of Local Ethical Commission (BN-001/93/07), the research was conducted in the years 2007-2008 among 871 thirteen-year-old pupils (431 girls and 440 boys) of 44 first classes of randomly selected 11 junior high schools in Szczecin (26.9% of the total number of schools). The selection of classes held by cluster sampling.

The children were anthropometrically examined, that is their body mass was measured with medical scales (legalized and standardized to 0.1 kg without shoes and in light clothes), body height in Frankfurt position with height meter attached to the medical scale accurate to 0.5 cm. The waist circumference (WC) measurement was taken midway between the tenth rib and the iliac crest accurate to 0.5 cm a non-elastic flexible tape measure was employed with the subject in a standing position [WHO 1995].

From the obtained measurements BMI (*Body Mass Index*) was calculated according to the formula: body mass, kg/height, m^2. WC index (*Waist Circumference*) and WHtR (*Waist-to-Height Ratio*) was calculated according to the formula: waist circumference, cm/height, cm. The obtained values of the BMI index were referred (according to sex and age) to centile nets [Palczewska and Szilágyi-Pągowska 2002] and BMI value was assumed: ≤ 5 percentile as underweight; 10-75 percentile as normal weight, 85-95 as overweight, ≥ 95 percentile as obesity. The values of WC and WHtR indexes were referred to centile nets [Nawarycz et al. 2010, Nawarycz and Ostrowska-Nawarycz 2007] and for both indexes the assumed values were ≥ 90 percentile as a criterion of the location of the visceral fat tissue, a risk of the development of heart and cardiovascular diseases and impaired glucose tolerance. Table 1 shows average values of anthropometric features of the 13-year-old children from the groups under evaluation.

In spite of the fact that average values of BMI, WC, and WHtR did not point to something improper, their thorough analysis based on centile nets showed a significant percentage of people with improper nourishment. Based on the WC ≥ 90 percentile index value a group of 230 (26.4% of all children under evaluation, that is 126 girls and 104 boys, which is 14.5% and 11.9% of total number of children under evaluation) was picked from the group of 871 children with visceral location of fat tissue, which were divided according to the value of BMI index into three groups (Table 2).

The selected children with WC ≥ 90 percentile received proper training to be able to regularly record time, kind and amount of consumed food during three (24 hours) random chosen days of the week (one weekend day included). Only 71 children (30.9% of the chosen children that is 38 girls and 33 boys) of the 230 with visceral obesity regularly and accurately recorded 213 menus. The amount of consumed portions was defined

Table 1. Values of anthropometric attributes and the BMI, WC, WHtR indicators in 13-year old children, x ±SD, n = 871

Parameters and indices	Girls (n = 431)	Boys (n = 440)
Body weight, kg	52.2 ±9.5	54.5 ±12.1
Body height, cm	160.2 ±6.1	1.63 ±0.08
BMI, kg·m^{-2}	20.2 ±3.3	20.4 ±3.5
WC, cm	72 ±8.2	74.1 ±9.7
WHtR, cm/cm	0.449 ±0.05	0.454 ±0.05

Table 2. Percentage of 13-year old children with WC ≥ 90 percentile index value, depending on BMI index value, n = 230

Range of BMI	Girls (n = 126)		Boys (n = 104)	
	n	%	n	%
10-75 percentile (norm)	34	27.0	21	20.2
85-95 percentile (overweight)	47	37.3	42	40.4
≥ 95 percentile (obesity)	45	35.7	41	39.4

on the basis of the "book of portions, products and dishes" [Szponar et al. 2002]. The evaluation of energy and nourishment values of the menus was made, based on a computer program "Dietetyk 2009," defining the consumption of ingredients during each day and an average consumption in the last three days in which loss of the nutritive value of products was taken into account and then compared with nutrition standards at the level of prescribed RDA consumption for this age and sex group. The consumption of dietary fiber and cholesterol was referred to the recommended amount in obesity and other non-infectious diseases prevention (analogically > 25 g and < 300 mg) [Jarosz and Bułhak-Jachymczyk 2008]. After taking into consideration the amount of waste in consumed groups the obtained values were compared with prescribed food rations [Turlejska et al. 2006].

The average glycemic index (GI) of a meal was calculated by summation of GI for each food multiplied by the amount of carbohydrates in the food portion and divided by the total amount of carbohydrates in the meal. The glycemic load (GL) in a meal was calculated by the sum of products glycemic index for constituent food, multiplied by the amount of carbohydrate in each food and was evaluated by means of tables [Foster-Powell at al. 2002]. GI values of the edible products were assumed as following: GI < 55 low, GI = 56-70 medium, GI > 70 high. GL value was assumed for standard portions of edible products as follows: GL ≤ 10 little, GL = 11-19 medium, GL ≥ 20 big [Wolever et al. 2006]. The Glycemic load < 80 of a diet for the whole day was assumed as low 80-119 as medium and > 120 as high [Monro and Shaw 2008]. Significance of differences (at the level $p \leq 0.05$ and $p \leq 0.01$) in percentage realisation of basic standards of nutritive components, consumed food groups and average value of GI and GL of menus were evaluated by application of the Anova test for factors systems by using a computer program Statistica ®9.0.

RESULTS

Analysis of the value of BMI and WC indexes evaluated on the basis of the anthropometric data shows (Table 3) that they were significantly higher for the boys than for the girls. No significant differences were found in the value of WHtR index between the girls and the boys. However, both in the girls and the boys significantly higher values of WC and WHtR indexes were found for higher values of BMI.

Table 3. Anthropometric parameters and indices in the examined girls (n = 126) and boys (n = 104) with WC ≥ 90 percentile index value, x ±SD, n = 230

Parameters and indices		Sex X ±SD	Groups BMI 10-75 percentile	BMI 85-95 percentile	BMI ≥ 95 percentile	Effect sex (S)	group (G)	S × G
Body weight, kg	girls	60.5 ±7.6	56.7 ±6.6	59.4 ±5.4	64.7 ±8.9	**	**	**
	boys	67.7 ±15.2	56.0 ±11.2**Bb**	66.5 ±7.3**Ba**	83.6 ±14.7**A**			
Body height, cm	girls	161.0 ±7.8	165.9 ±9.0**A**	161.2 ±5.9**AB**	157.1 ±7.0**B**	*	–	–
	boys	165.7 ±7.9	161.8 ±11.1	167.3 ±8.6	168.1 ±9.0			
BMI, $kg \cdot m^{-2}$	girls	23.3 ±2.6	20.6 ±1.0**B**	22.8 ±0.8**B**	26.1 ±1.9**A**	**	**	**
	boys	24.4 ±4.2	21.2 ±12.0**Bb**	23.7 ±0.8**Ba**	29.5 ±4.3**A**			
WC, cm	girls	80.8 ±6.0	78.4 ±3.5**b**	79.2 ±3.6**b**	84.4 ±8.1**a**	**	**	**
	boys	86.3 ±9.7	82.2 ±4.1**B**	81.8 ±5.7**B**	97.9 ±9.8**A**			
WHtR, cm/cm	girls	0.502 ±0.04	0.474 ±0.02**B**	0.491 ±0.02**B**	0.537 ±0.04**A**	–	**	–
	boys	0.510 ±0.05	0.510 ±0.05**B**	0.490 ±0.04**B**	0.584 ±0.07			

a, b – means denoted with the different letters are statistically significant difference p ≤ 0.05.
A, B – means denoted with the different letters are statistically significant difference p ≤ 0.01.
*Statistically significant difference p ≤ 0.05.
**Statistically significant difference p ≤ 0.01.

The analysis of nutrition of 71 chosen children (213 menus) showed that the optimum number of meals a day is 5 (Table 4), which was eaten only by every third girl and boy with normal weight and every fourth girl with excess weight and obesity. However, the girls frequently had snacks between meals (6 and more meals) no matter what their BMI value was.

The most frequently eaten meals by the children who took part in the research were dinners and breakfasts. Both girls and boys, regardless of BMI, most often resigned from lunch and afternoon snacks (Table 5), while higher percentage of girls resigned from eating supper.

Meals in the diets of children under evaluation, regardless of their BMI, in which products containing animal protein appeared most frequently, were breakfasts (products

Table 4. The number of meals consumed daily by 13-year old children with WC ≥ 90 percentile in the term of interview, n = 71

Number of meals	BMI, %					
	10-75 percentile		85-95 percentile		≥ 95 percentile	
	girls	boys	girls	boys	girls	boys
1-2	–	–	–	8.3	–	–
3	–	10.0	–	36.1	12.8	33.4
4	16.6	23.3	35.6	50.0	28.2	51.8
5	36.7	36.7	26.7	5.6	25.6	7.4
6 and more	46.7	30.0	37.7	–	33.4	7.4

Table 5. Percentages 13-year old children with WC ≥ 90 percentile eating basic meals in the term of interview, n = 71

Meal	BMI, %					
	10-75 percentile		85-95 percentile		≥ 95 percentile	
	girls	boys	girls	boys	girls	boys
Breakfast	86.7	100	100	91.7	100	100
Lunch	67.6	50.0	73.3	44.4	41.0	48.1
Dinner	100	96.7	100	100	100	92.6
Afternoon snack	46.7	20.0	35.6	38.9	38.5	33.3
Supper	83.3	83.3	75.6	97.2	74.4	92.6

such as milk, cheese, melted cheese, eggs, cold meats, pluck), dinners (pork, poultry, less often fish) and suppers (analogically to breakfasts). Vegetables were mainly eaten as vegetable salads with dinners or as additions to sandwiches. Fruit mainly imported was mainly eaten with afternoon snacks (Table 6).

Analysis of menus (Table 7) for the boys and the girls with WC ≥ 90 percentile, regardless of their BMI value, showed a low recommended energetic value of the diet, a low supply of dietary fiber, fat, mineral components (K, Ca, P, Mg, Fe, Zn, Cu), vitamins (E, B_1, PP) and liquids with simultaneously high supply of protein in general and animal protein, sodium and vitamins (A, B_2, B_6). A significantly higher supply in most aforementioned components has been found in the boys' diet.

There were significant differences found among the girls with WC ≥ 90 percentile, depending on the value of their BMI index, in the supply of the recommended amount of iron and vitamin A and B_1, whereas among the boys significant differences were found in the supply of the recommended amount of dietary fiber, potassium, calcium, vitamins A, B_2, and C and liquids.

In the diets of evaluated children the participation of energy emerging from basic components differed from the recommended value; for the girls too much of energy came from the fats and saccharose and too little from proteins and carbohydrates, whereas for the boys too much energy came from proteins, fats and saccharose and too little from carbohydrates (Table 7).

Table 6. Composition of basic nutrients levels in daily food rations in 13-year old children with WC ≥ 90 percentile according to BMI in the term of interview, n = 71

Meal	Meal containing, %												No basic meal in daily diet, %		
	total animal protein			including protein from milk and products			fruits and vegetables			animal protein-free meals					
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Breakfast															
Girls	83.3	95.6	76.9	60.0	51.1	33.3	20.0	22.2	30.8	3.4	4.4	23.1	13.3	0.0	0.0
Boys	93.3	75.0	92.5	70.0	61.1	70.3	23.3	25.0	18.5	6.7	25.0	7.5	0.0	8.3	0.0
Lunch															
Girls	33.3	40.0	25.6	3.3	20.0	7.7	16.7	15.6	15.4	33.3	33.3	15.4	32.4	26.7	59.0
Boys	30.0	33.3	33.3	16.7	27.8	14.8	16.7	13.9	14.8	70.0	66.7	66.7	50.0	55.6	51.9
Dinner															
Girls	76.7	88.9	76.9	3.3	2.2	5.1	83.3	100.0	69.2	23.3	11.1	23.1	0.0	0.0	0.0
Boys	90.0	94.4	85.2	6.7	19.4	14.8	76.7	77.8	55.5	10.0	5.6	14.8	3.3	0.0	7.4
Afternoon snack															
Girls	13.3	8.9	7.7	13.3	8.9	7.7	13.3	11.1	25.6	33.3	26.7	30.8	53.3	64.4	61.5
Boys	10.0	11.1	7.4	6.7	8.3	7.4	13.3	19.4	22.2	90.0	88.9	92.6	80.0	61.1	66.7
Supper															
Girls	66.7	71.1	48.7	46.7	33.3	38.5	23.3	33.3	38.5	16.7	4.4	25.6	16.7	24.4	25.6
Boys	80.0	69.4	50.0	53.3	66.7	40.7	46.7	36.1	14.8	20.0	30.6	50.0	16.7	2.8	7.4

a – BMI 10-75 percentile, b – BMI 85-95 percentile, c – BMI ≥ 95 percentile.

Table 7. Energy value and basic nutrients levels in daily food rations consumed by the 13-years old children with WC ≥ 90 percentile according to BMI under research, n = 71

Com-po-nents	Groups						Sex % of daily allowance	Effect		
	X ±SD			% of daily allowance						
	BMI 10-75 percentile	BMI 85-95 percentile	BMI ≥ 95 percentile	BMI 10-75 percentile	BMI 85-95 percentile	BMI ≥ 95 percentile		sex (S)	group (G)	S×G
1	2	3	4	5	6	7	8	9	10	11
Energy, kcal										
Girls	1 722 ±529	1 746 ±746	1479 ±485	70.3 ±21.6	71.3 ±30.4	60.4 ±19.8	67.3 ±24.8	–	–	–
Boys	1 988 ±1 296	2 059 ±355	1965 ±278	66.3 ±9.9	68.6 ±11.8	65.5 ±9.3	67.0 ±10.3			
Total protein, g										
Girls	61.1 ±17.6	58.0 ±19.6	52.1 ±14.1	109 ±31.5	104 ±35.0	93.0 ±25.1	101 ±30.8	**	–	–
Boys	73.7 ±16.8	80.9 ±13.4	76.3 ±11.0	127 ±28.9	140 ±23.2	132 ±19.0	133 ±24.1			
Animal protein, g										
Girls	41.2 ±12.9	39.5 ±14.3	34.9 ±12.9	111 ±34.5	106 ±38.4	93.7 ±34.5	103 ±35.8	**	–	–
Boys	49.9 ±17.0	55.3 ±10.9	52.8 ±8.5	129 ±44.1	143 ±28.1	137 ±21.9	137 ±32.6			

Table 1 – cont.

1	2	3	4	5	6	7	8	9	10	11
Assimilable carbohydrates, g										
Girls	225 ±75	231 ±113	192 ±73.4	173 ±58.0	177 ±86.6	147 ±56.4	166 ±69.9	–	–	–
Boys	215 ±43	218 ±28.9	203 ±47.8	165 ±32.8	168 ±22.3	156 ±36.8	163 ±29.8			
Dietary fibre, g										
Girls	13.5 ±4.1	12.9 ±4.0	11.8 ±4.1	54.1±16.4	51.5 ±15.8	47.3 ±16.4	50.8 ±16.0	**	–	–
Boys	16.3 ±4.2	18.6 ±5.4	14.3 ±1.1	65.2 ±16.8**ab**	74.4 ±21.7**a**	57.3 ±4.6**b**	66.7 ±17.9			
Total fat, g										
Girls	63.2 ±20.1	64.5 ±28.5	54.9 ±19.7	77.1 ±24.5	78.7 ±34.8	67.0 ±24.0	74.2 ±28.6	–	–	–
Boys	82.7 ±18.7	86.0 ±24.0	84.6 ±11.0	82.7 ±18.7	86.0 ±18.7	84.6 ±11.0	84.5 ±18.9			
Cholesterol, mg										
Girls	349 ±121	294 ±219	208 ±113	116 ±40.5	98.1 ±32.8	69.5 ±37.9	93.1 ±56.8	**	–	*
Boys	345 ±151	400 ±147	475 ±214	115 ±50.3	133 ±49.1	159 ±71.4	134 ±57.1			
Sodium, mg										
Girls	1 592 ±604	1 599 ±590	1 379 ±378	106 ±40.3	107 ±39.3	91.9 ±25.2	101 ±95.2	**	–	–
Boys	1 931 ±717	2 211 ±843	2 586 ±727	123 ±47.8	147 ±56.2	173 ±48.5	148 ±52.7			
Potassium, mg										
Girls	2249 ±761	2449 ±746	1979 ±658	47.9 ±16.4	52.1 ±15.9	42.1 ±14.0	47.6 ±15.6	**	*	
Boys	2776 ±517	3045 ±759	2352 ±396	59.1 ±11.0**ab**	64.8 ±16.1**a**	50.0 ±8.4**b**	58.9 ±13.8			
Calcium, mg										
Girls	672 ±291	557 ±353	450 ±161	51.7 ±22.4	42.9 ±27.1	34.6 ±12.4	42.4 ±22.2	**	–	–
Boys	634 ±228	898 ±273	678 ±255	48.7 ±17.6**b**	69.1 ±21.0**a**	52.1 ±19.6**ab**	57.7 ±21.1			
Phosphorus, mg										
Girls	1 032 ±310	999 ±360	824 ±171	82.6 ±24.8	80.0 ±28.8	65.9 ±13.7	75.8 ±24.0	**	–	–
Boys	1 165 ±212	1 328 ±227	1 239 ±211	93.2 ±16.9	107 ±18.1	99.1 ±16.9	99.9 ±17.8			
Magnesium, mg										
Girls	208 ±74.6	220 ±70.9	179 ±52.9	57.7 ±20.7	61.2 ±19.7	49.6 ±14.7	56.3 ±18.6	–	–	–
Boys	241 ±36.4	265 ±59.8	235 ±49.4	58.8 ±8.9	64.6 ±14.6	57,2 ±12,0	60.7 ±12.3			
Ferrum, mg										
Girls	10.0 ±2.8	8.9 ±3.7	7.2 ±1.6	66.8 ±18.4**a**	59.6 ±24.5**ab**	47.9 ±10.7**b**	57.5 ±20.1	**	–	–
Boys	9.5 ±1.7	10.4 ±2.4	9.6 ±1.9	79.4 ±14.2	86.7 ±20.2	80.0 ±15.9	82.4 ±17.1			
Zinc, mg										
Girls	7.5 ±1.9	7.3 ±2.6	6.3 ±1.5	82.9 ±20.6	81.4 ±29.0	70.2 ±16.5	78.0 ±23.3	–	–	–
Boys	9.2 ±2.0	9.6 ±1.9	10.2 ±1.7	83.2 ±18.0	86.9 ±17.4	92.5 ±15.1	87.2 ±16.9			
Copper, mg										
Girls	0.9 ±0.3	0.8 ±0.3	0.7 ±0.2	95.6 ±32.2	91.1 ±38.6	76.2 ±23.0	78.0 ±23.3	**	–	–
Boys	0.9 ±0.1	1.2 ±0.3	1.0 ±0.2	104.8 ±14.9	128.3 ±38.9	114 ±18.1	87.2 ±16.9			

Table 1 – cont.

1	2	3	4	5	6	7	8	9	10	11
Retinol equivalent, µg										
Girls	1 567 ±1 428	645 ±383	505 ±245	224 ±204**A**	92.1 ±54.8**B**	75.8 ±41.3**B**	120 ±25.3	–	–	**
Boys	686 ±241	1 322 ±706	858 ±439	76.3 ±26.8**b**	147 ±78.5**a**	84.9 ±32.9**b**	109 ±64.3			
Vitamin E, mg										
Girls	7.5 ±3.4	8.4 ±4.4	6.1 ±3.3	93.8 ±42.3	105 ±55.2	75.8 ±41.3	92.2 ±48.0	–	–	–
Boys	7.8 ±3.2	9.0 ±3.7	8.5 ±2.3	77.7 ±32.3	89.8 ±37.0	84.9 ±32.9	84.4 ±33.7			
Vitamin B_1, mg										
Girls	1.0 ±0.4	1.1 ±0.4	0.9 ±0.3	88.1 ±34.9	97.7 ±34.7	82.4 ±27.1	89.9 ±32.3	–	–	–
Boys	1.2 ±0.4	1.2 ±0.4	1.1 ±0.1	99.5 ±32.0	99.7 ±29.4	89.1 ±10.1	96.7 ±26.3			
Vitamin B_2, mg										
Girls	1.7 ±0.6	1.4 ±0.8	1.1 ±0.3	152 ±55.4**a**	128 ±68.6**ab**	96.4 ±30.1**b**	123 ±57.5	–	–	–
Boys	1.4 ±0.3	1.7 ±0.3	1.5 ±0.3	108 ±22.1	128 ±25.9	116 ±21.2	118 ±24.4			
Vitamin B_6, mg										
Girls	1.3 ±0.5	1.5 ±0.5	1.2 ±0.4	112 ±45.3	127 ±41.1	96.9 ±30.7	113 ±40.2	–	–	–
Boys	1.6 ±0.5	1.7 ±0.5	1.5 ±0.3	124 ±34.7	133 ±35.0	118 ±19.8	126 ±31.2			
Niacin, mg										
Girls	11.1 ±4.1	11.9 ±3.2	9.4 ±2.7	79.3 ±29.1	85.1 ±22.7	67.2 ±19.2	77.4 ±24.1	–	–	–
Boys	14.2 ±4.4	13.5 ±3.7	12.4 ±1.5	88.6 ±27.5	84.2 ±23.3	77.4 ±9.6	83.8 ±21.9			
Vitamin C, mg										
Girls	69.1 ±52.8	76.7 ±45.4	69.1 ±55.6	106 ±81.2	118 ±69.8	104 ±85.5	111 ±76.5	–	–	–
Boys	77.3 ±62.5	79.9 ±32.3	33.8 ±17.9	103 ±83.3**a**	107 ±43.1**a**	45.0 ±23.8**b**	88.6 ±61.2			
Water, g										
Girls	1 025 ±367	993 ±323	1 049 ±415	46.6 ±16.7	45.1 ±14.7	47.7 ±18.9	46.4 ±16.3	**	–	–
Boys	1 252 ±433	1 180 ±265	899 ±195	41.7 ±14.5**a**	39.3 ±88**a**	30.0 ±6.5**b**	37.6 ±11.3			
Protein, % energy										
Girls	14.5 ±2.2	14.0 ±2.2	14.7 ±3.5	97.0 ±14.6	93.7 ±14.5	97.8 ±23.3	96.0 ±17.6	**	–	–
Boys	15.0 ±2.6	16.2 ±2.3	16.1 ±0.9	107 ±18.4	115 ±16.6	115 ±6.6	113 ±15.3			
Fat, % energy										
Girls	32.9 ±4.9	32.9 ±6.3	32.4 ±4.7	110 ±16.3	110 ±21.1	108 ±15.8	109 ±17.7	**	–	–
Boys	36.9 ±6.0	36.7 ±4.7	38.9 ±3.6	123 ±20.1	121 ±15.7	130 ±11.9	125 ±16.2			
Carbohydrates, % energy										
Girls	52.6 ±4.7	53.0 ±7.0	52.9 ±6.5	95.6 ±8.5	96.4 ±12.7	96.2 ±11.8	96.1 ±11.2	**	–	–
Boys	48.1 ±6.5	47.2 ±3.5	45.0 ±4.0	85.9 ±11.7	84.2 ±6.2	80.4 ±7.1	83.7 ±8.6			
Sucrose, % energy										
Girls	12.7 ±3.3	14.2 ±5.9	14.0 ±7.7	127 ±32.9	142 ±58.5	140 ±76.8	138 ±59.3	**	–	–
Boys	10.0 ±6.1	10.0 ±4.0	7.9 ±3.0	100 ±60.7	101 ±40.1	79.1 ±30.0	94.6 ±45.5			

a, b – means denoted with the different letters are statistically significant difference $p \le 0.0$.
A, B – means denoted with the different letters are statistically significant difference $p \le 0.01$.
*Statistically significant difference $p \le 0.05$.
**Statistically significant difference $p \le 0.01$.

The anomaly in nutritive components supply resulted from a low consumption of wheat products, vegetables and fruit, leguminous plants and nuts, milk and its products and fish, and too high consumption of eggs, sugar and sweets by the children who took part in the research. The girls differed significantly, depending on their BMI index value, in the intake of the recommended animal and plant fats and the boys in the intake of recommended supply of potatoes and vegetables (Table 8).

Table 8. Consumption of the selected of product in daily food rations by the 13-year old children with WC ≥ 90 percentile according to BMI under research, n = 71

Product		Groups						Sex	Effect		
		X, g			% of daily allowance						
		BMI 10-75 percen-tile	BMI 85-95 percen-tile	BMI ≥ 95 percen-tile	BMI 10-75 percen-tile	BMI 85-95 percen-tile	BMI ≥ 95 percen-tile		sex (S)	group (G)	S×G
1		2	3	4	5	6	7	8	9	10	11
Wheat and rye bread	girls	111.5	101.3	90.0	53.1	48.2	42.8	47.7	–	–	–
	boys	121.3	166.6	164.1	37.9	52.1	51.3	47.0			
Flour, pasta	girls	42.4	17.7	20.8	70.6	29.5	34.7	42.1	*	–	–
	boys	56.9	43.3	61.6	87.6	66.6	94.7	80.9			
Groats, rice, breakfast cereals	girls	15.5	19.3	19.5	51.7	64.4	65.1	61.3	*	–	–
	boys	50.2	23.7	53.7	125.4	59.4	134.4	100.8			
Potatoes	girls	86.5	107.3	80.4	34.6	42.9	32.2	37.1	–	*	–
	boys	107.5	148.1	97.9	26.9**b**	37.0**a**	24.5**b**	30.4			
Vegetables	girls	69.8	69.1	64.5	14.0	13.8	12.9	13.5	**	*	*
	boys	129.2	194.7	66.6	25.8**b**	39.0**a**	13.0**b**	28.0			
Pulses seeds and nuts	girls	1.0	0.4	2.3	5.0	2.2	11.5	6.2	–	–	–
	boys	1.5	5.0	4.2	7.6	24.8	20.8	17.9			
Fruits	girls	77.3	83.9	113.3	19.3	21.0	28.3	23.1	–	–	–
	boys	83.1	61.3	78.1	20.8	15.3	19.5	18.3			
Milk and milk fermented beverages	girls	210.5	178.9	118.0	38.3	32.5	21.5	30.3	–	–	–
	boys	189.6	187.1	117.1	34.5	34.0	21.3	31.0			
Fresh cheeses	girls	43.9	10.9	36.8	62.6	15.6	52.5	78.1	–	–	*
	boys	25.3	49.6	20.2	33.7	66.2	118.7	118.3			
Ripening cheeses	girls	17.8	18.4	10.6	89.2	92.2	53.2	78.1	–	–	–
	boys	19.6	27.0	23.7	98.0	135.1	118.7	118.3			
Meat, poultry	girls	61.7	83.0	56.2	68.5	92.2	62.5	75.8	**	–	*
	boys	98.7	75.0	89.6	116.1	88.3	105.4	102.1			

Table 8 – cont.

1		2	3	4	5	6	7	8	9	10	11
Sausages	girls	19.0	20.8	34.3	42.2	46.3	76.2	55.5	**	–	–
	boys	46.6	33.5	56.9	133.1	95.8	162.5	125.3			
Fish	girls	0.7	9.6	4.1	3.3	47.8	20.5	26.8	–	–	–
	boys	11.5	17.0	7.5	38.4	56.8	25.0	42.5			
Eggs	girls	25.6	22.4	14.5	160.1	139.7	90.4	128.2	–	–	–
	boys	21.0	24.1	35.5	125.9	144.1	212.8	155.0			
Animal fats	girls	17.8	9.9	11.9	89.0**Aa**	49.5**B**	59.5**Bb**	63.3	–	–	–
	boys	23.2	20.8	30.5	77.4	69.3	101.5	80.1			
Vegetable fats	girls	10.2	12.6	4.8	46.2**B**	57.3**A**	21.0**B**	42.3	–	–	*
	boys	8.4	6.8	9.3	31.0	25.3	34.5	29.5			
Mixed fats	girls	1.0	2.1	1.5	33.4	70.4	51.3	54.1	**	–	–
	boys	5.8	7.6	8.2	193.5	254.8	274.2	238.6			
Sugar and sweets	girls	92.0	119.4	71.7	184.0	238.7	143.4	119.7	–	–	–
	boys	60.7	61.2	70.4	121.4	122.4	140.7	126.7			

a, b – means denoted with the different letters are statistically significant difference $p \leq 0.05$.
A, B – means denoted with the different letters are statistically significant difference $p \leq 0.01$.
*Statistically significant difference $p \leq 0.05$.
**Statistically significant difference $p \leq 0.01$.

The Glycemic Index value analysis of each meal in the diets of the children who took part in the research (Table 9) shows that it did not exceed the average values (IG 56-70) and was significantly higher for girls than for boys in breakfasts, dinners and suppers and average in three days. Resultant GI of each meal, as well as in three days, for the girls dependent on their BMI was not statistically significant. However, for the obese boys the GI was significantly higher in breakfasts, dinners and suppers than for boys with normal weight and excessive weight.

Table 9. GI and GL in daily diet rations of 13-year old children with WC ≥ 90 percentile depending on BMI ($x \pm SD$, n = 71)

Components		Sex	Groups			Effect		
			BMI 10-75 percentile	BMI 85-95 percentile	BMI ≥ 95 percentile	sex (S)	group (G)	S×G
1		2	3	4	5	6	7	8
GI breakfast	girls	61.5 ±7.1	60.9 ±6.1	61.5 ±6.2	62.1 ±9.1	**	–	–
	boys	50.5 ±8.7	47.9 ±6.9**b**	48.6 ±7.9**ab**	56.4 ±9.8**a**			
GI lunch	girls	55.4 ±20.9	62.3 ±6.8	59.2 ±18.5	45.9 ±27.6	–	–	–
	boys	54.7 ±13.3	50.9 ±2.1	58.3 ±15.3	54.2 ±11.7			
GI dinner	girls	62.5 ±7.3	60.2 ±5.1	62.1 ±6.8	64.7 ±8.9	**	*	–
	boys	47.5 ±6.8	45.4 ±7.7**b**	46.1 ±4.0**b**	51.9 ±7.5**a**			

Table 9 – cont.

1		2	3	4	5	6	7	8
GI afternoon snack	girls	49.8 ±18.3	54.6 ±11.7	46.4 ±25.1	50.0 ±12.7	–	–	–
	boys	56.2 ±11.3	58.9 ±11.9	56.5 ±11.3	52.5 ±10.7			
GI supper	girls	57.5 ±14.0	59.8 ±9.2	56.0 ±17.8	57.5 ±12.8	**	–	–
	boys	48.1 ±9.7	46.9 ±5.3**b**	43.6 ±10.0**B**	56.0 ±9.2**Aa**			
GI average daily	girls	57.0 ±7.4	59.6 ±4.5	57.0 ±8.1	56.1 ±8.5	**	–	–
	boys	51.4 ±4.6	50.0 ±4.0**b**	50.6 ±4.8**ab**	54.2 ±4.4**a**			
GL breakfast	girls	23.7 ±8.5	28.4 ±8.3	23.6 ±8.2	20.0 ±9.3	**	–	**
	boys	18.1 ±6.1	10.0 ±2.9 **B**	10.2 ±3.7**B**	15.2 ±7.6**A**			
GL lunch	girls	25.0 ±16.4	25.2 ±14.6	26.8 ±12.5	21.1 ±24.6	**	–	–
	boys	22.7 ±8.9	22.6 ±6.1	20.5 ±10.1	25.8 ±0.7			
GL dinner	girls	22.4 ±13.6	23.4 ±8.9	24.1 ±15.9	21.4 ±14.5	**	–	–
	boys	21.0 ±4.8	18.1 ±4.6 **B**	18.4 ±3.3**B**	26.5 ±5.6**A**			
GL afternoon snack	girls	26.2 ±18.6	28.6 ±15.2	27.6 ±17.5	23.5 ±11.5	–	–	–
	boys	25.7 ±12.7	23.3 ±16.8	23.4 ±6.2	28.4 ±14.8			
GL supper	girls	25.7 ±15.7	28.9 ±12.7	27.3 ±13.7	24.1 ±9.9	**	–	–
	boys	21.4 ±9.3	26.7 ±6.0	22.5 ±8.6	17.6 ±13.6			
GL average daily	girls	123 ±69.7	135 ±35.0	129 ±81.7	110 ±40.4	**	–	–
	boys	109 ±23.0	101 ±25.1	95.0 ±17.8	1 145 ±24.8			

a, b – means denoted with the different letters are statistically significant difference $p \leq 0.05$.
A, B – means denoted with the different letters are statistically significant difference $p \leq 0.01$.
*Statistically significant difference $p \leq 0.05$.
**Statistically significant difference $p \leq 0.01$.

The Glycemic Load of each meal of the girls' diet was high (GL > 20), however in the case of the boys it most frequently was medium (11-19) and high (> 20). Average GL of the girls in three days diet was high (GL > 120) and of the boys was medium (GL < 80-119). GL analysis of each meal in diets of the evaluated children (Table 9) shows that it was really higher for girls than for boys in breakfasts and lunches, dinners and suppers, as well as during the three days diet. Resultant GL of each meal, as well as in three days for girls, regardless of their BMI, was not statistically significant. However, for the obese boys the average GL was significantly higher in breakfasts and dinners than for boys with normal weight and excessive weight.

DISCUSSION

In many countries [Klein-Platat et al. 2003, Wang et al. 2002], as well as in Poland [Jarosz and Rychlik 2008], the growing population of children and teenagers with disorders resulting from improper nutrition and obesity can be observed, and it becomes one of the significant problems of public health. Many years of observations show that many obese children become obese adults, and that there is a high probability that teenagers will be overweight in later periods of their lives – it is 70-80% [Dietz 2004, Whitlock et al. 2005].

Based on the values of anthropometric features measurement, through the BMI index, the general content of fat tissue is defined in body; however, it is important to define its location around the waist [Hirsler et al. 2005]. To estimate location of the visceral fat tissue, indexes WC and WHtR are used, because it has been shown [Savva et al. 2000, Taylor et al. 2000] that they constitute better indexes to pinpoint the risk of circulatory system diseases than BMI index. It has already been shown [Moreno et al. 2002] that among children the values of WC ≥ 90 percentile significantly co-relate with lipid and lipoprotein concentration in blood and are connected to a higher risk of circulatory system diseases compared with children who have WC index value lower than 90 percentile.

WHtR index reflects interrelation between the rate of growing waist circumference and body height which changes with age [Nawarycz and Ostrowska-Nawarycz 2007]. In our own studies the obtained values of WC and WHtR of every fourth child (even with proper BMI) showed that the visceral fat tissue is connected with the probability of the occurrence of the metabolic syndrome and its characteristic disorders such as: atherogenic dyslipidemia, insulin resistance, hyperglycemia and higher blood pressure [Goran and Gower 1999].

It was pointed out that the metabolic syndrome in children is conducive to appearance of the metabolic syndrome in adult age, increasing morbidity rate and mortality of adults. Literature shows [Nader et al. 2006] that it is the period of sexual puberty that is the first moment to catch the unfavourable changes early. During the puberty the sensitivity to insulin of peripheral tissues decreases by almost 30 percent and significant rise of insulin and glucose concentration is found when the stomach is empty. Insulin resistance during this period in life seems selective for glucose metabolism and does not refer to protein metabolism, which causes anabolic effect of insulin and growth hormone GH [Chen et al. 2005, Zimmet et al. 2007]. This hormone takes part in a decrease of insulin sensitivity of tissues and influences the increase of lipase and concentration of free fatty acids [Sorof et al. 2004].

As the accumulation of visceral fat tissue, regardless of BMI, is strictly connected with an risk of disorders appearing in carbohydrate-lipid metabolism of body, the children's nutrition habits have been evaluated also from the point of view of GI and GL value. The evaluation of nutrition of the group of children who took part in the research, regardless of their BMI, showed that it was insufficient as to the energetic value. The discovered low energetic value of the diet of children who took part in the research, especially in this period of development, may be conducive to losing systemic protein lowering its synthesis which leads to inhibition growth and weakening of immunity functions of the body.

Improper number of meals eaten during the day by every second child with waist circumference ≥ 90 percentile but with normal weight (MONW) and every third overweight and obese child meant long periods between meals and led to an oscillation of concentration of glucose in blood – hunger – which the children appeased most often with sweets, chips, and cakes which were at hand in the school shops. These glucose oscillations may lead to a lower ability of concentration among children and limitations in their psycho – physical activity and it might have negative influence on their efficiency in learning. The ascertained anomaly among others could have caused a change of metabolism rate and a lower thermogenesis so that the body saved the consumed food, accumulating its part in the form of fat tissue [Farshchi et al. 2005]. What is more, resignation from basic meals (lunches and afternoon snacks) caused eating small snacks by every third girl (regardless of their BMI) and boys with normal weight.

The cause of visceral obesity in evaluated children could have been too big percentage of fat in energetic value of the diet in comparison to the recommended amounts, especially in the case of saturated fatty acids and their isomers from ripening and melted cheese, chips and fast food products [Law 2000], intensified by significant consumption of monosaccharides [Willet et al. 2002] (sweets, sweet pastry, coloured, sweetened and energizing beverages) which led to a deposition of fat tissue. A low percentage of carbohydrates in the energetic value of the diet, that is low complex carbohydrates consumption (rye, wholemeal bread, cereals, rice and pasta) rich, among others, in food dietary fiber, which is recognised as a factor improving glucose tolerance and physiological mechanisms regulating its concentration in blood [Jenkins et al. 2002, Weickert and Pfeiffer 2008, Willet et al. 2002] was also disadvantageous.

Deficiency of Ca, Mg, Zn (resulting from the low consumption of dairy products, fruit and vegetables and leguminous seeds) ascertained in diets of children who took part in the research could have also been conducive to accumulation of fat tissue and carbohydrates metabolism disorder. Negative dependence between magnesium consumption and diabetes type 2 development [Kao et al. 1999] was already pointed out, because a decrease in its concentration inside cells causes a decrease of the glucose utilization in cells which makes the risk of insulin resistance much bigger in peripheral tissues as a post receptor defect. It means that the lower concentration of magnesium ions in serum, the bigger amount of insulin is needed to metabolize the same amount of glucose, which suggests lowering of insulin sensitivity.

Calcium does not only play the role of a building material for teeth and bones but also can take part in body mass regulation because it influences adipocytes metabolism stimulating lipolysis and suppresses lipogenesis, which results in lowering of body mass increase [Zemel et al. 2000]. Zinc takes part among others in biosynthesis and in accumulating insulin in pancreas and releasing it to blood. In zinc deficiency an impairment in glucose tolerance can be observed, which leads to the development of diabetes type 2 [Chausmer 1998]. Earlier studies made by Grajeta et. al [2008] showed similar low content of Ca, Mg, Zn in the menus of Polish adolescents.

A low supply of B_1 vitamin, for which requirement grows along with the consumption of carbohydrates, was also disadvantageous in the diets of children who took part in the research. This could be the effect of significant consumption of white bread and pastry, and a low consumption of wholegrain bread, cereals, rice, leguminous seeds and vegetables. The lack of thiamin in body may cause transketolation disorder in the course of oxygen glucose metabolism and that is why we apply it in clinical therapy of kidney diabetes [Babaei-Jadidi et al. 2003].

In the conducted analysis of children's menus, regardless of their BMI, insufficient amount of liquids in the diet was ascertained; liquids are necessary for metabolic course and body functioning including the following systems: nervous, thermoregulation, water-mineral and discharge of metabolism products [Morris et al. 2006]. Children who took part in the research consumed mainly sweet fizzy beverages, containing carbon dioxide, taste additives, sweetening and preserving substances which are conducive to caries and losing calcium, magnesium and iron from the body and through the high GI and GL are conducive to obesity [Carr and Brunzell 2004].

Carbohydrates, which are the main source of energy in diet, influence many actions of our brain including regulation of food intake [Anderson et al. 2002]. Both in feeding and diabetes type 2 prophylactic and diet therapy of those diseases, attention is paid to postmeal glycaemia which is influenced by quantity, and mutual portions of carbohydrates (glucose, fructose, saccharose, lactose, and starch), their structure (amylose to amylopectin proportion), technological processes (the size of particles, form and structure of the product, degree of starch gelation) and content of other components in the product (fat, protein, dietary fiber, anti-nutritious components or organic acids), their capacity of assimilation and GI and GL [Brand-Miller and Marsh 2008, Jenkins et al. 1981, Pi-Sunyer 2002, Willet et al. 2002, Wolever et al. 2006].

In the course of our own research it was ascertained that the value of the resultant GI of three day menus of girls was medium (ca. GI 57) and significantly higher than that of boys, regardless of their BMI. However, only in boys' diet the value of resultant GI, as well as in meals (breakfast, dinner, supper) differed significantly and was BMI-dependent. The higher the BMI for boys, the higher the value of GI. Such a dependence was not found among girls though the participation of energy coming from carbohydrates and saccharose was higher for them than for boys. Different results were shown [Liu et al. 2000, Pi-Sunyer 2002] where the average GI of women diet differed from medium to high (GI 64-80). Consumption of meals with medium or high GI causes fast absorption of carbohydrates which leads to an increase of insulin in blood, forming strong, anabolic stimulus initiating storage of energy components (glucose and triacyloglycerols) by insulin sensitive tissues, as well as stimulates glycogenesis and lipogenesis and suppresses gluconeogenesis and lipolysis. What is more, after such a meal, after ca. 2 hours absorption of nutritive contents from alimentary tract and insulin concentration in blood goes down, although the biological effects of high insulin level and low level of glucagon sill last, which leads to reactive hypoglycemia. In consequence the lowered level of glucose stimulates glucagon, adrenalin and cortisol and also increases hormone secretion stimulating glycogen decomposition and glycogenesis (which normalizes glycaemia) but is also conducive to insulin resistance and proteolysis of proteins. It is felt as a state of hunger and usually the next meal is being consumed, resulting in a significant increase of glycaemia. Meals with medium and high GI also increase a postmeal lipidemia [Brand-Miller and Marsh 2008].

However, some products with medium or high GI in customary consumed portions contain small amount of absorptive carbohydrates, that is why their GL which takes into consideration quality and amount of carbohydrates in the product [Sheard et al. 2004] is important. The higher the GL, the bigger increase of glucose concentration in blood and stronger insulin reaction, which predestinates the occurrence of insulin resistance [Brand-Miller and Marsh 2008]. It has been shown that GL along with GI is a useful measure and index of the diabetes, circulatory system diseases, higher concentration of lipids in blood, risk of high blood pressure [Asp 1995], and also indirect marker, among others, of protein C – reactive [Flood et al. 2006]. In our own research the average total GL from three days menus of the girls who took part in the research was significantly higher than of the boys and exceeded permissible GL < 120. The highest GL (> 20) was brought to the girls' diet via lunches, dinners and afternoon snacks, but boys' GL was on a medium and high level. Results similar to our own were achieved by Liu et al. [2000] where average GL of women's diet oscillated between a high 117 and 177. High GL of the diet is a highly unfavourable phenomenon because it not only causes a supply of significant amount of carbohydrates, but also in response to their supply it forces insulin secretion from pancreas leading to hyperinsulinemia, which is a constant feature accompanying obesity, regardless of its cause, age or sex of the obese person. Among obese people, after some time, insulin resistance appears, which can be defined as lowered biological reaction to physiological amount of insulin. Naturally occurring hyperinsulinemia during the puberty spurt and accompanying it excess body mass and too high consumption of absorbable carbohydrates with high GL may, by growing insulin resistance, enlarge glucose intolerance and lead in consequence to diabetes type 2.

Insulin resistance formed in connection with consumption of diet rich in carbohydrates is connected with dyslipidemia which is characterised by a high concentration of triacyloglycerols and LDL-cholesterol fraction. Significant amount of fatty acids is released from visceral fat tissue, which causes increase of their concentration in blood serum, intensified penetration of cells, and thus lowering the uptake of glucose, which stimulates pancreas to insulin secretion. At the same time, fatty acids supplied in excess to liver suppress insulin degradation in it. And what is more, free fatty acids intensify very small density of lipoprotein (VLDL) synthesis in liver, which is conducive to overproduction of LDL [Ginsberg et al. 2005]. Increased activity of reductase HMG-CoA additionally causes increase of cholesterol synthesis in liver, which excess in diets of the overweight and obese boys who took part in the research was significantly higher than of the girls.

Taking into consideration the influence of diets rich in carbohydrates on health [Bouché et al. 2002, Ebbeling et al. 2005, Järvi et al. 1999, Leeds 2002] many scientists, in order to improve the carbohydrate - lipid metabolism, tried to correct diets of various groups of people by lowering their GI and GL. This correction is based on including bigger amounts of fruit and vegetables, which are the source not only of vitamins and minerals but also of dietary fibre, replacing white bakery products with rye bread and including thick cereals but limiting consumption of simple carbohydrates. In the course of the research, after postmeal glycaemia was lowered and a better insulin sensitivity was obtained; the decrease in the concentration of fatty acids, triacyloglycerols, total cholesterol and LDL fraction cholesterol in blood, the decrease in the activity of inhibitor activator of plasminogen – 1 (PAI-1), the decrease in leptin concentration and increase of the concentration of adiponectin in blood, the decrease in participation of fatty tissue in body and at the waistline, increase of fat free body mass and, in time, the feeling of satiety and delay in feeling of hunger were achieved. Thus taking into consideration the value of GI and GL in the diets of children and youth, especially with visceral location of fat tissue, is an efficient method of correcting glycaemia and preventing development of diabetes type 2.

CONCLUSIONS

Summing up the obtained results of the research conducted among thirteen-year-old children with abdominal obesity, many diet errors, regardless of BMI index, can be ascertained. Not only improper number of meals during the day, but also eating furtively especially during evening hours, a diet with unbalanced nutritive components, improper structure of consumption of basic nutritive components but also average GI and high GL, could have been the reasons of the already existing nourishment. In the range of values of GI and GL the girls' diets came out significantly worse. The presented nutrition among children who took part in the research may predetermine a deeper disorder in carbohydrate– lipid metabolism in the future and that is why health education aimed at changing dietary behaviour in terms of a proper diet is necessary in primary schools.

Considering this, all children who took part in the research (871 people) were the subject of pro-health education in the form of "live" workshops, with edible products, where they became familiar with the basics of proper nutrition according to their development, age and sex in the aspect of further physical and intellectual development and prevention of lifestyle diseases.

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INDEKS GLIKEMICZNY I ŁADUNEK GLIKEMICZNY DIET TRZYNASTOLETNICH DZIECI Z OBWODEM TALII (WC) ≥ 90 PERCENTYLA W ZALEŻNOŚCI OD BMI

Wstęp. Jedną z przyczyn gromadzenia tkanki tłuszczowej w organizmie, w tym wisceralnej, jest niezbilansowana dieta – między innymi pod względem ilości i struktury węglowodanów, a także wartości indeksu glikemicznego (Glycemic Index) oraz ładunku glikemicznego (Glycemic Load). Istnieją prace opisujące zależności pomiędzy wskaźnikami BMI (Body Mass Index), WC (Waist Circumference), WHtR (Waist-to-Height Ratio) a GI i GL u dorosłych, ale przeprowadzono tylko nieliczne badania na ten temat u dzieci będących w skoku pokwitaniowym. Dlatego celem pracy była ocena stanu odżywienia oraz sposobu żywienia dzieci trzynastoletnich z obwodem talii ≥ 90 percentyla i różnym BMI, w której uwzględniono GL i GL posiłków.

Materiał i metody. Oceniono stan odżywienia (BMI, WC, WHtR) 871 trzynastoletnich dzieci obojga płci, spośród których wytypowano 230 (26,4% ogółu badanych) z WC ≥ 90 percentyla i podzielono je na trzy grupy w zależności od BMI. Na podstawie analizy trzydniowych jadłospisów sporządzonych metodą bieżącego notowania u 71 dzieci (30,9%) oceniono sposób żywienia: wartości energetycznej i odżywczej jadłospisów, struktury spożycia grup produktów spożywczych, wartości GI i GL.

Wyniki. U chłopców stwierdzono istotnie większe wartości BMI i WC niż u dziewcząt. Nie odnotowano istotnych różnic w wartości wskaźnika WHtR pomiędzy dziewczynkami i chłopcami. Analiza jadłospisów dzieci obojga płci z obwodem talii ≥ 90 percentyla wykazała, bez względu na wartość BMI, małą realizację zalecanej wartości energetycznej diety, małą realizację zalecanej podaży: błonnika, tłuszczu, składników mineralnych (K, Ca, P, Mg, Fe, Zn, Cu), witamin (E, B_1, PP) oraz płynów. Zauważono występującą równocześnie dużą podaż: białka ogółem i zwierzęcego, sodu oraz witamin (A, B_2, B_6). W większości wymienionych składników istotnie większą podaż stwierdzono w dietach chłopców. W zależności od wartości wskaźnika BMI, w dietach dziewcząt wykazano istotne różnice w realizacji zalecanej podaży: Fe, witaminy A oraz B_1, natomiast u chłopców – w realizacji zalecanej podaży: błonnika, K, Ca, witaminy A, B_2 i C oraz płynów. Istotnie wyższy u dziewcząt był indeks glikemiczny (GI) i ładunek glikemiczny (GL) podstawowych posiłków: I śniadań, obiadów i kolacji oraz średni posiłków z trzech dni. W zależności od wartości BMI, GI oraz GL podstawowych posiłków i średni z trzech dni nie był statystycznie istotny u dziewcząt. Natomiast był istotnie wyższy w I śniadaniach, obiadach i kolacjach bardziej u chłopców otyłych niż u chłopców z normowagą i nadwagą.

Wnioski. U trzynastoletnich dzieci z występującą otyłością brzuszną stwierdzono liczne błędy żywieniowe bez względu na wartość wskaźnika BMI. Były to: niewłaściwa liczba posiłków w ciągu dnia, rezygnacja z posiłków podstawowych a częste podjadanie, dieta niezbilansowana w składniki odżywcze, niewłaściwa struktura spożycia podstawowych grup produktów spożywczych oraz średni indeks glikemiczny i duży ładunek glikemiczny. Prezentowany przez dzieci sposób żywienia mógł być przyczyną istniejącego stanu odżywienia, w tym otyłości wisceralnej. Sytuacja może prowadzić do głębszych zaburzeń w metabolizmie węglowodanowo-lipidowym, stąd niezbędna jest prozdrowotna edukacja żywieniowa już w okresie wczesnoszkolnym.

Słowa kluczowe: indeks glikemiczny (GI), ładunek glikemiczny (GL), WC (obwód talii), BMI (Body Mass Index), WHtR (obwód talii do wzrostu), dzieci

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