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ORIGINAL ARTICLE

EFFECT OF EATING HABITS, BMI VALUE, PHYSICAL ACTIVITY AND SMOKING CIGARETTES ON BLOOD LIPID INDICES OF ADOLESCENT BOYS FROM POLAND

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ABSTRACT

Background. The lifestyle of young boys has impact on the risks of cardiovascular diseases.

Objective. The aim of the study was to evaluate the effect of atherosclerosis risk factors determined by overweight and obesity and lifestyle, i.e.: eating habits, low physical activity and smoking cigarettes, on blood lipid profile of boys at the age of 16 to 18.

Material and Methods. The study covered 369 boys from secondary schools. They were evaluated for the supply of dietary constituents with atherogenic and protective actions, for nutritional status acc. to *Cole's* criteria, the level of physical activity, and smoking cigarettes. Lipid metabolism was determined based on criteria recommended by the American National Cholesterol Education Program (NCEP). Logistic regression analysis was conducted and risk odds ratio [OR] was determined.

Results. Analyses showed the boys to be characterized by overweight (10.8%) and obesity (2.7%), and by inappropriate concentration of total cholesterol (26.5%), LDL (13.3%), HDL (21.7%) and triglycerides (41.7%). High BMI turned out to be a significant risk factor of an elevated total cholesterol concentration: [aOR]=2.27; triglycerides: [aOR]=2.35 and LDL: [aOR]=2.41. Low physical activity was found to negatively affect the concentration of LDL: [aOR]=1.88. The boys smoking cigarettes were shown to have a reduced HDL: [aOR]=1.65. The total content of fat and saturated fatty acids in diet exerted a significantly negative impact on blood lipid profile of the boys.

Conclusions. The lifestyle of the young boys was demonstrated to determine the risk of cardiovascular diseases. Overweight and obesity, abdominal obesity in particular, were found to be a significant risk factor of disorders in their lipid metabolism.

Key words: *boys, eating habits, BMI, risk factors, blood lipid indices*

STRESZCZENIE

Wprowadzenie. Styl życia młodych chłopców ma wpływ na ryzyko chorób sercowo-naczyniowych.

Cel. Celem pracy była ocena wpływu czynników ryzyka miażdżycy zależnych od nadwagi i otyłości oraz stylu życia, tj.: nawyków żywieniowych, niskiej aktywności fizycznej i palenia papierosów, na profil lipidowy krwi u chłopców w wieku od 16 do 18 lat.

Materiał i metody. Badaniem objęto 369 chłopców ze szkół średnich. Zostali oni ocenieni pod kątem podaży składników diety o działaniu aterogennym i ochronnym, pod kątem stanu odżywienia według kryteriów *Cole'a*, poziomu aktywności fizycznej i palenia papierosów. Metabolizm lipidów określono na podstawie kryteriów zalecanych przez kryteria zalecane przez National Cholesterol Education Program (NCEP). Przeprowadzono analizę regresji logistycznej i określono iloraz ryzyka [OR].

Wyniki. Analizy wykazały, że chłopcy charakteryzują się nadwagą (10,8%) i otyłością (2,7%) oraz niewłaściwym stężeniem cholesterolu całkowitego (26,5%), LDL (13,3%), HDL (21,7%) i triglicerydów (41,7%)). Wysokie BMI okazało się istotnym czynnikiem ryzyka podwyższonego stężenia cholesterolu całkowitego: [aOR] = 2,27; triglicerydów: [aOR] = 2,35 i LDL: [aOR] = 2,41. Stwierdzono, że niska aktywność fizyczna negatywnie wpływa na stężenie LDL: [aOR] = 1,88. Wykazano, że chłopcy palący papierosy mają obniżoną HDL: [aOR] = 1,65. Całkowita zawartość tłuszczu i nasyconych kwasów tłuszczowych w diecie wywarła znacząco negatywny wpływ na profil lipidowy krwi chłopców.

Wnioski. Wykazano, że styl życia młodych chłopców determinuje ryzyko chorób sercowo-naczyniowych. Stwierdzono, że nadwaga i otyłość, w szczególności otyłość brzuszna, stanowią istotny czynnik ryzyka zaburzeń metabolizmu lipidów.

Słowa kluczowe: *chłopcy, nawyki żywieniowe, BMI, czynniki ryzyka, wskaźniki lipidów we krwi*

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INTRODUCTION

The atherosclerotic process begins already in the childhood or in the early adolescence and is proceeding with age [10, 16]. Results of pathophysiological and epidemiological investigations show explicitly that early dysfunctions of arterial vessels endothelium and arterial hypertension commence much earlier [6, 35]. A number of cross-sectional cohort studies [7, 45], have enabled determining risk factors of atherosclerosis in the adolescents. Results of multiple earlier investigations conducted in the XXth and XXIst century, among others: research by *Lutsey* et al. [26], *Li* et al. cross-sectional studies [23], research by *Kouki* et al. [22], and that by *Hu* et al. [17,18], have pointed to dependencies between lifestyle and anthropometric and biochemical indices as well as development of cardiovascular diseases (CVD). The composition of food products affects lipid metabolism of a body to a various extent, it may both enhance and inhibit atherogenic processes [39, 46]. The health-promoting effect of fruits and vegetables has also been thoroughly documented [14, 34, 36].

The objective of the study was to evaluate the effect of atherosclerosis risk factors determined by lifestyle, i.e.: eating habits, overweight and obesity, low physical activity and smoking cigarettes, on blood lipid profile of boys at the age of 16 to 18 years from the area of Poland.

MATERIAL AND METHODS

The study was conducted from 2008 to 2018 in a randomly selected group of 369 boys at the age of 16-18 years attending secondary schools in Poland (the city of Wrocław). Numbers of boys in particular age groups were as follows: 103 boys at the age of 16 (27.9% of total group), 104 boys at the age of 17 (28.2%), and 162 boys at the age of 18 (43.9%).

Ethical aspects

Parents, guardians or students who were of age, provided written informed consent to the study. In a statement provided guarantees covering confidentiality. The study was approved by the Research Ethics Committee of the Medical University in Wrocław, which is affiliated with the Council for National Research Ethics in Poland.

Nutritional survey

Eating habits of the boys were evaluated by means of a triple direct nutritional interview conducted 24 hours before examination. The nutritional value of daily food rations of the boys was determined with the use of "Dietetyk" software [33]. Results of eating habits assessments were compared with dietary allowances and recommendations [3, 20, 47].

Nutritional status

Values of Body Mass Index - BMI (body mass/body height^2) were computed based on measurements of body mass [kg] and body height [m] of the boys. Distributional cutoff values, such as the 85th or 95th percentiles of reference data, have been used most often. More recently, gender- and age- specific cutoff values that are tied to the adult overweight (25 kg/m^2) and obesity (30 kg/m^2) thresholds were developed. In these studies the BMI values obtained were evaluated using standards elaborated by *Cole* et al. [5].

The BMI values indicating overweight and obesity of the boys reached, respectively: 23.90 and 28.88 mg/kg^2 - for the 16-year-olds; 24.46 and 29.41 mg/kg^2 - for the 17-year-olds; and 25.00 and 30.00 mg/kg^2 - for the 18-year-olds. The evaluation of waist circumference values was conducted according to criteria postulated by *Katzmarzyk et* al. [21]. Threshold values above which an increase is observed in the risk of the incidence of metabolic disorders and arterial hypertension reached: 79.0 cm - for the boys at the age of 16, 79.8 cm - for those at the age of 17 and 80.4 cm for those at the age of 18.

Blood lipid profile

Blood biochemical indices determined in the study were evaluated based on guidelines of a Group of Experts of the American National Cholesterol Education Program (NCEP) [35]. The criteria of lipid metabolism assessment were as follows: concentration of total cholesterol - threshold 170-199 mg/dl, high ≥ 200 mg/dl; concentration of triglycerides - threshold 90-129 mg/dl, high ≥ 130 mg/dl; concentration of LDL-cholesterol - threshold 110-129 mg/dl, high ≥ 130 mg/dl; and concentration of HDL-cholesterol - threshold 45-35 mg/dl, low < 35 mg/dl.

Risk factors

Nutritional risk factors adopted in the study included:

- high energy value of diet >110 % of EAR (Estimated Average Requirement) (>3740 kcal)
- excessive intake of total fats >30 % of due energy
- excessive intake of SFA (Saturated Fatty Acids) ≥10% of due energy
- excessive intake of cholesterol >300 mg
- high contribution of energy derived from monosaccharides (saccharose) ≥10% of due energy
- low intake of PUFA (Polyunsaturated Fatty Acids) < 6% of due energy
- low intake of dietary fiber < 20 g
- small consumption of fruits and vegetables < 400 g

- overweight and obesity acc. to threshold values by *Cole's* [5]
- high values of waist circumference acc. to *Katzmarzyk* et al. [21]
- smoking cigarettes – irrespective of the number and frequency
- lack or low physical activity - exemption from classes of physical education and exercising only during school classes.

Statistical analysis

Results obtained were subjected to a statistical analysis with the use Statistica 10.0 software by StatSoft Inc. USA. Analysis of logistic regression was conducted and risk Odds ratio (OR) was determined. The level of statistical significance was stipulated at $p<0.05$.

RESULTS

Table 1 presents data on selected elements of the nutritive value of an average food ration and mean indices of the nutritional status of the 16-18-year-old boys surveyed in the study (n=369). Figure 1 depicts the percentage of boys with nutritional risk factors and Figure 2 - those with incorrect blood lipid profile, high values of waist circumference as well as overweight and obesity. The energy value of an average food ration reached 3631.2 ±1171 kcal, which constituted 107.0% of the (EAR). Considerable individual differences were observed in energy intake, which was indicated by minimal and maximal energy values accounting for 972.1 and 7161.4 kcal, respectively. In 43.1% of the food rations, the EAR for energy intake was exceeded (Table 1, Figure 1).

The content of total fat in the food rations examined turned out to be high. The contribution of fat-derived energy in the total energy value of an average daily food ration reached 36.4 ±5.8%. The recommended level of 30% of energy derived from fats was exceeded in as many as 85.1% of the food rations. Inappropriate values were also recorded in the structure of fatty acids intake. Especially alarming appeared to a high contribution of SFA - 14.4 ± 3.4% of energy in respect of the recommended level of <10%. A high content of SFA was demonstrated in 90.2% of the food rations. In contrast, analyses showed a low contribution of energy derived from PUFA in an average food ration, i.e. 5.1% of energy, with extreme values reaching 2.0% and 16.1%. Deficiency of PUFA was observed in 75.3% of the food rations. In the food rations analyzed, the mean content of cholesterol (554.5 mg) exceeded the recommended dietary allowances to a considerable extent (184.8%). The intake of that component with diet was highly diversified and ranged from 51.6 to 1394.2 mg. Its excessive content (>300 mg/day) was demonstrated in 84.3% of the food rations. Dietary fiber content of an average food ration reached 28.9 ±10.6 g. It was consistent with the adopted recommended values of 20 - 40 g, yet the minimal content of this component in the food ration accounted for as little as 9 g, whereas the maximal one - for ca. 69 g. A low content of dietary fiber (<20 g/day) was demonstrated in 19.2% of the food rations. Mean intake of monosaccharides, determined based on the content of saccharose, reached 11.4 ± 5.1 g, and their excessive concentrations were observed in 59.6% of the food rations. The content of fruits and vegetables in an average food ration of the boys examined reached 653.7 g, which appeared to be correct in respect of

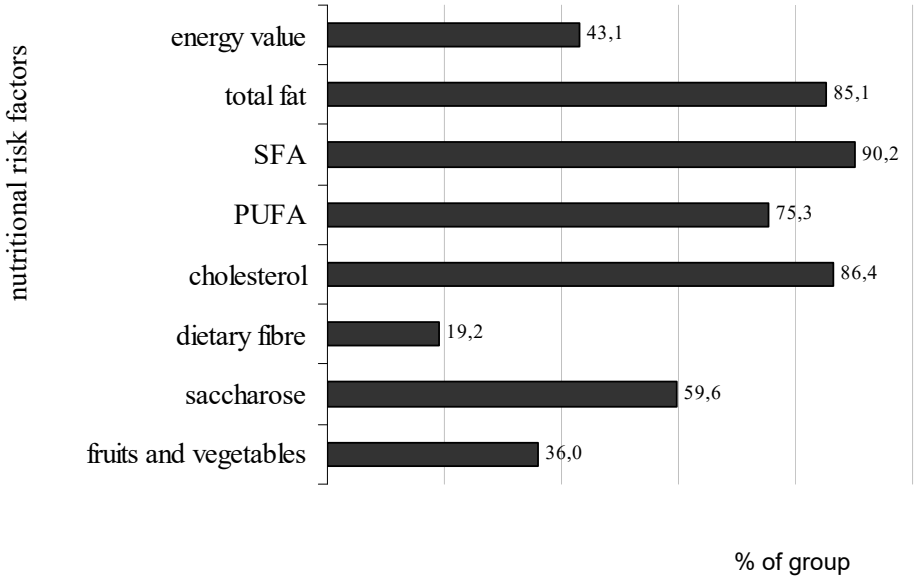

Figure 1. Nutritional risk factors in the boys examined (n=369)

Table 1. Selected components of an average daily food ration and mean indices of the nutritional status of the 16-18-year-old boys examined (n=369)

Dietary components *Diet assessment*	Unit	Dietary allowances and recommendations	Mean	SD	Min.	Max.	% of dietary allowances and recommendations
energy value	kcal MJ	3400 14.2	3631.2 15.2	1171.0 4.9	972.1 4.1	7161.4 30.0	107.0
total fat	% of energy	<30	36.4	5.8	19.1	65.2	121.3
saturated fatty acids	% of energy	<10	14.4	3.4	3.9	29.3	144.0
polyunsaturated fatty acids	% of energy	6-10	5.1	1.8	2.0	16.1	85.0
saccharose	% of energy	<10	11.4	5.1	1.3	33.9	114.0
dietary fibre	g	20-40	28.9	10.6	9.0	68.6	96.3
cholesterol	mg	≤300	554.5	253.1	51.6	1394.2	184.8
fruits and vegetables	g	>400	659.3	535.2	0.0	3342.4	164.7
Nutritional status							
body height	m		1.8	0.1	1.6	2.0	
body mass	kg		69.3	11.2	41.0	111.0	
BMI	kg/m^2	Acc. to Cole	21.6	3.0	15.8	34.8	
waist circumference	cm	Acc. Katzmarzyk	79.8	8.2	64.0	119.0	
cholesterol	mg/dl	< 170	156.8	93.0	269.0	26.9	
HDL-cholesterol	mg/dl	≥ 45	52.4	15.0	106.0	10.9	
LDL-cholesterol	mg/dl	< 110	86.8	40.0	400.0	28.1	
triglycerides	mg/dl	< 90	92.9	14.0	417.0	52.1	

WHO recommendations (≥400 g/day). Still, analyses showed great differences in their intake that ranged from 0.0 g to 3342.4 g. In 36% of the food rations, quantities of fruits and vegetables were found to be low (< 400 g/day).

In the examined group of boys, mean body mass accounted for 69.3 ±11.2 kg and mean body height for 1.80 ±0.1 m. The mean value of BMI was at a level of 21.6 ±3 kg/m^2. Overweight was demonstrated in 10.8%, and obesity in 2.7% of the boys surveyed. The mean value of waist circumference reached 79.8 ± 8.2 cm, and high values of that parameter were observed in 42.3% of the surveyed (Table 1, Figure 2).

The mean concentration of cholesterol in blood plasma of the 16-18-year-old boys was at a level of 156.8 ±26.9 mg/dl; with the minimum value of 93.0 mg/dl and the maximum value of 269.0 mg/dl. The threshold concentration of cholesterol, which acc. to current health criteria already requires correction by applying a diet and physical activity, was demonstrated in 18.4 % of the boys, whereas a high concentration of cholesterol - in 8% of the surveyed.

The mean concentration of the "atherogenic" LDL fraction of cholesterol reached 86.8 ± 28.1 mg/dl. In some of the boys, the concentration of that cholesterol fraction exceeded the values recommended for adolescents at this age The threshold concentration of LDL-cholesterol was demonstrated in 8.7% and its high concentration - in 4.6% of the group examined. The mean concentration of the HDL-cholesterol reached 52.4 ±10.9 mg/dl, with the extreme values being 15.0 and 106.0 mg/dl. The threshold concentration of HDL-cholesterol was observed in ca. 24.0% and its low concentration - in ca. 2% of the group surveyed. The average concentration of triglycerides in blood plasma of the boys examined was 92.9 ±52.1 mg/dl; and the extreme value was highly divergent (14-417 mg/dl). A considerable percentage of the boys (23.8% of the group) were characterized by an elevated concentration of triglycerides that ranged from 90 to 129 mg/dl. In turn, their high concentration was shown in 17.9% of the group surveyed. The habit of smoking cigarettes, irrespective of the number of smoked cigarettes, was observed in 28.4% of the group examined. A lack or low physical activity, undertaken only at school classes (3 times x 45 min/week) was demonstrated in 17.3% of the boys (Figure 2).

Risk factors

Analyses were also conducted for the effect of selected factors attributable to diet, low physical activity, smoking cigarettes, and high BMI values (overweight acc. to *Cole* et al. [5]) on blood lipid profile of the boys examined. In addition, the likelihood of blood lipid disorders was estimated by determining the Odds ratio. To this end, an analysis of logistic regression was conducted, the results of which were presented in Table 2.

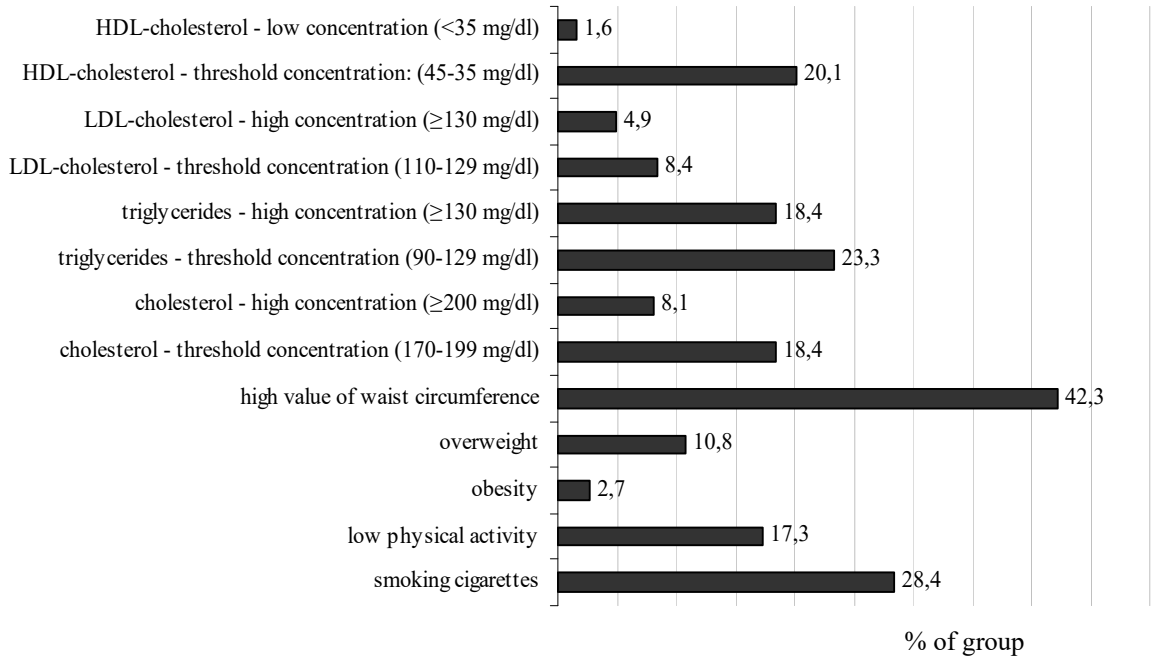

Figure 2. Percentage of boys with incorrect blood lipid indices, high value of waist circumference, overweight and obesity as well as with low physical activity and smoking cigarettes (n=369)

Table 2. Effect of selected factors of lifestyle on an increase in the likelihood of the risk of a high concentration of cholesterol, triglycerides, LDL- and HDL-cholesterol in blood of the 16-18-year-old boys examined (n=369)

Risk factors	Cholesterol		Triglycerides		LDL-Cholesterol		HDL-Cholesterol	
energy	0.88[a] (0.55-1.41)	NS[b]	0.81 (0.53-1.24)	NS	0.74 (0.39-1.38)	NS	1.05 (0.66-1.7)	NS
monosaccharides	0.73 (0.45-1.17)	NS	0.88 (0.57-1.34)	NS	0.89 (0.48-1.64)	NS	1.09 (0.67-1.78)	NS
total fat	1.75 (0.84-3.6)	NS	0.91 (0.51-1.63)	NS	2.97 (1.01-9.96)	SS	0.71 (0.38-1.33)	NS
cholesterol	1.16 (0.58-2.34)	NS	0.61 (0.34-1.12)	NS	1.14 (0.46-2.85)	NS	0.84 (0.43-1.65)	NS
SFA	2.40 (1.02-6.39)	SS[c]	-	-	1.76 (0.52-6.01)	NS	0.74 (0.35-1.58)	NS
PUFA	0.81 (0.48-1.38)	NS	0.88 (0.54-1.43)	NS	1.01 (0.48-2.09)	NS	1.26 (0.72-2.22)	NS
dietary fibre	1.54 (0.88-2.7)	NS	1.18 (0.7-1.99)	NS	1.25 (0.60-2.60)	NS	1.43 (0.81-2.54)	NS
vegetables and fruits	1.11 (0.68-1.78)	NS	0.88 (0.57-1.37)	NS	1.14 (0.61-2.13)	NS	0.91 (0.55-1.50)	NS
overweight, obesity	2.27 (1.22-4.23)	SS	2.35 (1.28-4.34)	SS	2.41 (1.15-5.03)	SS	1.48 (0.77-2.80)	NS
waist circumference	2.03 (1.26-3.24)	SS	1.80 (1.18-2.76)	SS	2.19 (1.19-4.04)	SS	1.96 (1.21-3.16)	SS
smoking cigarettes	1.38 (0.84-2.27)	NS	1.34 (0.85-2.11)	NS	1.18 (0.62-2.26)	NS	1.65 (1.1-2.70)	SS
physical activity	0.53 (0.30-0.94)	SS	0.78 (0.45-1.34)	NS	1.88 (1.06-3.36)	SS	0.76 (0.42-1.40)	NS

[a] – adjusted odds ratio (95% Cl), [b] – no statistical significance (NS), [c] – statistical significance (SS), SFA – saturated fatty acid, PUFA – polyunsaturated fatty acid

The nutritional risk factors adopted in the study included: high energy value of diet, high contribution of energy derived from saccharose (monosaccharides), high intake of total fats, SFA and cholesterol as well as low contents of PUFA, dietary fibre, fruits and vegetables. Analyses showed that with a high intake of SFA the likelihood of a high concentration of cholesterol in blood of the examined group of boys increased over 2 times (age-adjusted odds ratio [aOR]=2.4; 95% confidence interval [Cl] [1.02-6.39]). They also demonstrated a statistically significant effect of excessive body mass, determined by the BMI value (aOR=2.27 [1.22-4.23]), and high values of waist circumference (aOR=2.03 [1.26-3.24]) on the increase in cholesterol concentration in blood plasma. The likelihood of a high concentration of triglycerides was shown to increase over 2 times at overweight and obesity (aOR=2.35 [1.28-4.34]), and especially at increased values of waist circumference (aOR=1.8 [1.18-2.76]). This risk of a high concentration of LDL-cholesterol was observed to increase with an increasing intake of total fat (aOR=2.97 [1.01-9.96]), high BMI values (aOR=2.41 [1.15-5.03]) and high values of waist circumference (aOR=2.19 [1.19-4.04]), and at a low physical activity (aOR=1.88 [1.06-3.36]). In the group of the examined 16-18-year-old boys analyses showed about 2-fold increase in the risk of a low concentration of HDL-cholesterol at high values

of waist circumference (aOR=1.96 [1.21-3.16]). Of importance appeared to be also the habit of smoking cigarettes that reduced significantly the concentration of that cholesterol fraction (aOR=1.65 [1.21-2.70]) in respect of its concentration recorded in the non-smoking boys.

Results of the logistic regression analysis indicate that overweight and obesity, high values of waist circumference in particular, affected blood lipid parameters to the most significant effect. Analyses were also conducted for effects of lifestyle factors (diet, physical activity, smoking cigarettes) on the nutritional status of the boys (BMI, waist circumference).

Results of odds ratio analysis demonstrated that the likelihood of high BMI values was increasing 2.5 times at a low intake of dietary fibre (aOR=2.53 [1.31-4.91]) (Table 3).

Table 3. Effect of selected factors of lifestyle on an increase in the likelihood of overweight and obesity and a high value of waist circumference in the 16-18-year-old boys examined (n=369)

Risk factors	BMI		Waist circumference	
energy	0.25 (0.12-0.53)	SS[c]	0.68 (0.45-1.04)	NS
monosaccharides	0.58 (0.32-1.05)	NS[b]	0.79 (0.52-1.22)	NS
total fat	0.57 (0.27-1.19)	NS	1.02 (0.52-1.99)	NS
cholesterol	0.57 (0.27-1.23)	NS	1.24 (0.66-2.30)	NS
SFA	0.76 (0.30-1.94)	NS	1.07 (0.52-2.18)	NS
PUFA	0.82 (0.41-1.61)	NS	0.87 (0.54-1.40)	NS
dietary fibre	2.53 (1.31-4.91)	SS	1.36 (0.81-2.29)	NS
vegetables and fruits	0.45 (0.22-0.95)	SS	0.92 (0.59-1.40)	NS
smoking cigarettes	1.72 (0.93-3.19)	NS	0.84 (0.49-1.46)	NS
physical activity	0.62 (0.30-1.26)	NS	1.17 (0.74-1.85)	NS

[a] – adjusted odds ratio (95% Cl), [b] – no statistical significance (NS), [c] – statistical significance (SS), SFA – saturated fatty acid, PUFA – polyunsaturated fatty acid

DISCUSSION

The mean concentration of cholesterol in blood plasma of the boys examined in the study reached 156.8 mg/dl. Yet, abnormalities, including threshold concentration and high concentration of cholesterol, were observed in a considerable percentage of the boys, i.e. in 18.4% and 8.1% of the group, respectively. The report by *Nguyen* et al. [32] shows that there is a high concentration of total cholesterol among American children and adolescents was 7.4%. Adolescents aged 16-19 (8.9%) had a higher incidence of high total cholesterol than children aged 6-8 (6.0%) [32]. Analyses carried out on two subsamples consisting of the Beijing Child and Adolescent Metabolic Syndrome (BCAMS) in 2004 and the China Child and Adolescent Cardiovascular Health (CCACH) study in 2014 for children and adolescents aged 6-18 [9] showed that the mean concentration of cholesterol in their blood plasma reached 155 and 162 mg/dl (research in 2004 and 2014, respectively), which was similar to that in the reported study. Similar values of cholesterol concentration were shown in blood plasma of boys living in Germany (156.0 mg/dl) [37]. Identical average total serum cholesterol (156 ± 28 mg/dl) was found in a study of children and adolescents (6-14 years) from primary and secondary schools in a community of 14 cities in the south of Italy [28]. A study by *Murakami* et al. [30] showed that mean cholesterol values in children (n=324) and adolescents (n=523) are 164.0 mg/dl and 155.5 mg/dl, respectively. I n the group of 1427 participants (715 boys and 712 girls) aged 6-20 years, the average total serum cholesterol concentration was 157.9 mg/dl [48].

Ample epidemiological surveys showed differences in lipid profile as affected by race, gender, ethnic group and sexual maturation [12, 15, 42]. In turn, the National Health and Nutrition Examination Survey (NHANES) investigations conducted in the years 1999 to 2006 demonstrated that of 9.6% to 10.7% of the examined adolescents had a high concentration of total cholesterol (≥200 mg/dl), whereas later surveys (NHANES 1999-2000) did not demonstrate any significant changes in this respect [12].

In the reported study, the mean concentration of LDL-cholesterol reached 86.8 mg/dl, with its threshold concentration demonstrated in 8.7% and a high concentration in 4.6% of the boys examined. Amongst the American schoolchildren examined in the National Health and Nutrition Survey (NHANES) in 2011-2014, the mean concentration of LDL-cholesterol was similar to that recorded in Polish boys and reached 87 mg/dl [48]. Results of NHANES 1999 to 2006 investigations demonstrated that mean Concentrations of Low-Density Lipoprotein Cholesterol in US Adolescents accounted for 89.3 mg/dl (16-year-olds) and 88.9 mg/dl (17-year-olds), respectively. Based on

statistical data collected in America, diversification of LDL-cholesterol concentration was demonstrated in a group of adolescents depending on their origin. Its mean concentration in 12-17-year-old boys of white race accounted for 89.7 mg/dl, in the Mexicans - for 88.9 mg/dl, and in the adolescents of black race - for 91.4 mg/dl [10]. Higher LDL cholesterol values were recorded among boys from 11-18 years of age in research *Murakami* et al. - 99.4 mg / dl [30].

In our study, the mean concentration of HDL-cholesterol reached 52.4 mg/dl, with the threshold concentration noted in 23.6% and a low concentration - in 1.6% of the boys examined. The value of the mean concentration was less favorable as compared to the Japanese 16-year-old adolescents (59.6 mg/dl), in which as many as 50% of the subjects displayed a low concentration of that cholesterol fraction [1]. Results of the NHANES 2011-2014, the *Ito* et al. and the *Murakami* et al. research investigations were alike (53.5 ± 12.4 mg/dl 59 ± 11 mg/dl and 48.0 mg/dl, respectively) [19, 30, 48].

The mean concentration of triglycerides in the boys surveyed in our study was at a level of 92.9 mg/dl. A considerable percentage of the boys were displaying their threshold and high concentrations, i.e. 23.8% and 17.9% of the group, respectively. According to *Abe* et al. [1] the mean concentration of triglycerides in 16-year-old boys from Japan was 99.7 mg/dl, and with a high level observed in nearly 25% of respondents from this age group. From cross-sectional studies based on data from the National Diet and Nutrition Survey (NDNS), the concentration of triglycerides among 11-19-year-old British boys was comparable with results reported in Poland - 90.34 mg/dl [30].

Disorders in the lipid profile occur with a greater frequency in adolescents with overweight and obesity [29, 41]. *Sarganas* et al. found that about 34% of boys aged 11-17 years had low physical activity (up to 4 hours/week) [37]. Research conducted by *de Moraes* et al. [8] and *Sulo* et al. [44] indicate a decrease in morbidity and mortality due to cardiovascular diseases. However, there are regions at the festival in which this rate continues to increase. It depends mainly on the proper control of health habits, such as reducing smoking, increasing and regularly exercising, and avoiding overweight and obesity. A study on children and adolescents from Florianopolis risk factors of cardiovascular diseases demonstrated that 3.5% of the study group were smoking cigarettes, spend about 2.6 ± 2.3 hours/day on inactive free time, and as much as 48% had a positive family interview in terms of circulatory system diseases [13]. The evaluation of the nutritive value of an average food ration in *Murakami* et al. research indicated a high contribution of energy derived from total fats - 34.6%. It was shown that dietary fiber intake was not less than 26.6 g /10 MJ [28].

Our survey demonstrated even higher intake of total fats (36.4% of energy), including those from SFA (14.4% of energy), by the boys from Poland. Ca. 30 % of the respondents were smoking cigarettes, and 17.3% of the boys displayed a low physical activity. Worthy of notice is also the effect of dietary fibre content of food rations on the nutritional status of the boys examined. Results of the odds ratio demonstrated a 2.5-fold increase in the likelihood of high BMI values at a low intake of dietary fibre (aOR=2.53 [1.31-4.91]).

Savva [38] was searching for relationships between biochemical and anthropometric factors of 10-14-year-old participants of the Research and Education Program for Child Health from Cyprus. In the boys examined, the mean concentration of cholesterol accounted for 170.8 mg/dl, that of LDL-cholesterol - for 95.3 mg/dl, that of HDL-cholesterol - for 62.0 mg/dl, and that of triglycerides - for 67.7 mg/dl. The BMI value reached 19.3 kg/m^2 and waist circumference - 70.7 cm on average. Likewise in our study, at high BMI values, results of the odds ratio demonstrated a few fold increase in the risk of a high concentration of cholesterol (aOR=1.62 [1.20-2.17]), LDL-cholesterol (aOR=2.31 [1.69-3.16]) and triglycerides (aOR=4.65 [2.96-7.29]) in blood of the surveyed subjects. A high risk of health complications was also indicated at high values of waist circumference, adopted at a level of ≥75th percentile: for a high concentration of total cholesterol (aOR=1.58 [1.17-2.12]), LDL-cholesterol (aOR=2.11 [1.54-2.89]), and triglycerides (a OR=4.10 [2.63-6.41]), at $p<0.005$. In the reported own study, especially boys with overweight and obesity were characterized by an increased likelihood of a high concentration of total cholesterol (aOR=2.27 [1.22-4.23]), triglycerides (aOR=2.35 [1.28-4.34]), and LDL-cholesterol (aOR=2.41 [1.15-5.03]). A high value of waist circumference, acc. to *Katzmarzyk* et al. [21], also posed a risk of a high concentration of cholesterol (aOR=2.03 [1.26-3.24]), triglycerides (aOR=1.8 [1.18-2.76]), and LDL-cholesterol (aOR=2.19 [1.19-4.04]) as well as of a low concentration of HDL-cholesterol (aOR=1.96 [1.21-3.16]).

Investigations of *Raitakari* et al. [34] addressing risk factors of the circulatory system in children and adolescents from Finland confirmed that the impact of those factors at young age determined their health status in the adulthood.

Results of a research by *Nemet* et al. [31] demonstrated that a complex modification of a diet, eating habits and physical activity in obese children brought long-standing health benefits. Three-month intervention was found to yield noticeable effects in reduction of body mass (on average from 63.8 to 61.0 kg), BMI value (from 28.5 to 26.8 kg/m^2). What is more, positive changes were observed in blood lipid profile, i.e.: concentration of total cholesterol (170.1

- 147.8 mg/dl), LDL-cholesterol (106.5-89.7 mg/dl), HDL-cholesterol (43.6-44.8 mg/dl) and triglycerides (93.6-79.7 mg/dl). Changes in lifestyle continued over a long time span were observed to result in the successive, beneficial reduction of body mass and lipid indices observed after a year since the intervention.

A proper body mass, insulin-susceptibility, blood lipid profile and arterial blood pressure in the childhood and adolescence minimize the risk of the incidence of a metabolic syndrome in the adulthood and are implicated in a fewer likelihood of the incidence of circulatory system diseases [25, 42].

CONCLUSIONS

Results obtained in the study enabled concluding that the lifestyle of young boys was determining the risk of their cardiovascular diseases. Overweight and obesity, visceral obesity in particular, were demonstrated to be significant risk factors of disorders in lipid metabolism of the boys surveyed in the study.

Conflict of interest
None declared.

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