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## Selected atherosclerosis risk factors in youth aged 13–15 years\*

### Wybrane czynniki ryzyka rozwoju miażdżycy u młodzieży w wieku 13–15 lat

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- B** Data Collection
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#### Summary

##### Introduction:

The high frequency of cases of circulatory system conditions in Europe and other countries around the world requires scientific research to define risk factors of early atherosclerotic changes. The aim of the present study was to define which students are at danger of developing atherosclerosis by means of measuring cholesterol and triglyceride levels in blood as well as defining the correlation between atherosclerosis risk factors and arterial blood pressure, physical fitness and efficiency of the subjects.

##### Material/Methods:

The research covered 167 students of Public Junior High School #1 in Biała Podlaska aged 13–15 years. Accutrend GCT was employed to define the levels of total cholesterol and triglycerides in the screen test. Those students who were found to have increased values of biochemical parameters of capillary blood were subjected to additional blood tests aiming to define complete lipid profile of venous blood. The blood pressure in subjects was tested three times. The Moderate-to-Vigorous Physical Activity (MVPA) test, suggested by American authors, was employed to define physical activity in subjects. EUROFIT was employed to define physical efficiency.

##### Results:

Among the 167 subjects there were found 42 students (25.1%) whose lipid level in capillary blood proved to be increased. Full lipid profile tests proved that 16 students (9.6%) had increased blood lipid levels; those subjects constituted the risk group. Subjects in the risk group were characterized by lower levels of physical activity and physical efficiency compared to subjects with normal blood lipid level. Moreover, the frequency of hypertension was greater in risk group subjects compared to subjects with normal blood lipid levels.

##### Inferences:

Students diagnosed with atherosclerosis risk factors require observation and early prophylactics by adopting habits of healthy physical activity.

##### Key words:

**atherosclerosis • hypertension • physical activity • physical efficiency**

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## Streszczenie

**Wstęp:** Bardzo częste występowanie chorób układu krążenia w Europie i innych krajach na świecie uzasadnia podejmowanie badań profilaktycznych dotyczących identyfikacji czynników ryzyka rozwoju wczesnych zmian miażdżycowych. Celem pracy była próba rozpoznania grupy uczniów obciążonych ryzykiem rozwoju miażdżycy na podstawie oznaczenia stężeń cholesterolu i triglicerydów we krwi oraz poszukiwanie związków między stwierdzonymi czynnikami ryzyka a ciśnieniem tętniczym, wydolnością i aktywnością fizyczną badanych.

**Materiał/ Metody:** Badaniami objęto 167 uczniów obu płci w wieku 13–15 lat uczęszczających do Publicznego Gimnazjum nr 1 w Białej Podlaskiej. Oznaczenia cholesterolu całkowitego i triglicerydów metodą przesiewową dokonano za pomocą aparatu Accutrend GCT. Osoby, u których stwierdzono podwyższony poziom parametrów biochemicznych we krwi kapilarnej zostały poddane dodatkowym badaniom krwi, polegającym na pełnym oznaczeniu lipidogramu we krwi żyłnej. Wśród badanych dokonano 3-krotnego pomiaru ciśnienia tętniczego. Aktywność fizyczna badanych była oceniana na podstawie amerykańskiego testu MVPA (Moderate-to-Vigorous Physical Activity). Do oceny wydolności fizycznej badanych uczniów zastosowano jedną z prób Europejskiego Testu Sprawności fizycznej – EUROFIT.

**Wyniki:** W badaniach przesiewowych spośród 167 badanych uczniów wyłoniono 42 osoby (25,1%) z podwyższonymi wskaźnikami lipidowymi we krwi kapilarnej. Po oznaczeniu pełnego lipidogramu we krwi żyłnej tych osób, potwierdzono podwyższone wskaźniki lipidowe u 16 osób (9,6%) [grupa ryzyka]. Młodzież stanowiąca grupę ryzyka charakteryzowała się mniejszą aktywnością i wydolnością fizyczną od osób z prawidłowymi wartościami wskaźników lipidowych. Ponadto częstość występowania nadciśnienia tętniczego wśród uczniów należących do grupy ryzyka była większa niż w grupie z prawidłowymi wartościami wskaźników lipidowych.

**Wnioski:** Uczniowie, u których stwierdzono obecność czynników ryzyka miażdżycy wymagają obserwacji i wczesnej profilaktyki przez wyrabianie nawyków aktywnego wypoczynku.

**Słowa kluczowe:** miażdżycy • nadciśnienie tętnicze • aktywność fizyczna • wydolność fizyczna

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**Abbreviations:** HTN – hypertension; IHD – ischemic heart disease; PHTN – prehypertension; TC – total cholesterol; TG – triglycerides

## INTRODUCTION

Cardiovascular disorders are the most common cause of deaths in humans in numerous developed and developing countries around the globe. They cause over 4 million deaths in Europe annually (55% of deaths in females and 43% of deaths in males). In Poland cardiovascular disorders are responsible for 50% of all deaths, among which ischemic heart disease (IHD) is the most common [5,11].

Atherosclerosis is responsible for the basis of clinical symptoms of IHD, and is a chronic, inflammatory degenerative condition of complex etiopathogenesis. The atherosclerotic process is a continuous one and lasts many years, being characterized by focused accumulation of cholesterol, smooth muscle cells and fibrous tissue in tunica media of artery walls. As a result of those changes there develop

atherosclerotic plaques which cause occlusion of the artery and obstruct blood flow. Advanced atherogenesis often leads to death through such hard endpoints as heart attack, stroke, cardiac dysrhythmia and heart failure [3,5,11,18,21].

The process of **atherosclerosis** starts with reversible changes called fatty streaks. The first fatty streaks can appear in childhood [30,52,53,54]. However, clinical symptoms of atherosclerosis, caused by development of **atherosclerotic plaques** in arterial blood vessels, are usually pronounced only in the fourth decade of life. Therefore, early identification of risk factors of atherosclerosis in children and youth is considered to be of immense importance to prevent cardiovascular diseases in adults [3].

There are several risk factors for developing atherosclerosis which are related to both biological body features and

life style features, but the following are the most common: lipid metabolism disorders, hypertension (often resulting from unhealthy diet) and low physical activity which lead to obesity [6,16,33,37,44,56].

Numerous clinical and epidemiological studies prove the positive influence of regular physical activity on reducing both risk factors of atherosclerosis and mortality caused by cardiovascular disorders [4,12,15,17,27,28,32,46]. The protective role of regular physical activity is closely connected with anti-atherosclerotic effects resulting from improved lipid profile, reduced level of total cholesterol (TC), low-density lipoprotein (LDL) cholesterol (LDL-C) and triglycerides (TG) as well as increase of high-density lipoprotein (HDL) cholesterol (HDL-C) [20,23,24,32,36,48,50]. Moreover, regular physical activity is usually correlated with lower values of arterial blood pressure. It has been shown not only in adults but in children and youth as well [2,38].

Dietary interventions, which lead to improvement of blood lipid profile, reduction of body mass and arterial blood pressure, could significantly slow down, stop and even revert early atherosclerotic changes in arteries [14,26,29,40].

Increased levels of cholesterol and triglycerides are unquestionably factors which induce development of atherosclerotic (atheromatous) plaque, which is why defining those levels in youth has become very common.

The aim of the present paper was to define which students of Public Junior High School №1 in Biala Podlaska are at danger of developing atherosclerosis by means of measuring cholesterol and triglyceride levels in blood, as well as to define the relation between atherosclerosis risk factors and arterial blood pressure, physical fitness and efficiency of the subjects.

## MATERIAL AND METHODS

The research covered 167 students (85 females and 82 males) of Public Junior High School №1 in Biala Podlaska aged 13–15 years.

The research was conducted following the approval from the parents of subjects and the school's authorities. The aim of the screening was to define which subjects had increased blood levels of cholesterol and triglycerides which could signify danger or development of atherosclerosis.

Accutrend GCT by the Swiss manufacture ROCHE was employed to screen the subjects in order to define total cholesterol and triglyceride levels. The above mentioned biochemical parameters were measured in capillary blood of subjects (fasting conditions); blood samples were taken from finger tips. Values of total cholesterol <200 mg/dl and triglycerides <180 g/dl were considered normal.

Those students who were found to have increased values of biochemical parameters of capillary blood were subjected to additional blood tests aiming to define complete lipid profile of venous blood (TC, LDL-C, HDL-C, TG). Values of biochemical parameters in the subjects were compared with the laboratory norms [11,24].

Subjects who were found to have such poor health indicators as increased values of TC, LDL and TG as well as reduced values of HDL were classified in the risk group of atherosclerosis. Students from the risk group of atherosclerosis as well as students whose biochemical parameters were normal were subjected to further tests aiming to find such further atherosclerosis risk factors as increased blood pressure, low levels of physical activity and physical efficiency.

According to the fourth report from the National High Blood Pressure Education Program the blood pressure in subjects was tested three times [55]. Correct interpretation of blood pressure centiles for gender, age and body height (considering individual physical development of subjects) was used to define arterial hypertension in the subjects tested.

Physical activity of subjects was defined by means of a physical activity test suggested by American authors J. Prochaska, J. Sallisa and B. Long. The test estimated Moderate-to-Vigorous Physical Activity (MVPA) based on a 7-point system [42].

Physical efficiency was defined by means of EUROFIT **20 m endurance shuttle-run** test. The subjects were asked to increase their running speed after each 20 m section covered. Additionally, maximal oxygen consumption  $VO_{2max}$  (ml/kg/min) was defined based on the number of 20 m sections covered.

## RESULTS

Among the 167 subjects aged 13–15 years there were found 42 students (25.1%) whose lipid level in capillary blood proved to be increased (Table 1), including 16 students (9.6%) whose cholesterol level proved to be increased and 26 students (15.6%) whose triglyceride level proved to be increased.

Students whose lipid level in capillary blood proved to be increased were subjected to further tests (Table 2). After defining complete lipid profile of capillary blood (TC, LDL-C, HDL-C, TG) 16 students (9.6%) were found to have increased lipid values (atherosclerosis risk group). The atherosclerosis risk group contained 7 males (4.2%) and 9 females (5.4%). Five subjects (3%), 2 males (1.2%) and 3 females (1.8%) were characterized by increased values of total cholesterol (above 200 mg/dl). Average total cholesterol value in those five subjects was  $242 \pm 25.4$  mg/dl, whereas higher total cholesterol values were found in males ( $248.0 \pm 39.6$  mg/dl) compared to females ( $239.0 \pm 21.5$  mg/dl). Two subjects were found to have their LDL level increased (above 155 mg/dl), whereas the average value was  $160.6 \pm 2.6$  mg/dl. Only one subject was found to have an insufficient level of HDL with the result of 33.1 mg/dl. Eleven subjects (6.6%), 5 males (3.0%) and 6 females (3.6%) were found to have increased values of triglycerides (above 180 mg/dl). Average triglycerides value in the risk group was  $256 \pm 58.9$  mg/dl, whereas higher values were found in females ( $276.0 \pm 55.3$  mg/dl) compared to males ( $232.2 \pm 59.7$ ).

The data presented in tables 3 and 4 prove that subjects in the atherosclerosis risk group were characterized by lower

Table 1. Number and percentage (%) of subjects aged 13–15 years with increased values of biochemical parameters in capillary blood

Specification	Subjects					
	Males and females		Males		Females	
	N	%	n	%	n	%
	<b>167</b>	<b>100.0</b>	<b>82</b>	<b>49.1</b>	<b>85</b>	<b>50.9</b>
Cholesterol>200 mg/dl	16	9.6	8	4.8	8	4.8
Triglycerides>180 mg/dl	26	15.6	9	5.4	17	10.2
Subjects with increased values of biochemical parameters in capillary blood	42	25.1	17	10.1	25	15.0

Table 2. Number and percentage (%) of subjects aged 13–15 years with increased values of biochemical parameters in venous blood and the mean values of biochemical parameters (mean ± SD)

Specification	Subjects					
	Males and females		Males		Females	
	n	%	n	%	n	%
	<b>167<sup>#</sup></b>	<b>100.0</b>	<b>82</b>	<b>49.1</b>	<b>85</b>	<b>50.9</b>
Cholesterol>200 mg/dl	5	3.0	2	1.2	3	1.8
Total cholesterol (mg/dl) mean ± SD	242.6±25.4		248.0±39.6		239.0±21.5	
HDL<40 mg/dl	1	0.6	–	–	1	1.2
HDL (mg/dl)	33.1		–		33.1	
LDL>155 mg/dl	2	1.2	1	1.2	1	1.2
LDL (mg/dl) mean ± SD	160.6±2.6		158.7		162.6	
Triglycerides>180 mg/dl	11	6.6	5	3.0	6	3.6
Triglycerides (mg/dl) mean ± SD	256.1±58.9		232.2±59.7		276.0±55.3	
Atherosclerosis risk group	16	9.6	7	4.2	9	5.4

<sup>#</sup> only subjects with increased values of biochemical parameters in capillary blood were tested.

Table 3. Physical activity of subjects (mean ± SD)

Specification	Subjects N=167 (100%)	
	Risk group subjects N <sub>1</sub> =16 (9.6%)	Non-risk group subjects N <sub>2</sub> =151 (90.4%)
Physical activity (MVPA points) mean ± SD	3.6±0.9	4.0±1.1

level of physical activity and physical efficiency when compared to subjects whose lipid values proved to be normal. Physical activity measured by means of MVPA was 3.6±0.9 points in the risk group and 4.0±1.1 points in subjects whose lipid values proved to be normal (Table 3). Physical efficiency measured by means of maximal oxygen consumption (VO<sub>2</sub>max) was found to be 29.3±3.6 ml/kg/min in the risk group and 30.0±4.3 in subjects whose lipid values proved to be normal.

Hypertension (HTN) was frequently found in the risk group subjects compared to subjects whose lipid values proved to be normal (Table 5). However, prehypertension was more frequently found in subjects who did not belong to the group of risk. Also average values of hypertension (both systolic and diastolic) were more frequently found in risk group subjects compared to the rest of the subjects. Average systolic hypertension was 135.1±17.1 mmHg in risk group subjects and 127.0±12.6 mmHg in

Table 4. Maximal oxygen consumption ( $VO_2$ max) of subjects (mean  $\pm$  SD)

Specification	Subjects N=167 (100%)	
	Risk group subjects N <sub>1</sub> =16 (9.6%)	Non-risk group subjects N <sub>2</sub> =151 (90.4%)
Number of 20 m sections covered mean $\pm$ SD	38.6 $\pm$ 10.8	40.3 $\pm$ 12.7
$VO_2$ max (ml/kg/min) mean $\pm$ SD	29.3 $\pm$ 3.6	30.0 $\pm$ 4.3

Table 5. Number and percentage of subjects with hypertension (HTN), prehypertension (PHTN), normal blood pressure values and mean values of arterial blood pressure (mean  $\pm$  SD)

Specification	Subjects N=167 (100%)					
	Both risk group subjects and non-risk group subjects N=167 (100%)		Risk group subjects N <sub>1</sub> =16 (9.6%)		Non-risk group subjects N <sub>2</sub> =151 (90.4%)	
	n	%	n	%	N	%
HTN	35	20.9	4	25.0	31	20.5
PHTN	30	18.0	2	12.5	28	18.5
Normal blood pressure	102	61.1	10	62.5	92	60.9
Blood pressure						
- systolic mean $\pm$ SD	128.4 $\pm$ 13.7		135.1 $\pm$ 17.1		127.0 $\pm$ 12.6	
- diastolic mean $\pm$ SD	77.0 $\pm$ 8.5		79.8 $\pm$ 9.8		76.3 $\pm$ 8.1	

HTN – hypertension; PHTN – prehypertension.

non-risk group subjects. Average diastolic hypertension was 79.8 $\pm$ 9.8 mmHg in risk group subjects and 76.3 $\pm$ 8.1 mmHg in non-risk group subjects.

## DISCUSSION

Numerous clinical studies indicate that atherosclerotic conditions can be found in humans even in early life stages, whereas atherosclerosis risk factors significantly influence the spread and advancement of the problem [30,53].

Our research proved that atherosclerosis risk factors are present in young age in humans. Among the 167 tested subjects aged 13–15 years there were found 16 students (9.6%) whose lipid level in venous blood proved to be increased, where 5 subjects (3%) had increased level of cholesterol and 11 subjects (6.6%) had increased level of triglycerides.

The autopsy research conducted in years 1987–1994 by the Pathobiological Determinants of Atherosclerosis in Youth Research Group (PDAY) covered 2876 subjects aged 15–34 years and proved the presence of fatty streaks in each tested subject. Moreover, the significant development of fatty streaks in subjects aged 30–34 years has been proved. Also there has been proved a positive correlation between lipid profile disorders, high BMI, hypertension and progression of atherosclerotic plaques [31].

Defining levels of total cholesterol, LDL, HDL and triglycerides in blood serum has become a basic clinical test in estimation of lipid profile disorders [9,10,22,34,40,43]. Epidemiological tests have definitely proved direct dependence between cholesterol level in blood and development of atherosclerotic plaque [7,47]. The risk of developing atherosclerosis is close to zero in cases when the cholesterol level does not exceed 170 mg/dl, but the risk increases with the increase of cholesterol level [1]. In the present research the average cholesterol value was 242.6 $\pm$ 25.4 mg/dl. Such condition could lead to development of ischemic heart disease in the future if precautions aimed at reducing cholesterol level are not taken. It must, though, be clearly mentioned that atherosclerosis could be developed even when cholesterol level in blood is low due to the fact that such factors as increased blood level of homocysteine, blood coagulation disorders and intensification of lipid peroxidation processes are widely known to increase atherosclerosis risk [13]. Not long ago scientists used to believe that 10% increase of total cholesterol level increases atherosclerosis risk by 20%. Nowadays it has been proved that 10% increase of total cholesterol level has much greater influence on atherosclerosis risk and increases atherosclerosis risk more than 40%. Population studies have proved that 1% reduction of total cholesterol level in blood serum decreases the risk of developing ischemic heart disease by about 2% [1,45]. The level of total cholesterol in blood serum could be reduced

either by proper diet alone or proper diet combined with intensified physical activity, which significantly reduces the risk of heart attack and death caused by ischemic heart disease [25]. The level of total cholesterol in blood serum is considered to be normal below 5.2 mmol/l (200 mg/dl), because the risk of developing ischemic heart disease when the level of total cholesterol in blood serum is below 5.2 mmol/l (200 mg/dl) is insignificant. Cholesterol level within the range of 5.2–6.5 mmol (200–250 mg/dl) is considered to be pre-hypercholesterolemic, whereas cholesterol level which exceeds 6.5 mmol/l is considered to be dangerously hypercholesterolemic [41]. It has been proved that the increase of LDL in blood leads to accumulation of cholesterol in blood vessel walls and development of atherosclerosis [7,47]. Among the subjects tested the authors found two students, who belonged to the risk group, with increased values of LDL; the average value of LDL was 160.6±2.6 mg/dl. It is widely considered that increased LDL cholesterol level is less dangerous for developing atherosclerosis than increased total cholesterol level, but LDL level should not exceed 135 mg/dl when other atherosclerosis risk factors are present (hypertension, obesity). However, LDL cholesterol level could be tolerated up to 160 mg/dl when there are no additional atherosclerosis risk factors [41].

High level of triglycerides is often connected with low HDL level, high LDL level and blood coagulation disorders. A triglyceride level which exceeds 150 mg/dl is considered to be abnormal, but the triglyceride level limit is considered to be 200 mg/dl. In tested subjects the level of triglycerides was found to be abnormal, with a value of 256.1±58.9 mg/dl. HDL cholesterol level is widely credited with preventing atherosclerosis development. Gordon et al. [19] showed, based on the research conducted in Framingham, that mortality was four times more frequent in subjects with a HDL level of 35 mg/dl and lower compared to subjects with a HDL level equal to or higher than 55 mg/dl. One mg/dl increase of HDL level (e.g. by means of regular physical activity) reduces the risk of developing ischemic heart disease within the range of 2–3% [39,49]. Only one subject from the risk group proved to have a HDL level less than 35 mg/dl in the present research (33.1 mg/dl).

It has been proved by clinical research that low level of physical activity is one of the most important causes of developing cardiovascular diseases [12,46]. This was also confirmed by the present research, since subjects in the atherosclerosis risk group were characterized by lower level of physical activity (low number of MVPA points) and lower level of physical efficiency (low level of maximal oxygen consumption), when compared to subjects with a normal lipid profile. The reason is the positive metabolic changes during physical activities, which reduce the risk of cardiovascular diseases. The consequent changes in lipid profile are the most beneficial for reduction of triglycerides and

LDL level as well as increasing HDL level. Also, physical activity positively influences insulin sensitivity of tissues and reduces insulin resistance. Physical activity along with body mass reduction positively influences functioning of tunica media in blood vessels, which reduces the risk of developing atherosclerosis [35,49].

Hypertension has been widely proved to be among the primary causes of circulatory system conditions. Hypertension induces atherosclerotic changes, widening their range and increasing lipid level, which, in turn, causes development of atherosclerotic plaques [51]. Epidemiologic tests clearly prove that primary hypertension has been constantly rising in children and youth. Around 20% of youth are reported to have prehypertension or hypertension. The majority of children who are diagnosed with prehypertension in the period of 2–3 years develop primary hypertension. Hypertension tests are usually followed by interview to define any predispositions for hypertension or other cardiovascular conditions. In the present research 20% of subjects have been diagnosed with hypertension, and subjects in the atherosclerosis risk group have been significantly more frequently diagnosed with hypertension than subjects with normal lipid profile. Moreover, average blood pressure values (both systolic and diastolic) were higher in risk group subjects (systolic 135.1±17.1 mmHg; diastolic 79.8±9.8 mmHg) when compared to subjects with normal lipid profile (systolic 127.0±12.6 mmHg; diastolic 76.3±8.1 mmHg). Children and youth with primary hypertension are often diagnosed with low level of HDL cholesterol, increased level of triglycerides, abnormal glucose tolerance and insulin resistance [8,55].

The research results clearly suggest the necessity of regular lipid level tests in children and youth. Screening tests could be limited to defining levels of total cholesterol and triglycerides.

## INFERENCES

1. 9.6% of subjects within the tested population of 167 students aged 13–15 years have been diagnosed with increased biochemical blood parameters.
2. Hypertension results analysis based on centile charts showed that subjects with increased lipid profile have been significantly more frequently diagnosed with hypertension compared to subjects with normal lipid profile.
3. Subjects in the atherosclerosis risk group have been diagnosed with lower levels of physical activity and physical efficiency.
4. Students diagnosed with atherosclerosis risk factors require observation and early prophylactics by adopting habits of healthy physical activity. Moreover, such students should have blood pressure and lipid profile tests performed on a regular basis.

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