Family Medicine & Primary Care Review 2017; 19(4): 387–392 https://doi.org/10.5114/fmpcr.2017.70813

ORIGINAL PAPERS

ISSN 1734-3402, eISSN 2449-8580

Discrepancies in occurrence of metabolic disturbances related to gender among young people

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A – Study Design, **B** – Data Collection, **C** – Statistical Analysis, **D** – Data Interpretation, **E** – Manuscript Preparation, **F** – Literature Search, **G** – Funds Collection

Summary **Background.** Metabolic disturbances are the most establishing risk factors for cardiovascular diseases at an elderly age. Early identification and behavioral or pharmacological treatment of metabolic abnormalities is the best way to prevent cardiovascular incidents in the future.

Objectives. The aim of our study was to investigate the prevalence of the metabolic disturbances and metabolic syndrome among young, apparently healthy, Polish people.

Material and methods. 292 apparently healthy people (71 males and 221 females) aged 18–31 years participated in this study. The following variables were analyzed: height, weight, waist and hip circumferences, blood pressure, fasting glucose and lipid profiles. The diagnostic criteria for the metabolic syndrome according to the International Diabetes Federation (2009) were used.

Results. The prevalence of metabolic disturbances was from 6.5% (19) for Diastolic Blood Pressure ≥ 90 mm Hg up to 20.2% (59) for LDL-cholesterol ≥ 3.0 mmol/L in all participants. After dividing in subgroups of male and female, the most frequently observed were LDL hypercholesterolemia 33.8% (24) and 15.8% (35), respectively. Metabolic syndrome was observed in 10.3% (30) of the total studied group, and there was a significant difference between male – 31% (22), and female – 3.6% (8). Prevalence of metabolic syndrome was associated with overweight and obesity only in males.

Conclusions. The prevalence of metabolic disturbances and metabolic syndrome was found in a large proportion of the studied group, and a substantial discrepancy between males and females was observed. All types of disturbances were more often met in males. These observations could be useful when carring out different health promotion strategies for young people in Poland.

Key words: metabolic diseases, metabolic syndrome X, young adult.

Płaczkowska S, Pawlik-Sobecka L, Kokot I, Piwowar A. Discrepancies in occurrence of metabolic disturbances related to gender among young people. *Fam Med Prim Care Rev* 2017; 19(4): 387–392, doi: https://doi.org/10.5114/fmpcr.2017.70813.

Background

The main causes of premature mortality in the world, as well as in Poland, are diabetes and cardiovascular diseases (CVD). The greatest risk factors for these non-infectious diseases are metabolic disturbances, such as hyperglycemia, atherogenic dyslipidemia, high blood pressure and an excess of fat tissue, especially in the abdominal region. Nowadays, a gender gap in mortality is observed, which is increasing over the years. In comparison to males, the generally longer life of females is caused by many factors, such as social and economic status, more frequent use of healthcare services and differences in health behaviors, especially smoking [1–3]. These same, good socio-economic factors consequently lead to the development of metabolic syndrome and premature mortality in males [4].

Development of type 2 diabetes (T2D) and the rising number of incidences of cardiovascular diseases are especially associated with three or more co-existing metabolic features, called metabolic syndrome (MS). The definition of MS has changed several times since 1988, when Reaven introduced it for the first time [5], with a tendency to emphasize the importance of insulin resistance or central adiposity [6]. The current definition of MS takes into account such factors as central obesity, raised blood pressure, elevated triglycerides and glucose concentration and reduced high density lipoprotein concentration. Metabolic syndrome occurrence is related to a 2–3 times higher risk of CVD and 5 times higher risk of T2D in comparison to normal weight individuals, independent of other risk factors, such as smoking or alcohol drinking. Despite of the fact that each metabolic disturbance independently increases the risk of cardiovascular complications, recognition of metabolic syndrome is widely discussed in world literature, and studies in this area are still conducted [7]. Indeed, for a person with fixed metabolic abnormalities, like T2D, recognition of metabolic syndrome does not bring about new information concerning CVD risk [8]. However, it could be very important in clinical practice and a useful tool for identifying recipients of prevention and educational health programs, especially among young, apparently healthy people [9].

The increase of the prevalence of metabolic syndrome with age is well documented among middle-aged people [10]. It is generally accepted, that metabolic diseases have their origin many years before the appearance of overt clinical symptoms. In recent years, disclosure of these disorders has been increasingly observed in younger people, and this situation is undoubtedly caused by the common sedentary lifestyle of adolescents and young adults [11]. According to this fact, the best way to prevent premature mortality due to cardiovascular diseases is early identification of metabolic disturbances. Data about the prevalence of metabolic disorders and recognition of metabolic syndrome according to the 2009 definition of the International Diabetes Federation (IDF) is limited for the young population of Poland [12, 13].

Objectives

The aim of this cross-sectional study was to assess the incidence of metabolic disturbances and metabolic syndrome among young Polish people according to current recommendations. The data obtained in this study can be useful for planning preventive programs in order to improve the health condition of the young population of Poland.

Material and methods

The participants were recruited from young, apparently healthy people aged 18–31, living at least for three years in the urban area of Wroclaw. The total sample size included in this study was 292 participants and consisted of 221 females and 71 males. The study protocol was approved by the appropriate University Ethics Commission, decision no. 194/2009. Each of the participants provided written informed consent. The study was conducted in three phases. At first, epidemiological data was collected using a questionnaire created by the authors, which consisted of questions about family history of metabolic disorders, the frequency of use of health services and life-style habits. In the second step, anthropometric measurements: weight, height, waist and hip circumference, were taken under fasting conditions, without shoes and in light clothes. Blood pressure was measured two times, after at least 10 minutes resting in a sitting position, and the mean was calculated for further analysis. The third stage of our study included laboratory examinations of glucose level (Thermo Elektro Oy, Vantaa, Finland) and a lipid serum profile (total and HDL-cholesterol, triglycerides) (DiaSys, Holzheim, Germany) using the chemistry analyzer Konelab 20i (Thermo Scientific, Waltham, Massachusetts, USA). LDL-cholesterol was calculated using the Friedewald formula. All laboratory parameters were determined using routine methods.

Based on laboratory parameters, metabolic disturbances were diagnosed according to current recommendations. Hyperglycemia was recognized when fasting plasma glucose (FPG) ≥ 5.6 mmol/L [14]. For recognition of lipid profile abnormalities, the following criteria were applied: total cholesterol ≥ 5.0 mmol/L, triglycerides ≥ 1.7 mmol/L, LDL cholesterol ≥ 3.0 mmol/L, HDL cholesterol < 1.0 mmol/L for males and < 1.2 mmol/L for females [15]. Blood pressure was classified according to the Polish Hypertensive Association: ≥ 130/85 mm Hg for high correct and ≥ 140/90 mm Hg for hypertension I^0 [16]. General obesity was distinguishing on the basis of World Heath Organization (WHO) recommendations for body mass index (BMI). As a cut-off point for general obesity, ≥ 25 kg/m^2 was used for both genders. The World Health Organization cut-off criteria were also applied for excess Waist-Hip Ratio (WHR) recognition: > 0.9 for males and > 0.85 for females [17].

Recommendations of the International Diabetes Federation Task Force on Epidemiology and Prevention, established in 2009, were used to recognize metabolic syndrome. Participants were defined as having MS according to the IDF recommendations if they met, or exceeded, three or more of the following criterions: waist circumference (WC) ≥ 80 cm for females and ≥ 94 cm for males, systolic blood pressure (SBP) ≥ 130 mm Hg and/or diastolic blood pressure (DBP) ≥ 85 mm Hg, FPG ≥ 5.6 mmol/L, HDL < 1.0 mmol/L for males and < 1.3 mmol/L for females and TG ≥ 1.7 mmol/L. IDF criterions for waist circumference were also used for central obesity recognition [7]. We assessed the prevalence of incorrect anthropometric parameters, metabolic disturbances and metabolic syndrome in the male and female groups.

Statistical analysis was performed using the statistical software STATISTICA 10 PL, StatSoft Poland. Distribution of the variables were tested with the Shapiro–Wilk test, and all data were presented as median with minimal and maximal ranges, because of non-parametric distribution of variables. The non-parametrical Mann–Whitney U test for medians was used for comparison of the differences between males and females. Categorical variables were compared with the χ^2 test, but if the group consisted of 5 or less participants, the Fisher's exact test was used. *p*-values < 0.05 were accepted as significant.

Results

The general anthropometric and metabolic characteristics of our study participants are provided in Table 1. The results of our study showed a high prevalence of all metabolic disturbances in the studied young, apparently healthy, people living in an urban area. The lipid profiles were the most frequent disorders observed for males and females, but incidence of nearly all metabolically features, except of high correct diastolic blood pressure, differed significantly between the genders. These results are presented in Table 2 and Figure 1.

The prevalence of disturbances established as features of metabolic syndrome was estimated according to IDF criterions 2009. These results are presented in Table 3 and Figure 2.

Table 1. Characteristics of the study participants

Variables	All	Male	Female	*p*
Number of participants (*n*)	292	71	221	–
Age, year	23 (18–31)	24 (19–31)	22 (18–30)	< 0.001
Weight, kg	61.1 (40.0–132.0)	81.7 (56.1–132.0)	58.0 (40.0–98.0)	< 0.001
Height, cm	168 (150–197)	180 (164–197)	165 (150–180)	< 0.001
BMI, kg/m^2	21.6 (16.0–41.7)	25.4 (18.2–41.7)	20.8 (16.0–38.3)	< 0.001
Waist circumference, cm	74.0 (54.0–129.0)	88.0 (72.0–129.0)	70.0 (54.0–110.0)	< 0.001
Hip circumference, cm	97.0 (63.0–125.0)	102.5 (85.0–125.0)	95.0 (63.0–116.0)	< 0.001
Waist-Hip Ratio	0.75 (0.59–1.08)	0.82 (0.70–1.08)	0.73 (0.59–0.94)	< 0.001
Fasting plasma glucose, mmol/L	4.9 (3.4–6.4)	5.1 (4.0–6.4)	4.8 (3.4–5.9)	< 0.001
Total cholesterol, mmol/L	4.4 (2.3–7.4)	4.4 (2.3–7.4)	4.4 (3.0–6.6)	0.652
HDL-cholesterol, mmol/L	1.5 (0.7–2.5)	1.1 (0.7–2.1)	1.5 (0.9–2.5)	< 0.001
LDL-cholesterol, mmol/L	2.5 (0.8–5.9)	2.6 (0.8–5.9)	2.5 (1.2–4.1)	0.092
Triglycerides, mmol/L	0.9 (0.3–4.8)	1.0 (0.4–4.8)	0.8 (0.3–2.4)	0.003
Systolic blood pressure, mm Hg	117 (90–154)	126 (105–140)	114 (90–154)	< 0.001
Diastolic blood pressure, mm Hg	76 (55–98)	80 (68–98)	75 (55–95)	< 0.001

Data presented as median with min–max range. Abbreviations: *p* – a two-tailed probability value of Mann–Whitney U test for male and female comparison.

Table 2. Prevalence of metabolic disturbance in the entire study group including a comparison between males and females

Metabolic disturbances		All [%] *n* = 292	Male [%] *n* = 71	Female [%] *n* = 221	*p*
Fasting plasma glucose: ≥ 5.6 mmol/L		7.9 23	19.7 14	4.1 9	< 0.001
Triglycerides: ≥ 1.7 mmol/L		10.3 30	16.9 12	8.1 18	0.034
HDL-cholesterol: < 1.0 mmol/L male < 1.2 mmol/L female		12.4 36	25.3 18	8.1 18	< 0.001
LDL-cholesterol: ≥ 3.0 mmol/L		20.2 59	33.8 24	15.8 35	0.001
Total cholesterol: ≥ 5.0 mmol/L		16.4 48	23.9 17	14.0 31	0.049
High correct blood pressure	SBP: ≥ 130 mm Hg	9.6 28	22.5 16	5.4 12	< 0.001
	DBP: ≥ 85 mm Hg	9.6 28	11.3 8	9.0 20	0.580
Hypertension I^{o}	SBP: ≥ 140 mm Hg	8.2 24	23.9 17	3.2 7	< 0.001
	DBP: ≥ 90 mm Hg	6.5 19	19.7 14	2.3 5	< 0.001
Waist-Hip Ratio: > 0.9 male > 0.85 female		7.9 23	23.9 17	2.7 6	< 0.001

The results are presented as a percentage of a proper group and number of participants.
Abbreviation: DBP – diastolic blood pressure; SBP – systolic blood pressure; *p* – a two-tailed probability value of the χ^2 test for male and female comparison.

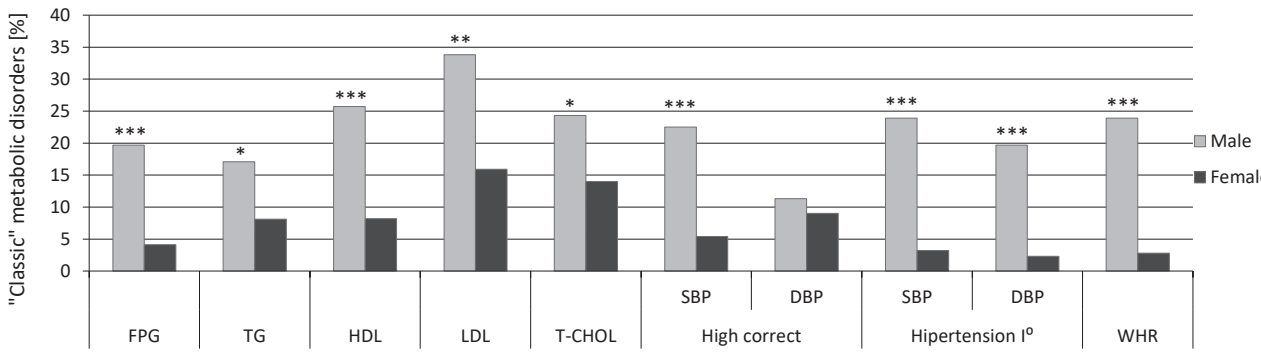

Figure 1. Prevalence of metabolic disturbances with a comparison between males and females

p-value: *< 0.05; **0.01; ***< 0.001. Abbreviations: FPG – fasting plasma glucose; TG – triglycerides; HDL – high density lipoprotein; LDL – low density cholesterol; T-CHOL – total cholesterol; SBP – systolic blood pressure; DBP – diastolic blood pressure; WHR – waist-hip ratio.

Table 3. Prevalence of metabolic syndrome features in the study group (according to IDF 2009)

Feature of metabolic syndrome	All [%] *n* = 292	Male [%] *n* = 71	Female [%] *n* = 221	*p*
Waist circumference: ≥ 94 cm male ≥ 80 cm female	24.3 71	40.8 29	19.0 42	< 0.001
Systolic blood pressure: ≥ 130 mm Hg	17.8 52	46.5 33	8.6 19	< 0.001
Diastolic blood pressure: ≥ 85 mm Hg	16.1 47	31.0 22	11.3 25	< 0.001
Fasting plasma glucose: ≥ 5.6 mmol/L	7.9 23	19.7 14	4.1 9	< 0.001
HDL-cholesterol: < 1.0 mmol/L male < 1.3 mmol/L female	19.2 56	28.2 20	16.3 36	< 0.001
Triglycerides: ≥ 1.7 mmol/L	10.3 30	16.9 12	8.1 18	0.034

The results are presented as a percentage of a proper group and number of participants.
Abbreviations: *p* – a two-tailed probability value of the χ^2 test for male and female comparison.

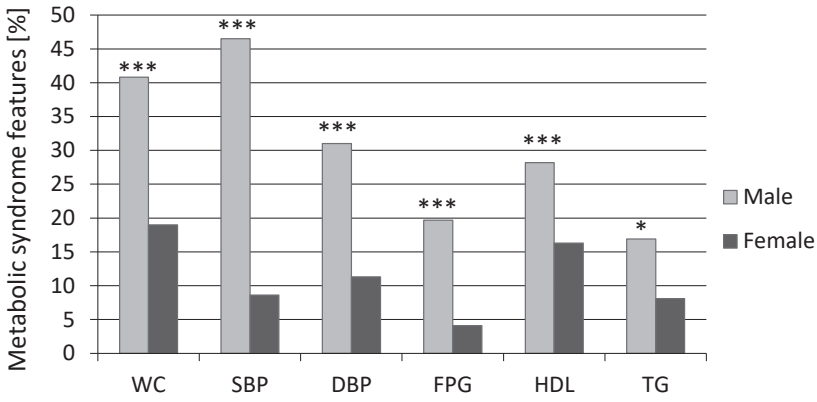

Figure 2. Prevalence of features of metabolic syndrome comparison in males and females

p-value: *< 0.05; ***< 0.001.
Abbreviations: WC – waist circumference; SBP – systolic blood pressure; DBP – diastolic blood pressure; FPG – fasting plasma glucose; HDL – high density cholesterol; TG – triglycerides.

Table 4. The number of metabolic syndrome features in all participants including a comparison between males and females

Number of features of metabolic syndrome	All [%] *n* = 292	Male [%] *n* = 71	Female [%] *n* = 221	*p*
1	30.5 89	25.3 18	32.1 71	0.281
2	10.9 32	14.1 10	10.0 22	0.332
3	8.2 24	22.5 16	3.6 8	< 0.001
4	2.1 6	8.4 6	0.0	–

The results are presented as a percentage of a proper group and number of participants.
Abbreviations: *p* – a two-tailed probability value of the χ^2 test for male and female comparison.

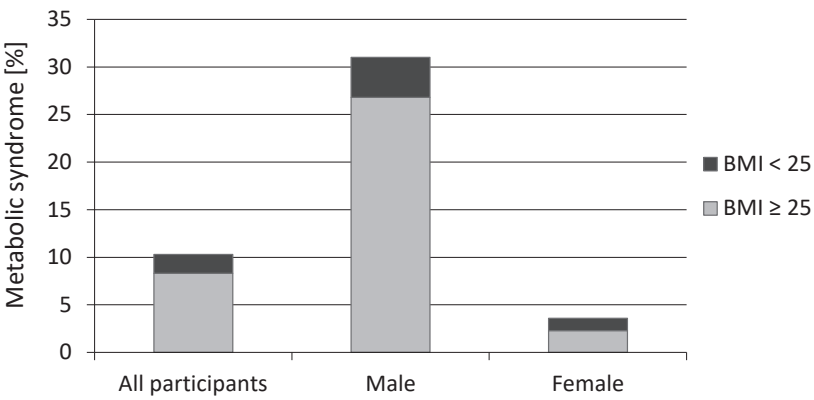

Figure 3. The frequency of metabolic syndrome in the studied group in relation to BMI

Abbreviations: BMI – body mass index.

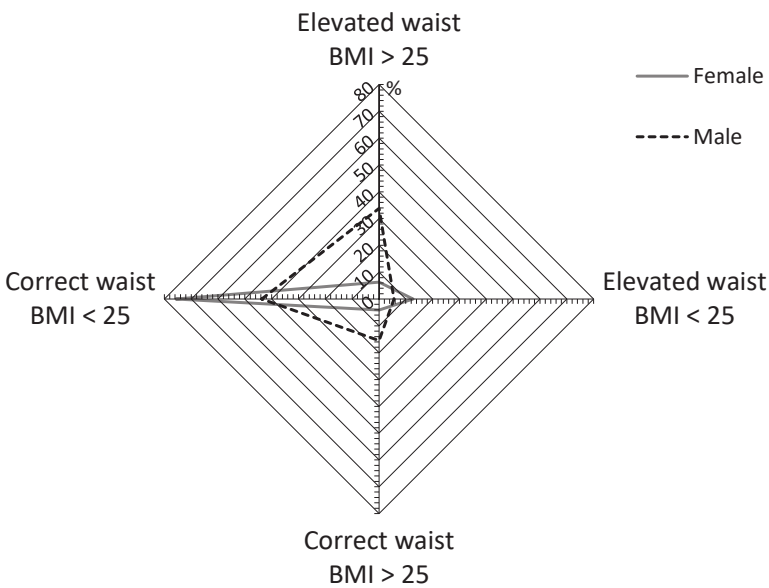

Figure 4. The frequency of excessive waist circumferences in the studied group in relation to BMI

Excessive waist circumference was the most often observed abnormalities in our study group, and abnormal blood pressure and low HDL concentration were observed with a similar frequency. Hyperglycemia and elevated triglycerides concentration were identified the least in both genders. All metabolic syndrome variables showed a significantly higher prevalence in males. The number of features of MS revealed in all participants, taking into account gender, are presented in Table 4.

Analyzing the number of features of metabolic syndrome, we found that about half of the females did not have any of them, but for males, this criterion was met in only every third male, and there was a difference in regard to gender in this group (male $n = 21$) 30% vs female ($n = 120$) 54%; $p < 0.001$). Among all participants, no one met all five features of metabolic syndrome.

In the entire study group, only one feature of metabolic syndrome was observed the most often, while four metabolic components were found the least frequently. Moreover, four features were simultaneously found only in males. In the study population, at least three features of metabolic syndrome were present in nearly 10.3% (30) of the participants. Males were characterized by a significant higher prevalence ($p < 0.001$) of metabolic syndrome – 31% (22), compared to females – 3.6% (8).

We also examined the relation of MS to general overweight measured by BMI, and these results are presented in Figure 3. Metabolic syndrome was related to general obesity (BMI ≥ 25 kg/m^2) only for males, and this relationship was not present in females. The prevalence of metabolic syndrome was similar in males and females with normal body weight (BMI < 25 kg/m^2): 4.2% (3) vs 1.4% (3) of the entire study group, respectively.

The prevalence of central obesity, identified in our study on the basis of excessive waist circumference, was met by nearly half of the males and was more frequent in this group in comparison to females (40.8% (29) vs 19% (42); $p < 0.001$). After the division of participants into subgroups of normal and excessive body weight, an elevated waist circumference occurred more often among males with BMI ≥ 25 and among females with BMI < 25 [kg/m^2]. These data are presented in Figure 4.

Discussion

The results of our study point to a remarkably high incidence of metabolic disturbances among apparently healthy young adults. The most frequently observed abnormalities were, successively: those of lipid metabolism 38% (111), excessive weight or obesity 20% (58) and hypertension 11% (33). Current data about incidences of these abnormalities in the young Polish population are limited, and the latest information derived from a large study covering similar age intervals to our participants was conducted in 2002 (NAT-POL Plus) [18] and 2003–2005 (WOBASZ) [19]. In our study, the frequency of these abnormalities was lower among young females as compared to the general Polish population > 20 years (WOBASZ), while among young males, these disorders were as frequent as in the elder portion of the general population [19].

Data from a PONS Study conducted in 2011 among the Polish population aged 45–64 indicated that metabolic syndrome is very common nowadays, and its incidence increases with age [10]. But some studies reported that this problem concerns not only people of middle age. In the past decade, two epidemiological studies were conducted on metabolic syndrome in the Polish population, but they used the NCEP ATP-III definition [18, 20]. For this reason, we could not directly compare our results with those studies. Especially limited and divergent data about the incidence of metabolic syndrome is available for the young Polish population [12, 21, 22]. In our work, we found that metabolic syndrome is also very common among apparently healthy young people, especially in males, and this relates to a general and central excess of fat tissue.

Our findings for the incidence of metabolic syndrome correspond to the data published by Ford [23] for a comparable aged group (20–29 years) of young Americans. Despite fact using a different definition for metabolic syndrome recognition (IDF 2009) in this publication, we can compare our results, because in our study all metabolic syndrome participants met the criterion of excess waist circumference. As observed by Ford [23], the percentage of metabolic syndrome among females was about four times higher than in our study, bur for males, the frequency was 10% lower. For the Polish population, we can compare our finding to the results of Ilow et al. [24], where metabolic syndrome was recognized in 28.5% of the habitants of Wroclaw aged 40–50 (in 12.7% among females and 30.4% among males). Although the general frequency of metabolic syndrome in our study was nearly three times lower, when taking into account gender, we received the same frequency as in the Ilow et al. [24] study for males, but for females, metabolic syndrome was observed less often. According to the obtained results, the frequency of metabolic disturbances, a known risk factor of cardiovascular diseases and diabetes, is very high among males and may explain the higher incidence of these diseases in the middle-aged male group. Somewhat disturbing is the fact that many of the individuals who volunteered for our study were not aware of their metabolic disorder condition.

An excess of fat tissue is a large source of inflammatory agents, also free fat acids released from adipose tissue disturb glucose uptake and utilization by muscular cells. This condition leads to the development of insulin resistance and is an important risk factor of cardiovascular diseases. We reveled that metabolic syndrome was associated with overweight and obesity in males. This relation was not so clear for females, but the female group with metabolic syndrome assessed by us was very small. A connection between MS and an excess of fat tissue were also presented by Koziarska-Rościszewska et al. [12] for students of Universities in Lodz. However, in their study, metabolic syndrome was related to overweight and obesity in the entire study population.

We also found that a higher than normal waist circumference occurred in a large proportion of females with BMI < 25 kg/m^2, in comparison to males, for which a higher than normal waist was mainly connected with BMI ≥ 25 kg/m^2. This disparity probably indicates a difference in mechanisms of metabolic regulation between genders and confirms our previous observation that Metabolically Obese Normal Weight (MONW) syndrome is more frequent among young females, whereas metabolic syndrome is more common in males [25].

Limitations of the study

We are aware of the limitations of our study. First, the qualification to the abnormal blood pressure class was made on the basis of only one visit. Furthermore, our study group consisted of more females than males; therefore, and because of this disparity we cannot exclude that for male population our findings are more burdened.

Conclusions

We would like to highlight that in our study, glucose and lipid profiles were assessed under fasting conditions. This method is not widely used in epidemiological studies; therefore, the results for large studies could sometimes be overestimated.

Regardless of criteria used, our study showed a large proportion of occurrences of metabolic disturbances in young, apparently healthy Polish people. The lack of awareness concerning these abnormalities in this group is a huge health problem and can generate social and economic burdens in the future. The progression of civilization diseases can be stopped in future generations by the introduction of the adequate diagnostic tools and by making life-style changes at the early stages of de-

velopment of metabolic disturbances. Effective actions directed towards these goals requires awareness from patients and physicians, supported by laboratory examinations, not only in CVD risk factors groups. This report also outlines the different distribution of metabolic burdens between young males and females. This fact implies a need for the use of a miscellaneous preventive program, focused on different risk factors for males and females, and highlights the importance of efforts directed to active searching for metabolic disturbances, including in laboratory practice.

Source of funding: This paper was developed under the research project ST-ST-796 of the Wroclaw Medical University, Poland, in the years 2015–2016.
Conflict of interest: The authors declare no conflict of interests.

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Received: 24.01.2017
Revised: 08.03.2017
Accepted: 14.03.2017

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