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Index of cardiometabolic risk based on waist circumference (WHT.5R) and metabolic profile in Polish sedentary male and female students

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ABSTRACT

Introduction: This study aimed to evaluate the potential of WHT.5R to determine metabolic risk in Polish college students of both sexes.

Material and methods: In all volunteers, body weight, body height, and waist circumference were measured and a waist-to-height ratio $^{0.5}$ (WHT.5R) was calculated. Of all volunteers, only those with WHT.5R ≤ 0.726 were included in further procedures (132 males, 162 females). Circulating glucose, insulin, triacylglycerol, total cholesterol, and HDL-cholesterol were determined. Plasma concentrations of non-HDL-cholesterol and HOMA-IR were calculated.

Results: In the male group, there was a significantly higher percentage of participants with disturbed lipid profiles, with 20.4% and 28.0% for TC and non-HDL-C, respectively compared to females (13.0% and 9.9%, respectively). No sex-related differences were noted in the percentage of participants with disturbed circulating HDL-C, glucose, and HOMA-IR. Pronounced metabolic disturbances were noted despite WHT.5R values that did not exceed the established cut-off.

Conclusions: In the study population, WHT.5R turned out not to be a reliable index of metabolic disturbances and health risks. However, WHT5.R showed sex-related differences in metabolic profile and confirmed lower metabolic risk in female compared to male students.

Keywords: college students, index of metabolic risk, lipoproteins, insulin resistance

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Introduction

The global epidemic of obesity markedly increases the risk of non-communicable diseases including type 2 diabetes and cardiovascular disease [1, 2]. On the other hand, the reliability of the methods used for the evaluation of body fat is still under discussion. In large population-based studies, body mass index (BMI) seems to be a precise measure of body fat and health risk [3, 4]. However, there are also studies indicating that BMI is not a precise index of adiposity and health status [5, 6]. This suggestion seems to be especially important in young adults, who are characterized by a high contribution of fat-free mass to total body weight, but also in older adults, characterized by high contribution of fat mass [7, 8].

The above-mentioned doubts about body mass index reliability as a measure of body fat brought about many studies searching for more valid and easily calculated indices of body adiposity such as body adiposity index (BAI), body roundness index (BRI), and a body shape index (ABSI), all including waist circumference in respective formulas [9, 10]. However, their reliability as measures of body fat and health risk is still under discussion [11, 12].

Recently Nevill et al. [13] proposed a new index of body composition based on waist circumference and body height 0.5 R (WHT.5R) and recognized it as a reliable measure of cardiometabolic risk score calculated from blood pressure, and circulating glucose, triglycerides, and HDL-cholesterol. Moreover, the cut-off value of 0.726 of the new index was proposed. However, the age

of the study population ranged from 20 to 69 years (mean age of 48.6 years) but the percentage of participants in different age groups was not defined. Furthermore, it should be stressed that high concentrations of blood glucose, triglycerides, and HDL cholesterol indicate elevated health risks. However, they are usually accompanied by disturbances in other metabolic risk factors such as e.g. total cholesterol or non-HDL-cholesterol [14, 15].

Thus, this study was undertaken and aimed at the verification of WHT.5R's potential to evaluate metabolic risks expressed by circulating glucose, insulin, and lipoproteins in Polish college students of both sexes.

Material and methods

Subjects

The participants were recruited among students of both sexes based on word-of-mouth and advertisements in student dormitories. All volunteers declared no health problems, did not smoke, and were not taking supplements regularly. None of the participants were engaged in regular physical activity. Before the study, all participants provided written consent for participation in all procedures. Finally, 308 students (144 males and 164 females) were included in the experimental procedure. The study protocol was approved by the local Ethics Committee.

Anthropometric measurements

Body mass and body height were measured in all participants using standard medical equipment after all outer clothing and shoes were removed. Waist circumference (WC) was measured to the nearest 0.1 cm at the level of the iliac crest using a non-stretchable tape measure while participants were at minimal respiration. All measurements were performed by a trained technician and were repeated twice, but, in the case of discrepancy, they were repeated for the third time. Waist-to-height ratio $^{0.5}$ (WHT.5R) was calculated for all volunteers [13]. Only the participants with WHT.5R ≤ 0.726 were included in the experimental procedure (Fig. 1).

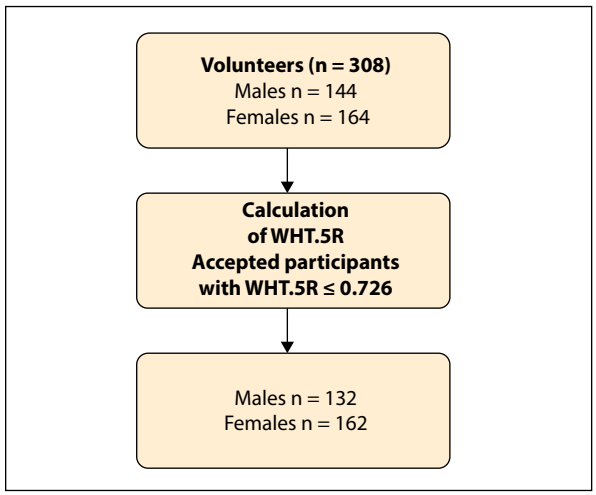

Figure 1. The procedure for participant recruitment

Biochemical analyses

The participants were instructed to eat the last meal at least 8 hours before blood sampling. Blood was withdrawn between 7:30 and 9:00 a.m. from the antecubital vein under aseptic conditions into plastic tubes with anticoagulant and centrifuged for 15 min at 4000 rpm and 4°C to obtain plasma. Plasma was stored at –70°C before analysis. Plasma glucose was determined using the GOD-PAP method. Triacylglycerols (TG), total cholesterol (TC), and HDL-cholesterol (HDL-C) were assayed using colourimetric methods and commercial kits (Randox Laboratories, UK). Coefficients of variation for all parameters did not exceed 5%. Non-HDL-cholesterol (non-HDL-C) was calculated by subtraction of HDL-C from TC [16]. Circulating LDL-cholesterol was not calculated because there were doubts about the reliability of the Friedewald formula in case of low circulating LDL-C [17]. Plasma insulin was measured using a standard radioimmunoassay (RIA) with human monoclonal antibodies against insulin and BioSource kits (Biosource, Belgium). Inter- and intra-assay coefficients of variation for insulin determination did not exceed 7%. All measurements were done in duplicate. Insulin resistance index (HOMA-IR) was calculated according to the following formula [18]:
HOMA-IR = [glucose (mmol/L) × insulin (μIU/mL)] /22.5

According to the International Diabetes Federation, circulating glucose should not be higher than 5.5 mmol/L [19]. The following values of circulating lipids were used as optimal: TC < 5.2 mmol/L, HDL-C > 1.0 mmol/L in males and > 1.3 mmol/L in females, TG < 1.7 mmol/L, and non-HDL < 3.4 [20, 21]. The cut-off value of HOMA-IR was established at the level of the 75th percentile (2.188 for males and 2.642 for females) [22, 23].

Statistical analysis

All data were tested for normality using the Shapiro-Wilk test. Statistical significance was tested using the Mann-Whitney test. The Spearman rank correlation coefficients between HOMA-IR and lipids were calculated. Data are presented as means ± SD, medians,

Table 1. Anthropometric and biochemical characteristics of students with WHT5.R ≤ 0.726. (Mean ± SD) and (Me; IQR)

	Males (n = 132)	**Females (n = 162)**	**p**
	Mean ± SD	Mean ± SD	
Age (years)	22.3 ± 3.0	21.8 ± 3.9*	< 0.001
Weight (kg)	77.2 ± 12.1	60.5 ± 8.8*	<0.001
Height (cm)	181.1 ± 6.9	167.8 ± 6.0*	< 0.001
WC (cm)*	80.0 ± 6.8	70.5 ± 6.6*	< 0.001
WHT. 5R	0.59 ± 0.05	0.54 ± 0.05*	< 0.001
	Me; IQR	Me; IQR	
TG (mmol/L)	1.1; 0.6	0.8; 0.5	0.075
TC (mmol/L)	4.9; 0.8	4.7; 0.6	0.083
HDL-C (mmol/L)	1.7; 0.3	2.2; 0.7*	< 0.001
non-HDL (mmol/L)	5.1; 0.9	3.7; 0.7*	< 0.001
Glucose (mmol/L)	5.8; 0.9	4.9; 0.8*	< 0.030
Insulin (μIU/mL)	10.5; 7.4	12.3; 5.6	0.064
HOMA-IR	2.36; 2.34	2.00; 1.34	0.058

Results are expressed as mean ± standard deviation and as medians; interquartile range; *significantly different *vs.* males; HDL-C — high-density cholesterol; HOMA-IR — insulin resistance index; non-HDL-C — non-high density cholesterol; TC — total cholesterol; TG — triglycerides; WC — waist circumference,

Table 2. Per cent of participants with metabolic variables exceeding optimal levels but with WHT.5R cut-off ≤ 0.726

	Males (n = 132)	**Females (n = 162)**	**p**
TG (mmol/L)	5.3	1.8*	< 0.050
TC (mmol/L)	20.4	13.0*	< 0.001
HDL-C (mmol/L)	7.5	9.9	0.069
non-HDL (mmol/L)	28.0	18.5*	< 0.030
Glucose (mmol/L)	3.8	3.7	0.071
HOMA-IR	25.0	24.1	0.094

*significantly different *vs.* males; HDL-C — high-density cholesterol; HOMA-IR — insulin resistance index; non-HDL-C — non-high density cholesterol; TC — total cholesterol; TG — triglycerides

and interquartile ranges for better visualization of data distribution. A p-value ≤ 0.05 was considered significant. All calculations were carried out using Statistica v.12 (Statsoft, Illinois, USA).

Results

Female students were slightly but significantly younger than their male counterparts ($p < 0.001$). Body weight, body height, waist circumference, and WHT.5R were markedly lower in females compared to males ($p < 0.001$) (Tab. 1).

There were no sex-related significant differences in circulating TG, TC, insulin, and HOMA-IR values. However, plasma HDL-C in females was significantly higher than in males ($p < 0.001$). In contrast, circulating non-HDL-C and glucose in females were markedly lower than in males ($p < 0.001$ for non-HDL-C and $p < 0.003$ for glucose). Furthermore, female participants were characterized by a significantly lower frequency of non-optimal plasma levels of TG ($p < 0.05$), TC ($p < 0.001$), and non-HDL-C ($p < 0.03$) than their male counterparts (Tab. 2).

The frequency of above-optimal circulating HDL-C, glucose, and HOMA-IR did not differ between sexes. In

Table 3. The Spearman rank correlation coefficients between HOMA-IR and circulating lipoproteins in male and female sedentary students

	Males (n = 132)	Females (n = 162)
TG (mmol/L)	0.210[a]	0.318[c]
TC (mmol/L)	0.136	0.120
HDL-C (mmol/L)	–0.206[a]	–0.210[d]
non-HDL	0.191[b]	0.293[e]

HDL-C — high-density cholesterol; non-HDL-C — non-high density cholesterol; TC — total cholesterol; TG — triglycerides
[a] $p < 0.02$; [b] $p < 0.03$; [c] $p < 0.001$; [d] $p < 0.008$; [e] $p < 0.001$

both male and female students, significant positive correlations were noted between HOMA-IR and circulating TG and non-HDL- cholesterol ($p < 0.02$ and $p < 0.03$ in males and $p < 0.001$ for both variables in females, respectively). It was also shown that the correlations in the female group were stronger than in the male group (Tab. 3).

Moreover, in both groups, negative correlations were found between HOMA-IR and HDL-C ($p < 0.02$ and $p < 0.001$ in males and females, respectively).

Discussion

The most important finding of this study is the pronounced metabolic disturbances in HOMA-IR, circulating total cholesterol, and non-HDL-cholesterol in college students of both sexes classified according to a cut-off of WHT.5R ≤ 0.726. Therefore, the proposed cut-off turned out to be not a reliable index of cardiometabolic risk in the study participants. The present findings can be explained by the adverse effect of elevated HOMA-IR on circulating lipids [24, 25].

It should be stressed that visceral fat, with waist circumference being its proxy measure, is not the only fat depot that adversely affects metabolic profile including insulin resistance and circulating lipids. It is well documented that both excess subcutaneous fat and ectopic fat adversely affect metabolic risk [26, 27]. Moreover, numerous data have indicated a pronounced inhibitory effect of intrahepatic fat on insulin clearance, peripheral insulin resistance, and circulating lipids [28, 29]. Consequently, measurements of body fat using anthropometric indices cannot predict the prevalence of metabolic disturbances caused by other fat depots.

Furthermore, college students, who were mostly male, are considered a population with high-risk behaviours including unhealthy dietary habits, alcohol drinking, and low physical activity, which adversely affect metabolic risk including insulin sensitivity and lipid profile [30, 31]. Furthermore, adverse effects of dietary habits on metabolic risk are especially true in the Polish population consuming a diet high in saturated fat and sugar, with low consumption of polyunsaturated fat and micronutrients [32, 33]. Therefore, it cannot be excluded that the present data reflect the effect of ectopic fat depots but also the specific diet and lifestyle of students on metabolic risk.

On the other hand, WHT.5R values, lower in females than in males, are in agreement with data indicating lower visceral fat in the former compared to the latter [34, 35]. Thus, taking into account the pronounced adverse effect of visceral fat on metabolic risk, lower WHT.5R in female students partially explains the difference in the lipid profile and its disturbances. Moreover, the positive metabolic effects of estrogens on health status in premenopausal women have to be taken into consideration as a cause of the lower frequency of disturbances in circulating lipids in female participants in the present study [36, 37, 38].

Limitations of the study

Although the following study is the first to use WHT.5R to evaluate the metabolic risk in college students its limitations include a small number of participants and cross-sectional data collection.

Conclusions

In conclusion, the WHT.5R cut-off in the college students in this study does not exclude metabolic disturbances and health risks but it reflects sex-related differences in circulating variables. Therefore, in this population, WHT.5R is not a reliable index of metabolic disturbances and health risks.

Article information

Data availability statement: *All authors agree to share the data.*

Ethics approval and consent to participate: *Ethical clearance was obtained from the Bioethical Commission of the University of Physical Education in Warsaw. Also, informed written consent was obtained from all participants after explaining the purpose of the study, the importance of their contribution as well as the right to refuse participation. All the information gathered was kept confidential.*

Author contributions: *Marzena Malara — conception, design, execution and interpretation of the data being published, wrote the paper. Patrycja Widłak — execution and interpretation of the data being published. Grażyna Lutosławska — conception, design, execution and interpretation of the data being published.*

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Competing interests: *None.*

Supplementary material: *None.*

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