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Waist-to-Height Ratio – an Alternative Index for Evaluating Obesity and Assessing the Cardio-Metabolic Risk. A Study in Warsaw Adolescents

Talia-wzrost – alternatywny wskaźnik oceny otyłości oraz związanego z nią ryzyka metabolicznego i sercowo-naczyniowego. Badanie młodzieży warszawskiej

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Summary

Introduction. Overweight and obesity are well-established causes of increased metabolic and cardio-vascular risk, also in children and adolescents. Since the adverse effects of excess adiposity are believed to be mostly associated with abdominal fat waist-to-height ratio (WHtR) has been proposed as a superior tool for early screening in adults. However, its utility in predicting high metabolic risk in youth is still debatable, with little data concerning adolescents in Poland.

Aim. Our study aimed to compare the association of different adiposity indices with metabolic syndrome components and to determine whether WHtR similarly to body mass index (BMI) predicts high cardio-metabolic risk in Warsaw adolescents.

Material and methods. The study was performed on a sample of 342 individuals (209 girls and 133 boys), aged 17 to 19, recruited in Warsaw. Height, weight and waist circumference were measured, and then BMI and WHtR were calculated. Metabolic Risk Score (MRS) was computed based on fasting glucose, triglycerides, HDL, systolic and diastolic blood pressure.

Results. WHtR and BMI were positively associated with MRS in both girls and boys, for BMI the relationship was slightly stronger.

Conclusions. Both WHtR and BMI proved adequate in predicting high combined metabolic risk score, as well as higher values of individual metabolic syndrome components. Further studies on larger groups allow to determine if one of the mentioned indices of adiposity is better predictor of increased cardio-metabolic risk.

Key words: obesity, waist-to-height ratio, BMI, adolescents

Streszczenie

Wstęp. Nadwaga i otyłość są dobrze udokumentowanymi czynnikami ryzyka zaburzeń metabolicznych i chorób sercowo-naczyniowych, również wśród dzieci i młodzieży. Ze względu na silniejszy związek wymienionych zaburzeń z otyłością brzuszną, wielu autorów postuluje wykorzystanie wskaźnika talia-wzrost jako narzędzia do badań przesiewowych wśród dorosłych. Jego przydatność do oceny ryzyka metabolicznego wśród młodzieży jest jednak wciąż niepotwierdzona, a niewiele danych dotyczy młodzieży polskiej.

Cel pracy. Celem pracy była ocena związku antropometrycznych wskaźników otyłości z ryzykiem kardio-metabolicznym wśród młodzieży warszawskiej.

Materiał i metody. Badanie przeprowadzono na grupie 342 uczniów (209 dziewcząt i 133 chłopców) w wieku 17-19 lat, uczęszczających do dwóch warszawskich liceów. U badanych zmierzono wzrost, masę ciała i obwód talii, a następnie obliczono wskaźnik masy ciała (BMI) oraz wskaźnik talia-wzrost (WHtR). Wskaźnik ryzyka metabolicznego (MRS) został obliczony z uwzględnieniem składowych zespołu metabolicznego: stężenia triglicerydów, cholesterolu HDL i glukozy oraz ciśnienia skurczowego i rozkurczowego.

Wyniki. Wykazano pozytywny związek MRS z BMI oraz z WHtR zarówno u dziewcząt, jak i chłopców. Zależność ta była nieznacznie silniejsza dla BMI. BMI i WHtR korelowały ze stężeniem HDL i ciśnieniem skurczowym.

Wnioski. Zarówno WHtR, jak i BMI okazały się dobrymi predykatorami podwyższonego ryzyka metabolicznego, jak również wartości poszczególnych składowych zespołu metabolicznego. Dalsze badania na większej grupie osób pozwolą ustalić, który z wymienionych wskaźników otyłości najlepiej odzwierciedla poziom ryzyka kardio-metabolicznego.

Słowa kluczowe: otyłość, wskaźnik talia-wzrost, BMI, młodzież

INTRODUCTION

Obesity and its associated metabolic and cardiovascular complications epidemic is one of the most serious challenges that public health care systems have to take up. It is estimated that in 2008 more than 1.4 billion adults worldwide were overweight, and 500 million was suffering from obesity. According to the WHO statistics, yearly obesity kills almost 3 million people, and the costs of treatment of the obesity-related disorders are inconceivably high. Unfortunately, the problem of obesity is facing not only the adult population, but more and more often it applies to children. In 2011 more than 40 million children under the age of five all over the world were overweight (1). Also, in Poland over 14% of children who reached the age of seven are overweight and more than 5% are obese (2). Overweight and obesity are known risk factors for many diseases: respiratory and musculoskeletal disorders, atherosclerosis, coronary heart disease, stroke, hypertension, non-alcoholic fatty liver disease, type 2 diabetes mellitus, gallbladder disease, obstructive sleep apnea, and some forms of cancer (3). Childhood obesity is associated with greater prevalence of mentioned disorders in adult life, so early-stage diagnosis and taking appropriate efforts towards body mass reduction are indispensable (4). Many different anthropometrical measures of obesity have been proposed, but still there is no agreement which one is the best predictor of metabolic risk. It seems, that the most widely applied body mass index (BMI) does not account body fat distribution and posture. Moreover, the cut-off points for different metabolic risk groups strongly depend on age, gender and ethnicity, which is confounding, especially for parents and other non-healthcare-professionals (5, 6). Waist circumference (WC) was believed to be a stronger predictor of cardiovascular and metabolic risk than BMI, both in adults and children. An important merit of WC is that it diversifies between peripheral and central obesity which is a stronger risk factor for cardio-metabolic disorders (7). Nevertheless likewise BMI, WC cut-off points are race-, age- and sex-dependent, and its appliance to children requires the usage of specific percentile labels. Recently waist-to-height (WHtR) – a new anthropometric obesity indice has emerged. It is less complicated, cheaper, and it does not depend on ethnicity, gender and age (8).

AIM

The aim of this study was to estimate the usefulness of waist-to-height ratio (WHtR) in assessing the obesity-related cardio-metabolic risk, and to compare WHtR value to other indices of adiposity.

MATERIAL AND METHODS

479 participants (284 girls and 195 boys) aged 17 to 19 were examined. Our subjects were recruited in two secondary schools located in the Żoliborz district, representative for the population of high-school students in Warsaw. The data were obtained between 20th and 30th of May 2013. All participants were provided with information regarding the aim and the design of the study. A written consent for both noninvasive and invasive medical procedures were obtained from each participant or from legal guardians, if individual was under the age of 18. Participation in all procedures was voluntary; a number of 137 individuals did not appear for blood sampling, failing to complete the study. We included them in the initial descriptive characteristics of the group but excluded their data from final statistical analysis.

Interventions

In all participants we recorded the following parameters: height, weight, waist circumference and hip circumference. Height was measured to the nearest 0.5 cm with the participant standing barefoot, back against a stadiometer. Weight was measured to the nearest 0.1 kg with the use of a physician beam weight. Waist circumference was measured at the middle point between the costal arch and the greater crest. Hip circumference was measured at the level of the greater trochanters. BMI was calculated as body weight (kg) divided by height (m) squared. Subjects with BMI between 25 and 30 kg/m^2 were considered as overweighed, whereas subjects with BMI between 30 and 40 kg/m^2 were considered as obese.

WHtR was calculated as waist circumference (cm) divided by height (cm). WHR was calculated as waist circumference (cm) divided by hip circumference (cm). During the same consultation all participants had their blood pressure taken, after having rested in a sitting position for at least 5 minutes. An automatic sphygmomanometer was applied. All measurements were performed by medical students, who had been instructed on the proper technique prior to the beginning of the work. Hypertension was recognized when blood pressure was higher than 130/85. Fasting blood samples for triglycerides, total cholesterol, HDL cholesterol and LDL cholesterol were collected from the intermediate cubital vain by trained nurses in the following day. An enzymatic colorimetric method was used to measure total cholesterol in the presence of cholesterol oxidase and esterase. The sensitivity was 0.116 mg/dL. HDL-cholesterol was measured with enzymatic colorimetric method; sensitivity was 3 mg/dL. Triglycerides were also measured with enzymatic colorimetric method with sensitivity 0.85 mg/dL. All mentioned biochemical measurements were performed using Roche Cobas Integra 400 chemistry analyzer (Roche Diagnostics). Glucose levels was determined with a glucometer in blood drawn from the participant's little finger. All blood samples were collected between 7:30 and 10 am, the participants were instructed to remain fasting. The norms for blood pressure and laboratory values were derived from the IDF consensus worldwide definition of the metabolic syndrome.

Assessment of the metabolic risk

In order to estimate the overall cardio-metabolic risk for the participants we created a continuous Metabolic Risk Score (MRS), primarily based on a similar scores used in several previous studies (9, 10). In the MRS we included the following components of metabolic syndrome: triglycerides, HDL cholesterol, glucose, systolic and diastolic blood pressure. For each of the above variables a z-score was calculated, for the whole group and separately for boys and for girls. An MRS was established for every individual by calculating the mean of all z-scores.

Statistical analysis

All calculations were performed with the Statistica 7.0 software package (StatSoft Inc, Tulsa, OK, USA).

RESULTS

497 high school students were initially invited and enrolled to the study. A total of 342 individuals completed both anthropometric and laboratory investigations. Anthropometric characteristics of all subjects who entered into the study are presented in table 1.

Boys had higher mean height, weight, waist circumference, hip circumference, BMI, WhtR, WHR, systolic and diastolic blood pressure than girls. The difference was significant in all cases with the exception of diastolic blood pressure. In the male subpopulation 25 individuals (12.8%) met the BMI criteria for overweight. 28 of the all females (9.9%) were overweight. According to the WHtR criteria for overweight (WHtR > 0.5) only 4 boys (2.1%) and 6 girls (2.1%) were overweight. 88 boys (45%) had systolic blood pressure above the upper limit compared to 41 girls (14.4%). Increased diastolic blood pressure was found in 11 boys (5.6%) and 14 girls (4.9%). In table 2 serum lipids and glucose are shown. Only 5 boys (3.6%) and 3 girls (1.4%) had increased triglyceride levels, but as many as 15 boys (10.9%) and 29 girls (36%) had HDL-cholesterol levels below the lower limit.

In table 3 and 4 correlations of metabolic parameters and blood pressure with WHtR and BMI, respectively are presented. We found correlations between BMI, HDL cholesterol levels, and systolic blood pressure. In addition, a correlation between BMI and triglycerides in the group of boys was shown. Both in boys as in girls BMI correlates with MRS. However we have failed to show a correlation between BMI, total cholesterol and LDL cholesterol levels. WHtR also proved to correlate with HDL cholesterol and systolic blood pressure. Only in boys correlation between total and LDL cholesterol was found. As in the case of BMI a correlation with MRS has been demonstrated.

DISCUSSION

Childhood and adolescent adiposity are important risk factors for development of cardio-vascular and metabolic disorders in adult life (11). Early diagnosis of overweight and obesity, and assessment of future risks are indispensible for effective prevention and treatment. An ideal measure for obesity and risk of obesity-related disorders should be simple to asses, easy to use and cheap. The most widely used is the body mass index, but it's value is more and more often

Table 1. Anthropometric characteristics and blood pressure of the initial study sample.

Variable	Girls (n = 284)		Boys (n = 195)		Total (n = 479)	
	mean ± SD	median	mean ± SD	median	mean ± SD	median
Height (m)	1.67 ± 0.06	1.67	1.79 ± 0.07	1.79	1.72 ± 0.09	1.71
Weight (kg)	59.57 ± 9.45	58.15	71.48 ± 10.45	70.7	64.42 ± 11.47	62.5
Waist circumference (cm)	67.09 ± 6.19	67	75.12 ± 6.58	75	70.35 ± 7.56	69
Hip circumference (cm)	85.44 ± 7.34	85	87.55 ± 2.83	87	86.29 ± 7.11	86
BMI (kg/m^2)	21.41 ± 3.01	20.99	22.06 ± 2.84	21.79	21.67 ± 2.95	21.26
WHtR	40.28 ± 3.7	39.71	41.72 ± 3.74	41.28	40.89 ± 3.78	40.48
WHR	0.79 ± 0.05	0.78	0.86 ± 0.048	0.86	0.81 ± 0.06	0.81
SBP (mmHg)	117.92 ± 14.38	118	130.61 ± 11.76	129	123.07 ± 17.75	123
DBP (mmHg)	72.33 ± 7.62	72	73.25 ± 8.24	73	72.70 ± 7.88	72

BMI – body mass index; WHtR – waist-to-height ratio; WHR – waist-to-hip ratio; SBP – systolic blood pressure; DBP – diastolic blood pressure

Table 2. Biochemical plasma parameters.

Variable	Women (n = 212)		Man (n = 134)		Total (n = 346)	
	mean ± SD	median	mean ± SD	median	mean ± SD	median
TC (mg/dL)	163.96 ± 28.89	162.52	153.049 ± 29.08	152.05	159.69 ± 29.41	159.06
HDL (mg/dL)	64.35 ± 13.52	63.8	5.613 ± 11.61	52.64	60.15 ± 13.82	59.27
LDL (mg/dL)	89.99 ± 74.49	83.92	83.85 ± 23.65	82.45	87.59 ± 59.98	82.71
TG (mg/dL)	106.62 ± 509.89	67.13	76.22 ± 40.20	69	94.72 ± 398.47	67.22
Glucose (mg/dL)	81.763 ± 9.89	83	83.23 ± 10.33	84	82.33 ± 10.08	83

TC – total cholesterol; HDL – high-density cholesterol; LDL – low-density cholesterol; TG – triglycerides

Table 3. Correlations between waist-to-height ratio (WHtR) and cardio-metabolic parameters in Warsaw adolescents.

Variable	Women (n = 212)			Man (n = 134)			Total (n = 346)		
	R	R^2	p-value	R	R^2	p-value	R	R^2	p-value
TC	-0.01	< 0.01	0.8345	0.20	< 0.01	0.0226	0,03	< 0.01	0.5317
LDL	0.03	< 0.01	0.7026	0.15	0.02	0.0832	0,03	< 0.01	0.5491
HDL	-0.21	0.04	0.0025	-0.18	0.03	0.0405	-0,25	0.06	< 0.0001
TG	0.12	0.02	0.0783	0.23	0.05	0.0067	0,09	0.01	0.0908
SBP	0.06	< 0.01	0.3912	0.31	0.11	0.0001	0,22	0.05	< 0.0001
DBP	-0.01	< 0.01	0.9401	0.06	< 0.01	0.5257	0,04	< 0.01	0.4312
Glucose	0.05	< 0.01	0.5139	< -0.01	< 0.01	0.9900	0,04	< 0.01	0.4655
MRS	0.18	0.03	0.0091	0.21	0.04	0.0168	0.19	0.04	0.0004

TC – total cholesterol; LDL – low-density cholesterol; HDL – high-density cholesterol; TG – triglycerides; SBP – systolic blood pressure; DBP – diastolic blood pressure; MRS – metabolic risc score

Table 4. Correlations between body mass index (BMI) and cardio-metabolic parameters in Warsaw adolescents.

Variable	Women (n = 212)			Man (n = 134)			Total (n = 346)		
	R	R^2	p-value	R	R^2	p-value	R	R^2	p-value
TC	-0.03	< 0.01	0.6346	0.14	0.02	0.0982	0.01	< 0.01	0.8311
LDL	< -0.01	< 0.01	0.9821	0.10	0.01	0.2434	0.01	< 0.01	0.8883
HDL	-0.25	0.06	0.0003	-0.18	0.03	0.0386	-0.25	0.06	< 0.0001
TG	0.10	0.01	0.1535	0.21	0.04	0.0145	0.08	0.01	0.1405
SBP	0.16	0.03	0.0180	0.42	0.18	< 0.0001	0.28	0.08	< 0.0001
DBP	0.06	< 0.01	0.4289	0.10	0.01	0.3037	0.08	0.01	0.1301
Glucose	0.06	< 0.01	0.4220	0.10	0.01	0.3473	0.08	0.01	0.1665
MRS	0.24	0.06	0.0004	0.28	0.08	0.0013	0.25	0.06	< 0.0001

questioned (9, 12). Many indices for evaluating obesity and associated risk have been proposed. Recently the waist-to-height ratio (WHtR) has emerged. Its values have already been proven in adults and it has been reported to be a better discriminator of cardio-vascular factors than BMI (5, 13-15). By now, data supporting usefulness of WHtR in the children and adolescent population are inconsistent (6, 9,16-18).

In this survey we found that the percentage of overweight and obese adolescents based on body mass index (19), was 12.8% in man and 9.9% in women, showing a substantial raise comparing to similar studies conducted in years 1971-2000 (20). However, up to our best knowledge, there are only few studies concerning Warsaw school children aged from 17-19 years available, and further examination is needed (21). Surprisingly when WHtR was used to assess the rates of overweight and obesity in the same group of children (22) the percentage was substantially lower: 2.1% in both gender groups. It may be associated with the fact that BMI fails to accurately assess the accumulation of the abdominal fat and the tissue distribution. A lot of students, especially boys, were practicing sport disciplines that may have influenced their muscle mass. Many authors have questioned the value of BMI in estimating degree of obesity and associated cardio-metabolic risk, especially in children. Moreover, its use in children and adolescent population is inconvenienced by the necessity to apply centile labels. For example, identifying of obesity and overweight in children aged from 8 to 18 years requires 52 BMI cut-off values (4). WHtR seems to lack those shortcomings – it's convenient and inexpensive. The widely suggested cut-off point of 0.5 is useful to both adults and children (23).

The systolic blood pressure in over 45% of males proved to be above the upper limit. This can be, however, most likely attributed to stress reaction to the procedures involved in the study, as well as high physical activity in the preceding hours. In female subpopulation the percentage of individuals with increased systolic blood pressure was only 14.4%.

To determine the overall level of cardio-metabolic risk we created a continuous metabolic risk score – MRS, integrating factors included in the metabolic syndrome definition (22). Our study showed a correlation both between MRS and BMI (r = 0.25), and MRS and WHtR (r = 0.19). These results confirmed the importance of BMI as a prognostic of cardio-vascular and metabolic risk and emphasized the potential usefulness of WHtR.

CONCLUSIONS

The study confirmed the importance of BMI and showed a potential role of WHtR in assessment of obesity-related cardio-metabolic risk. However, further studies of the issue on larger groups are needed to establish which one of indices of adiposity is the better predictor for clinical purposes.

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