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ORIGINAL ARTICLE

Nutritional status and prevalence of abdominal obesity in adolescents aged 11 to 15 years in Vojvodina (the Republic of Serbia)

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Summary. *Introduction/Aim* Inadequate nutritional condition of adolescents (underweight or overweight/obesity) is a growing problem worldwide. This study was carried out to determine nutritional condition and the prevalence of abdominal obesity in a sample of adolescents living in Vojvodina. *Methods* Cross-sectional anthropometric surveys were conducted in 2012-2014 and 2017. The surveys included 1592 adolescents (706 boys and 886 girls) aged 11- 15. The subjects were classified into four groups: underweight, normal weight, overweight and obese, according to the International Obesity Task Force (IOTF). Abdominal obesity (AO) was assessed according to waist circumference (WC) ≥ 90th percentile, waist-to-hip ratio (WHR) ≥ 0.9 and waist-to-height ratio (WHtR) ≥ 0.5. *Results* The total prevalence of underweight was 12.2%, normal weight 69.3%, overweight 14.5 % and obesity 4.0%. A total of 10.1% subjects showed abdominal obesity based on WC, 14.0% on WHR and 14.6% based on WHtR. When the four groups were evaluated in terms of abdominal obesity status, the prevalence was 0.0%, 2.6% and 0.0% in the underweight, 2.0%, 11.8% and 3.5% in the normal, 37.2%, 29.0% and 59.7% in the overweight, and 82.5%, 33.3% and 88.9% in the obese groups according to WC, WHR and WHtR. *Conclusion* Boys showed greater prevalence of general and abdominal obesity than girls. The highest abdominal obesity in the overweight and obese adolescents was observed in relation toWHtR ≥ 0.5, both in boys and girls. Abdominal obesity is a condition that should be given more attention, including non-obese adolescents as well, in order to prevent health problems.

Key words: nutritional condition, abdominal obesity, adolescents

Introduction

A number of studies conducted in the last few decades have reported an upgoing trend of overweight and obesity in children and adolescents worldwide (1-4). As overweight and obesity present a risk to health, the World Health Organization (WHO) addresses overweight and obesity as one of general public health issues (5). It is predicted that by the year 2020, this trend will reach, even among preschool children, 9.1%, i.e. 60 million children will be overweight and obese (6). Together with exceeded weight, undernutrition in childhood and adolescence is a considerably large public health problem. It has been reported that in some European countries (France, the UK, the Czech Republic, Spain, Poland) the number of overweight/obese as well as underweight individuals is on the increase (7).

Referring to the health status of Republic of Serbia population, studies report that in 2013 70.1% children and adolescents aged 7–14 were with normal weight, 15% were overweight, 4.9% obese, while 5.0% were underweight. In case of adolescents aged 10-19, 20.2% were overweight and 8.9% obese. In compari-

son with the year 2000 the results point to an increase in overweight and obese adolescents by 5.9 and 4.5%, respectively (8). As the body mass index is an unreliable indicator of childhood obesity the assessment of abdominal (central) obesity is important since it is related to the risk of cardiovascular and metabolic disorders in children and adolescents.

Waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height–ratio (WHtR) are sensitive and specific measurements for both total and intraabdominal body fat (9). These anthropometric parameters serve as good indicators of the development of viscelar fat tissue and health risks of a number of problems related to obesity, such as glucose intolerance, diabetes mellitus type 2, dyslipidemia, hypertension and many other disorders being part of metabolic syndrome (10). Also, the use of abdominal obesity measurements can identify individuals within the normal range of BMI who may have a higher metabolic risk (11).

To the best of our knowledge, there are no reports on the prevalence of abdominal obesity by using the above indexes in Serbian children and adolescents. The aim of this cross-sectional survey was to estimate the nutritional status and abdominal fat distribution in a sample of adolescents living in Vojvodina (Republic of Serbia).

Methods

The cross-sectional study conducted in 2012-2014 and 2017 included 1592 adolescents (706 boys and 886 girls) aged 11-15 years. The study refers to the data obtained in various towns of Vojvodina region. The age of each individual in the study was obtained using the date of the survey and the birth date. The subjects were grouped into five age categories (10.50 -15.49).

The inclusion of subjects was on voluntary basis and prior to acceptance their parents were fully informed about the objectives and methods of the study. The research protocol was approved by the Scientific Committee of the Department for Biology and Ecology, University of Novi Sad and primary school principles. The same measurement protocol, as described by Weiner and Lourie (12) and Lohman et al. (13) was used in all studies. All anthropometric measurements were recorded by a trained person with the participants wearing light clothes and no shoes. Height was measured with anthropometer (±1 mm; Sieber-HegnerMaschinen AG Zürich Switzerland) with the head positioned in the Frankfurt plane, and portable and electronic digital scale was used to measure weight with accuracy ± 0.1 kg. Waist circumference (WC) was measured above the iliac crest and below the lowest rib margin at minimum respiration with an inelastic flexible tape in a standing position. Hip circumference (HC) was measured at the maximum protuberance of the buttocks. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Waist-to-hip ratio (WHR) was calculated as waist circumference (cm) divided by hip circumference (cm), and WHtR was calculated as waist circumference (cm) divided by height (cm).

The subjects were classified into four groups: underweight, normal, overweight and obese, according to the International Obesity Task Force - IOTF (14). Abdominal obesity (AO) was defined according to waist circumference (WC) ≥ 90th percentile (15), waist-to-hip ratio (WHR) ≥ 0.9 (16) and waist-to-height ratio (WHtR) ≥ 0.5 (11).

Statistical Analysis

The variables are expressed as Mean ± SD, frequency and percentages and Shapiro-Wilk test was used for investigating the distribution normality. The differences between sexes were established applying the t-test, total age differences by One-Way ANOVA and differences between the ages by means of Bonferroni Post Hoc test. The prevalence of underweight, overweight, obesity and abdominal obesity were estimated, and proportions were compared using the Chi-square test. Statistical analyses were carried out using the SPSS Statistics 20. Results were considered significant at $P < 0.05$.

Results

The means of BMI and WC linearly increase in both sexes by age (Table 1). However, WHR means show linear decrease by the age of 14, while WHtR values show irregular distribution. Boys are charac-

terized by significantly higher BMI at the age of 12 and show greater WC and WHR in all ages (P<0.01). Male subjects also show higher WHtR values in all ages and the difference is significant (P<0.01) between the ages 11 and 13. The results of One-Way ANOVA point to significant differences in all variables in both sexes (P<0.05). In boys significant age differences in WC are observed between the ages 12 and 13 (P<0.05). Significant differences are also seen between the ages 13 and 14 and refer to the WHR (P<0.01) and WHtR (P<0.05) values where a noticeable decrease is detected. As for girls, significant age differences refer to BMI and WC and appear between the ages 12 and 13 and the ages 14 and 15.

The prevalence of overweight/obesity in the overall sample (Table 2) equals 18.5% and is significantly higher (P < 0.001) in boys (22.6%) than in girls (15.3%). With reference to the sex, the results indicate that the highest number of adolescents is with normal weight (68.0% boys; 70.3% girls). The number of underweight girls (14.4%) is higher than in boys (9.5%), but the difference is insignificant. As for overweight, the prevalence is significantly greater (P < 0.001) in boys (17.6%) than in girls (12.1%). Boys also show greater obesity (5.0%) than girls (3.2%). Abdominal obesity for WC ≥ 90th percentile is also slightly higher in boys than in girls (10.8% opposed to 9.5%). In addition, significantly higher (P < 0.05) number of boys show WHR ≥ 0.9 (21.1% boys and 8.4% girls). A considerable decrease in the prevalence of WHR ≥ 0.9 is seen after the age of 13 in boys (P<0.05), while in girls it appears after the age of 11. WHtR ≥ 0.5 is observable in 19.4% boys and 10.8% girls. The highest percentage of abdominal obesity based on WHtR appears among 12-year-old boys (25.0%) and 15-year-old girls (15.4%).

The results indicate that in the underweight group abdominal obesity based on WHR appears in 2.6% of adolescents (Table 3). In case of normal weight subjects, the highest prevalence of AO is observable in relation to WHR (11.8%) and smallest in relation to WC (2.0%). The overweight adolescents show highest

Table 1. Statistical data of body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) for Vojvodina adolescents aged 11–15 years

	Age (years)	Boys (N=706)			Girls (N=886)			
		N	Mean ± SD	IAD†	N	Mean ± SD	IAD†	ISD‡
BMI (kg/m²)	11	73	18.78 ± 3.23		110	18.27 ± 3.23		0.289
	12	180	19.42 ± 3.90	0.707	218	18.53 ± 3.16	0.966	**0.014**
	13	180	19.53 ± 3.17	0.999	195	19.73 ± 3.69	**0.004**	0.581
	14	141	19.99 ± 3.87	0.791	207	19.91 ± 3.59	0.983	0.849
	15	132	20.70 ± 3.67	0.474	156	21.02 ± 3.36	**0.020**	0.445
WC (cm)	11	73	70.14 ± 8.48		110	66.62 ± 7.60		**0.004**
	12	180	71.79 ± 10.70	0.745	218	67.14 ± 7.71	0.983	**0.000**
	13	180	74.67 ± 9.69	**0.045**	195	70.40 ± 8.39	**0.000**	**0.000**
	14	141	75.00 ± 10.17	0.998	207	70.58 ± 8.60	0.999	**0.000**
	15	132	77.59 ± 9.07	0.189	156	73.54 ± 7.96	**0.005**	**0.000**
WHR	11	73	0.861 ± 0.059		110	0.829 ± 0.058		**0.000**
	12	180	0.858 ± 0.068	0.998	218	0.810 ± 0.066	0.102	**0.000**
	13	180	0.857 ± 0.062	1.000	195	0.802 ± 0.059	0.707	**0.000**
	14	141	0.832 ± 0.060	**0.007**	207	0.799 ± 0.068	0.995	**0.000**
	15	132	0.837 ± 0.071	0.980	156	0.806 ± 0.083	0.821	**0.001**
WHtR	11	73	0.457 ± 0.048		110	0.434 ± 0.049		**0.002**
	12	180	0.461 ± 0.063	0.992	218	0.431 ± 0.045	0.983	**0.000**
	13	180	0.460 ±0.054	1.000	195	0.437 ± 0.047	0.650	**0.000**
	14	141	0.442 ± 0.054	**0.027**	207	0.432 ± 0.048	0.742	0.060
	15	132	0.447 ± 0.050	0.963	156	0.445 ± 0.047	0.069	0.748

SD- Standard deviation; IAD- Inter-age differences; †Bonferroni Post Hoc tes; ISD- inter-sex differences; ‡t-test; Bold-typed numbers are statistically significant

Table 2. Prevalence of general and abdominal obesity in relation to the sex and age

Age (years)	N	BMI category, % (n)				Abdominal obesity, % (n)		
		UW	NW	OW	OB	WC ≥ 90th percentile	WHR ≥ 0.90	WHtR ≥ 0.50
Boys								
11	73	8.2 (6)	67.1 (49)	19.2(14)[b]	5.5 (4)	11.0 (8)	23.3 (17)	19.2 (14)[c]
12	180	8.9 (16)	63.9 (115)	10.4 (35)	7.8 (14)[b]	11.1 (20)	27.2 (49)[c]	25.0 (45)[c]
13	180	8.3 (15)	71.7 (129)	16.1 (29)	3.9 (7)	11.1 (20)	26.7 (48)[a]	20.6 (37)[a]
14	141	11.6 (16)	68.1 (96)	16.3 (23)	4.3 (6)	9.9 (14)	13.5 (19)	14.9 (21)
15	132	10.6 (14)	68.9 (91)	17.4 (23)	3.0 (4)	10.6 (14)	12.1 (16)	15.2 (20)
All	706	9.5 (67)	68.0 (480)	17.6 (124)	5.0 (35)	10.8 (76)	21.1 (149)	19.4 (137)
Girls								
11	110	10.9 (12)	72.7 (80)	11.8 (13)	4.6 (5)	10.0 (11)	15.4 (17)	10.9 (12)
12	218	17.4 (38)[a]	67.4 (147)	13.3 (29)	1.8 (4)	9.6 (21)	8.3 (18)	7.8 (17)
13	195	15.4 (30)[a]	67.7 (132)	12.8 (25)	4.1 (8)	9.7 (19)	5.6 (11)	12.3 (24)
14	207	15.0 (31)	72.5 (150)	9.2 (19)	3.4 (7)	8.2 (17)	6.3 (13)	9.2 (19)
15	156	10.9 (17)	73.1 (114)	13.5 (21)	2.6 (4)	10.3 (16)	9.6 (15)	15.4 (24)
All	886	14.4 (128)	70.3 (623)	12.1 (107)	3.2 (28)	9.5 (84)	8.4 (74)	10.8 (96)
Total								
11	183	9.8 (18)	68.3 (125)	16.9 (31)	4.9 (9)	10.4 (19)	18.6 (34)	14.2 (26)
12	398	13.6 (54)	65.8 (262)	16.1 (64)	4.5 (18)	10.3 (41)	16.8 (67)	15.6 (62)
13	375	12.0 (45)	69.6 (261)	14.4 (54)	4.0 (15)	10.4 (39)	15.7 (59)	16.3 (61)
14	348	13.5 (47)	70.7 (246)	12.1 (42)	3.7 (13)	8.9 (31)	9.2 (32)	11.5 (40)
15	288	10.8 (31)	71.2 (205)	15.3 (44)	2.8 (8)	10.4 (30)	10.8 (31)	15.3 (44)
All	1592	12.2 (195)	69.3 (1103)	14.5 (231)	4.0 (63)	10.1 (160)	14.0 (223)	14.6 (233)

BMI- body mass index; UW- Underweight; NW- Normal weight; OW- Overweight; OB- Obesity; WC- waist circumference; WHR- waist-to-hip ratio; WHtR- waist-to-height ratio; Chi-square Test: [a] $P < 0.05$; [b] $P < 0.01$; [c] $P < 0.001$

AO with WHtR ≥ 0.5 (59.7%), 37.2% of them show WC ≥ 90th percentile, and 29% WHR ≥ 0.9. In obese subjects category, AO is highest (88.9%) in WHtR ≥ 0.5 and smallest (33.3%) in WHR ≥ 0.9. AO values of overweight and obesity are highest in relation to WHtR ≥ 0.5 in both boys and girls.

Table 3

Discussion

This cross-sectional survey conducted in Vojvodina shows that the prevalence of underweight in adolescents aged 11-15 is 9.5% in boys and 14.4% in girls. The overall prevalence of overweight/ obesity is 22.6% in boys and 15.3% in girls, while obesity prevalence is 5.0% and 3.2%, respectively. Prevalence of abdominal obesity using the WC index is 10.8% and 9.5% in boys and girls, for WHR it is 21.1% and 8.4% in boys and girls, while in case of WHtR index, it is 19.4% and 10.8%, respectively.

Earlier studies in Serbia (17) showed that the prevalence of underweight boys and girls aged 11-15 equaled approximately 5%, which is in line with the official statistics reports (8). The present study points to a higher prevalence of underweight adolescents, which might be explained by current trends in promoting skinny looks among young people through mass media and in particular, by fashion magazines. The detected prevalence of underweight is higher in both males and females than it is reported by Chirita Emandi et al. (18) in Romania (7.5% in boys; 12.5% in girls), Grammatikopoulou et al. (19) in Greece (3.4% in boys; 7.3% in girls), Mladenova and Andreeenko (2015) (20) in Bulgaria (8.0% in boys; 10.4% in girls) and is similar to the results obtained by Hurbo et al. (2018) (21) in Belarus (10. 8% in boys; 13.1% in girls).

Table 3. Prevalence (%) of WC, WHR and WHtR categories in adolescents according to their body nutritional status; n (%)

BMI categories	WC ≥ 90th percentile	WHR	WHtR
		≥ 0. 9	≥ 0.5
Boys (N=706)			
Underweight (n=67)	0 (0.0)	1 (1.5)	0 (0.0)
Normal (n=480)	8 (1.7)	83 (17.3)	23 (4.8)
Overweight (n=124)	41 (33.1)	50 (40.3)	84 (67.7)
Obesity (n=35)	27 (77.1)	15 (42.9)	30 (85.7)
Girls (N=886)			
Underweight (n=128)	0 (0.0)	4 (3.1)	0 (0.0)
Normal (n=623)	14 (2.2)	47 (7.5)	16 (2.6)
Overweight (n=107)	45 (42.1)	17 (15.9)	54 (50.5)
Obesity (28)	25 (89.3)	6 (21.4)	26 (92.9)
Total (N=1592)			
Underweight (n=195)	0 (0.0)	5 (2.6)	0 (0.0)
Normal (n=1103)	22 (2.0)	130 (11.8)	39 (3.5)
Overweight (n=231)	86 (37.2)	67 (29.0)	138 (59.7)
Obesity (n=63)	52 (82.5)	21 (33.3)	56 (88.9)

WC- waist circumference; WHR- waist-to-hip ratio; WHtR- waist-to-height ratio; WC ≥ 90th percentile for age and sex, WHR ≥ 0.9 and WHtR ≥ 0.5 - with central obesity.

Compared with a previous study in Vojvodina (22) conducted 14 years ago, also based on IOTF cut-off values, we can observe similar results related to overweight/ obesity (overweight was 17.9% and 14.7%, and obesity 5.0% and 2.9% in boys and girls, respectively). A more recent study referring to similar age groups in Serbia (23) reports that the prevalence of overweight is 16.6% and obesity 4.3%.

The present results show that the WC, WHR and WHtR indexes point to a noticeably greater number of obese adolescents of both sexes than it is the case with BMI. Using the above classification for WC, WHR and WHtR, abdominal obesity in the present population is present in 10.1%, 14.0% and 14.6% of adolescents, respectively. Boys tend to show greater abdominal obesity than girls, which is in line with the findings referring to Spanish adolescents (24), children aged 6-12 in Greece (25), in Germany (26) and in Bulgaria (20). Slightly higher prevalence of abdominal obesity based on WC is reported in Spain (24), equaling 11.6% in adolescents from 12 to 17 years of age, while the results based on WHtR show similarity with the present findings (14.3%). Considerably higher prevalence of abdominal obesity is reported in US adolescents aged 12 to 18 years (27) for WC (18.78%) and WHtR (35.59%), as well as in Iran adolescent girls (28), where the AO prevalence based on WC is 13.2% and on WHtR 18.2%. The reported abdominal obesity in Turkish adolescent girls (9) is higher (16.9%) based on WC, but lower (10.4%) based on WHtR.

Abdominal obesity, based on all three indicators of central adiposity is highly prevalent in Vojvodina (North Serbia) adolescents. A considerable proportion of normal weight adolescents show abdominal obesity based on WHR (11.8%), however, the prevalence is noticeably higher in overweight and obese adolescents. Consistent with other studies (9, 27) the majority of the overweight and obese adolescents are abdominally obese according to WC (overweight 37.2%; obese 82.5%), WHR (overweight 29.0%; obese 33.3%) and WHtR (overweight 59.7%; obese 88.9%). Data for AO status for adolescents with normal BMI and underweight subjects are scarcy. The study of Iranian adolescent girls (28) with normal BMI, reports the prevalence of abdominal obesity of 2.9% and 6.1% based on WC and WHtR, respectively. The present results point to AO for underweight adolescents according to WHR (2.6%), but not when WC and WHtR are considered, which is in line with other studies (28).

The prevalence rates of abdominal obesity based on WC, WHR and WHtR measures exceed those of general obesity based on IOTF classification. Consequently, regardless of the obesity status, abdominal obesity should be regularly evaluated in adolescent population as it can enable detection of the health risks at an early stage. However, there is still no consensus on an international WC threshold for abdominal obesity in children and adolescents. This situation has probably contributed to the wide range of abdominal obesity in adolescents (29) which varies from 3.8% to 33.2% in the countries studied. It might be the result of the differences in surrogate measures of abdominal adiposity and the cut-off points used to define abdominal obesity (24).

The major limitation of the present study lies in the fact that the sample of selected adolescents is not representative for the whole Serbia. Nevertheless, the sample is quite large, and the results seem valuable for further national and/or international studies.

Conclusion

The present results indicate that both the problems of underweight and overweight in adolescents aged 11-15 must be currently addressed. Obesity and underweight represent opposite extremes on the spectrum of adiposity and both can cause serious health problems in adulthood. Cultural and social factors (the level of physical activity, nutritional habits, life style) might well be the major cause for this situation in Serbia. Abdominal obesity is highly prevalent in Serbian adolescents. The prevalence of abdominal obesity is highly present in overweight and obese adolescents, but it is also found in normal weight respondents, and in a smaller percentage in underweight adolescents. The results indicate that abdominal obesity is a condition that should be considered in case of adolescents of both normal and exceeded weight. High abdominal obesity in this age group is likely to cause an epidemic of adult obesity and related health complications. Prevention, therefore, needs to be high priority, and constant monitoring can be of great help for developing effective population-based programs and policies.

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