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SHORT COMMUNICATION

## Central adiposity in 9- and 15-year-old Swedish children from the European Youth Heart Study

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### Abstract

The aim of this study was to provide percentile values for several indices of central adiposity in 9- and 15-year-old Swedish children from the European Youth Heart Study (N = 1 075). Age- and sex-specific percentiles for waist circumference, hip circumference, waist-to-height ratio and waist-to-hip ratio were provided. No significant differences were found in the proportion of individuals with a high waist-to-height ratio (using the 0.500 cut-off) between age or sex groups. The percentile values for waist circumference and waist-to-height ratio provided in this paper, together with data from other cohorts, could help to establish international criteria for defining central obesity. For comparative purposes, future studies reporting reference data for waist circumference and/or waist-to-height ratio, should also report age- and sex-specific height values. More studies involving children of different ages and from different regions in Scandinavia are needed.

**Key words:** Abdominal, adiposity, adolescents, central, children, circumference, fatness, height, ratio, waist

### Introduction

Central adiposity has shown to be associated with a range of risk factors for cardiovascular disease already in young people (1) and is becoming of increasing importance in pediatrics. Anthropometric indices, such as waist circumference (WC), waist-to-height ratio (WHtR) and waist-to-hip ratio are commonly used for assessing central adiposity in epidemiological and clinical settings. Waist circumference is an accurate surrogate for central adiposity (2) and a powerful marker associated with a number of cardiovascular risk factors and metabolic syndrome, both in non-overweight and overweight individuals (3). Height is positively associated with WC and may influence the observation of fat accumulation and/or distribution; thereby, the use of WHtR has been recommended in both children and adults (4). There is growing evidence indicating that WHtR is also a good predictor of cardiovascular disease risk in young people (5). Sex- and age-

specific data for WC and WHtR from different cohorts may help to establish international criteria for determining central obesity.

The aim of this study was to provide percentile values for several indices of central adiposity in 9- and 15-year-old children from Sweden. Additionally, we reported the prevalence of having a high WHtR ( $\geq 0.500$ ) and having a WC value for predicting risk factor clustering, according to cut-off values previously reported.

### Methods

A total of 1 075 children aged 9 (range 8.5–10.3) and 15 (range 14.7–16.7) years old from the Swedish part of the European Youth Heart Study participated in this study. Most of the individuals belonged to the age range 9.0 to 9.9 years old, or 15.0 to 15.9 years old (~80%). The 92% of the participants were Caucasian, a proportion comparable to the national figures reported in 1998 (94%) (6). The

non-Caucasian sample included black-west Indian, black-African, Indian, Pakistani, Vietnamese, Chinese, and Arab individuals. Data collection took place from September 1998 to May 1999 in 37 schools from eight municipalities (Botkyrka, Hanninge, Huddinge, Nynäshamn, Salem, Södertälje, Tyresö, and Örebro) in central Sweden (7). Socio-economic status data for the study region corresponded well to national data (8). In this region, all state schools with more than 20 children in the study age groups were initially included, and stratified according to the mean income level in their catchment areas. A random sampling procedure from each stratum was carried out (8). The participant and non-participant children did not substantially differ on several studied variables, including self-reported weight and height, as well as prevalences of overweight/obesity (8). The study was approved by the Research Ethics Committees of Örebro County Council and Huddinge University Hospital. Written informed consent was obtained from parents or legal guardians.

*Height* and *weight* were measured by standardized procedures and *body mass index* (BMI;  $\text{kg/m}^2$ ) was calculated. The children were categorized according to the BMI international cut-off values (9). *Waist circumference* was measured over skin with a metal anthropometric tape midway between the lower rib margin and the iliac crest, at the end of a gentle expiration. The age- and sex-specific WC cut-off values for predicting risk factor clustering proposed by the Bogalusa Heart Study (10) were used to class the individuals as having a higher or lower metabolic risk (hereinafter called high/low-risk WC). Several reference values for WC are available in the literature. The sex- and age-specific cut-off values chosen for this study provide meaningful information about a WC size associated with higher metabolic risk, and not only a high level of abdominal fatness.

*Hip circumference* was measured over the buttocks, normally at the level of the great trochanter but not lower than symphysis level. *Waist-to-height ratio* and *waist-to-hip ratio* were calculated. Individuals were also categorized according to the WHtR levels. High (low) WHtR was defined when WHtR was  $\geq 0.500$  ( $< 0.500$ ) (4). *Pubertal stage* was assessed by a trained researcher according to the Tanner stages (I–V).

#### Statistical analysis

The differences between sex and age groups on continuous variables were assessed by two-way analysis of variance (two-way ANOVA). All the residuals showed a satisfactory pattern. Nominal

variables were analyzed by Chi-squared tests. All the percentiles were sex and age specifically calculated. The analyses were performed using SPSS v.15.0 software. For all analyses, the significance level was set at 5%.

## Results

Descriptive characteristics and anthropometric indices of the participants are shown in Table I. Sex and age differences were found for WC, hip circumference and waist-to-hip ratio (all  $p < 0.01$ ). The proportion of people having a high-risk WC was lower in 15-year-old boys compared with girls of the same age, and compared with 9-year-old boys. Waist-to-height ratio was higher in the younger group than in the older group, but no significant differences were found in the proportion of individuals with a high WHtR between age groups. No sex differences were found in the WHtR. Age- and sex-specific percentiles for WC, hip circumference, WHtR and waist-to-hip ratio are presented in Table II.

## Discussion

For WC, data from the UK (11), Spain (12), the Netherlands (13), Turkey (14), Australia (15), Canada (16), USA (17) and Brazil (18) have been reported. The WC values observed in our children are lower than their age-matched peers from Spain, similar to those from Australia, Canada and USA, and higher than those from Britain, Turkey, the Netherlands and Brazil. As body size is strongly related to WC, for a proper comparison, individuals should be matched for body size, rather than for age (19). Waist-to-height ratio may be a useful anthropometric to deal with this problem, as height is taken into account.

As the height and WC of children increases continually as they age, it has been recommended to use the same WHtR cut-off value in different age groups, i.e., 0.500. On the other hand, McCarthy et al. have reported that the value of 0.500 could lightly overestimate the prevalence of children above the cut-off in younger compared with older children and in boys compared with girls (4). In this study, no significant differences between sex or age groups were found in the percentage of people with a high-WHtR, yet some age differences are appreciated in boys. Sex- and age-specific international criteria for WHtR are required.

Both the mean WHtR values and the percentage of individuals with a high-WHtR were substantially lower in our children than in similar age children

Table I. Characteristics of the study children and adolescents by sex.

	9 years		15 years		Differences	
	Girls (n = 288)	Boys (n = 269)	Girls (n = 280)	Boys (n = 238)	Sex	Age
Age (years)	9.5 ± 0.4	9.5 ± 0.3	15.5 ± 0.4	15.6 ± 0.4	–	–
Sexual maturation status (%):						
Pre-pubescents (Stage 1)	58	98	0	1	***	***
Pubescents (Stages 2, 3 and 4)	42	2	46	16		
Post-pubescents (Stage 5)	0	0	54	83		
Weight (kg)	33.7 ± 6.7	33.4 ± 6.2	57.8 ± 8.8	64.2 ± 10.7	***	***
Height (m)	1.39 ± 0.07	1.39 ± 0.06	1.65 ± 0.06	1.76 ± 0.07	***	***
Body mass index (kg/m <sup>2</sup> )	17.3 ± 2.4	17.2 ± 2.4	21.2 ± 2.7	20.7 ± 2.8	NS	***
Overweight (%)	16	10	11	11	*†	NS
Obesity (%)	2	4	1	1		
Waist circumference (cm)	60.2 ± 6.1	60.7 ± 6.0	70.0 ± 6.7	73.8 ± 7.1	***	***
High-risk WC (%)	29	27	30	17	***‡	**II
WHtR	0.43 ± 0.04	0.44 ± 0.04	0.42 ± 0.04	0.42 ± 0.04	NS	***
High-WHtR (%)	5	8	5	4	NS	NS
Hip circumference (cm)	72.5 ± 0.8	71.6 ± 0.9	92.3 ± 0.8	91.0 ± 0.8	**	***
Waist-to-hip ratio	0.83 ± 0.04	0.85 ± 0.04	0.76 ± 0.05	0.81 ± 0.04	***	***

Data shown as mean ± standard deviation or percentages. WC, waist circumference; WHtR, waist-to-height ratio.

Sex and age group differences were analysed by two-way ANOVA (continuous variables) or Chi-square tests (nominal variables).

\*p < 0.05; \*\*p < 0.01; \*\*\*p < 0.001; NS, non-significant.

†Sex differences were found only in 9-year-old children. ‡Sex differences were found only in 9-year-old adolescents. II Age group differences were found only in boys.

from Guatemala (20), Australia (19), Spain (12) and the UK (4). However, height can be a misleading factor in these comparisons. Among the studies referred to above (11–20), an age-matched comparison for height was possible only for British and Brazilian populations. The results showed that the

Swedish children were lightly taller than their peers from Britain (11), Brazil (18) and Spain (unpublished data from the AVENA study). In the light of these results, studies reporting reference data for waist circumference and/or WHtR, should also report age- and sex-specific height values.

Table II. Age- and sex-specific percentile values for central adiposity and body fat distribution indices in Swedish children and adolescents by sex.

	5 <sup>th</sup>	10 <sup>th</sup>	15 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>
9 years									
Girls									
Waist circumference (cm)	52.5	53.7	54.5	56.0	59.0	63.5	66.3	69.0	71.3
Hip circumference (cm)	61.5	63.5	65.1	68.0	71.5	77.5	80.1	82.5	85.0
Waist-to-height ratio	0.39	0.40	0.40	0.41	0.42	0.45	0.47	0.48	0.50
Waist-to-hip ratio	0.76	0.78	0.79	0.80	0.83	0.86	0.88	0.89	0.91
Boys									
Waist circumference (cm)	53.4	54.4	55.5	56.7	59.8	63.0	66.0	69.2	74.0
Hip circumference (cm)	64.1	65.4	66.6	67.8	70.5	74.0	77.3	79.8	83.6
Waist-to-height ratio	0.38	0.40	0.40	0.41	0.43	0.46	0.47	0.48	0.51
Waist-to-hip ratio	0.79	0.80	0.81	0.82	0.85	0.87	0.88	0.89	0.90
15 years									
Girls									
Waist circumference (cm)	61.5	63.5	64.0	65.5	69.0	73.0	75.5	78.0	84.9
Hip circumference (cm)	80.4	83.0	85.7	88.0	92.0	96.0	99.0	102	107
Waist-to-height ratio	0.37	0.38	0.39	0.40	0.42	0.44	0.46	0.48	0.50
Waist-to-hip ratio	0.69	0.70	0.71	0.73	0.75	0.79	0.80	0.82	0.84
Boys									
Waist circumference (cm)	64.5	66.2	67.6	69.5	72.5	76.9	79.9	82.3	87.1
Hip circumference (cm)	81.0	82.5	84.6	86.8	90.2	94.0	97.7	100	106
Waist-to-height ratio	0.38	0.38	0.39	0.40	0.41	0.44	0.45	0.47	0.49
Waist-to-hip ratio	0.76	0.77	0.78	0.79	0.81	0.83	0.84	0.85	0.87

The prevalence of having a high-risk WC reported for American young people (~43%) is much higher than that observed in the Swedish sample studied (~25%). Comparable cut-off values have also been used in Australian children (21). The figures were also higher for the Australian children than for our children (35–47% and 17–30%, respectively).

### Limitations

Only longitudinal studies are able to assess natural changes in individual growth and development. In addition, WC is currently measured in different locations and ways. The question of which is the best method needs to be answered by appropriate validation studies involving magnetic resonance imaging.

### Conclusion

In the absence of a recognized definition of high central adiposity in young people, the terms “overweight” and “obesity” when referring to central adiposity are currently being arbitrarily defined. Therefore, the percentile values for WC and WHtR provided in this paper, together with data from other cohorts, could help to establish international criteria for determining central obesity based on these simple and valuable anthropometric measurements. For comparative purposes, future studies reporting reference data for WC and/or WHtR, should also report age- and sex- specific height values. More studies involving children of different ages and from different regions in Scandinavia are needed.

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