International Journal of Pediatric Obesity
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t725414071

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

Francisco B. Ortega [ab]; Jonatan R. Ruiz [ab]; German Vicente-Rodríguez [ac]; Michael Sjöström [a]
[a] Unit for Preventive Nutrition, Department of Biosciences and Nutrition, Karolinska Institutet, Huddinge, Sweden
[b] The EFFECTS-262 research group. Department of Physiology, School of Medicine, University of Granada, Granada, Spain
[c] Escuela Universitaria de Ciencias de la Salud, Universidad de Zaragoza, Zaragoza, Spain

First Published on: 13 June 2008

To link to this article: DOI: 10.1080/17477160802068965
URL: http://dx.doi.org/10.1080/17477160802068965

International Journal of Pediatric Obesity
2008, 1–5, iFirst article

informa
healthcare

SHORT COMMUNICATION

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

FRANCISCO B. ORTEGA[1,2], JONATAN R. RUIZ[1,2], GERMAN VICENTE-RODRÍGUEZ[1,3] & MICHAEL SJÖSTRÖM[1]

[1]*Unit for Preventive Nutrition, Department of Biosciences and Nutrition, Karolinska Institutet, Huddinge, Sweden,* [2]*The EFFECTS-262 research group, Department of Physiology, School of Medicine, University of Granada, Granada, Spain,* [3]*Escuela Universitaria de Ciencias de la Salud, Universidad de Zaragoza, Zaragoza, Spain*

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 ($\sim$80%). The 92% of the participants were Caucasian, a proportion comparable to the national figures reported in 1998 (94%) (6). The

Correspondence: Francisco B. Ortega. Karolinska Institutet, Department of Biosciences and Nutrition at NOVUM, 14157 Huddinge, Sweden. Fax: 46 8 608 3350. E-mail: ortegaf@ugr.es

(Received 21 November 2007; accepted 16 March 2008)

ISSN Print 1747-7166 ISSN Online 1747-7174
DOI: 10.1080/17477160802068965

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, Haninge, Huddinge, Nynäshamn, Salem, Södertälje, Tyresö, and Örebro) in central Sweden (7). Socioeconomic 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; 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. W*aist-to-height ratio* and w*aist-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 at 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^2)	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. IIAge 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.

	5th	10th	15th	25th	50th	75th	85th	90th	95th
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.

Acknowledgements

The study was supported by grants from the Stockholm County Council. Francisco B. Ortega and Jonatan R. Ruiz were supported by grants from CSD (109/UPB31/03, 13/UPB20/04), Ministerio de Educación y Ciencia de España (AP2003–2128, AP2004–2745 and EX2007–1124), EU DG Sanco, project ALPHA (2006120) and the Margit and Folke Pehrzon Foundation. The authors wish to thank Prof. Olle Carlsson for his assistance with the statistical analysis of the data.

References

1. Gutin B, Johnson MH, Humphries MC, Hatfield-Laube JL, Kapuku GK, Allison JD, et al. Relationship of visceral adiposity to cardiovascular disease risk factors in black and white teens. Obesity (Silver Spring) 2007;15:1029–35.
2. Brambilla P, Bedogni G, Moreno LA, Goran MI, Gutin B, Fox KR, et al. Crossvalidation of anthropometry against magnetic resonance imaging for the assessment of visceral and subcutaneous adipose tissue in children. Int J Obes (Lond) 2006;30:23–30.
3. Janssen I, Katzmarzyk PT, Srinivasan SR, Chen W, Malina RM, Bouchard C, et al. Combined influence of body mass index and waist circumference on coronary artery disease risk factors among children and adolescents. Pediatrics. 2005;115: 1623–30.
4. McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message–'keep your waist circumference to less than half your height'. Int J Obes (Lond) 2006;30:988–92.
5. Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord. 2000;24:1453–8.
6. Statistics Sweden. Summary of Population Statistics 1960–2006. 2007 [cited 2008 25th Feb]; Available from: www.scb.se
7. Poortvliet E, Yngve A, Ekelund U, Hurtig-Wennlof A, Nilsson A, Hagstromer M, et al. The European Youth Heart Survey (EYHS): an international study that addresses the multi-dimensional issues of CVD risk factors. Forum Nutr. 2003;56:254–6.
8. Wennlof AH, Yngve A, Sjostrom M. Sampling procedure, participation rates and representativeness in the Swedish part of the European Youth Heart Study (EYHS). Public Health Nutr. 2003;6:291–9.
9. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320:1240–3.
10. Katzmarzyk PT, Srinivasan SR, Chen W, Malina RM, Bouchard C, Berenson GS. Body mass index, waist circumference, and clustering of cardiovascular disease risk factors in a biracial sample of children and adolescents. Pediatrics. 2004;114:198–205.
11. McCarthy HD, Jarrett KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0–16.9 y. Eur J Clin Nutr. 2001;55:902–7.
12. Moreno LA, Mesana MI, González-Gross M, Gil CM, Ortega FB, Fleta J et al. Body fat distribution reference standards in Spanish adolescents: the AVENA Study. Int J Obes (Lond). 2007;31:1798–805.
13. Fredriks AM, van Buuren S, Fekkes M, Verloove-Vanhorick SP, Wit JM. Are age references for waist circumference, hip circumference and waist-hip ratio in Dutch children useful in clinical practice? Eur J Pediatr. 2005;164:216–22.
14. Hatipoglu N, Ozturk A, Mazicioglu MM, Kurtoglu S, Seyhan S, Lokoglu F. Waist circumference percentiles for 7- to 17-year-old Turkish children and adolescents. Eur J Pediatr. 2008;167:383–9.
15. Eisenmann JC. Waist circumference percentiles for 7- to 15-year-old Australian children. Acta Paediatr. 2005;94:1182–5.
16. Katzmarzyk PT. Waist circumference percentiles for Canadian youth 11–18y of age. Eur J Clin Nutr. 2004;58:1011–5.
17. Fernandez JR, Redden DT, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and

Mexican-American children and adolescents. J Pediatr. 2004;145:439–44.

18. de Assis MA, Rolland-Cachera MF, de Vasconcelos FA, Bellisle F, Conde W, Calvo MC, et al. Central adiposity in Brazilian schoolchildren aged 7–10 years. Br J Nutr. 2007;97:799–805.
19. Dollman J, Olds TS. Secular changes in fatness and fat distribution in Australian children matched for body size. Int J Pediatr Obes. 2006;1:109–13.
20. Groeneveld IF, Solomons NW, Doak CM. Determination of central body fat by measuring natural waist and umbilical abdominal circumference in Guatemalan schoolchildren. Int J Pediatr Obes. 2007;2:114–21.
21. Garnett SP, Cowell CT, Baur LA, Shrewsbury VA, Chan A, Crawford D, et al. Increasing central adiposity: the Nepean longitudinal study of young people aged 7–8 to 12–13 y. Int J Obes (Lond) 2005;29:1353–60.