Licenciatura em Ciências da Nutrição

Comparison between Body Mass Index and Waist Circumference in 7-11 year old Swedish children

Projecto Final de Licenciatura

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Barcarena, Fevereiro de 2013

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Abstract

Background and aim: Pre-obesity and obesity in children and adolescents is a severe public health problem, and is now considered a worldwide epidemic by the World Health Organization. This is of great concern since childhood obesity seems to pass through to adulthood resulting in an onset of obesity-related chronic disease in adult life, increasing morbidity and mortality.

Body Mass Index (BMI) is commonly used to assess overweight and obesity. However, as it does not distinguish between body weight associated with muscle and body weight associated with fat it may lead to some error in classifying obesity and overweight.
Waist Circumference (WC) is an alternate measure of abdominal adiposity and it is related to be a strong predictor of abdominal fat, being oftentimes used as an indirect screening marker for abdominal obesity applied in epidemiological studies along with the BMI.

Methods: As part of the second phase of the Childhood Obesity Surveillance Iniciative study (COSI II Sweden), 1097 children aged 7-11 were evaluated with regards to anthropometric variables of weight and height, as well as WC. Nutritional status was assessed by calculating the BMI.

Results: The prevalence rates for overweight (pre-obese and obese) using the WHO cut-off values for the BMI ranged from 22.9% in boys to 17.8% in girls. 77.1% of boys were classified as having normal weight while 17.3% were pre- and 5.6% obese. As for the girls 82.2% were classified as normal weight,14.2% pre-obese and 3.6% obese.

Using the WC cut-offs 94.1% of boys were classified with a normal WC, while 5.4% were classified as pre-obese and 0.5% obese. A similar tendency was verified in girls with 92.2% classified with a normal WC while 5.9% were pre-obese and 1.2% obese.

Conclusion: Overweight prevalence was lower when using the WC rather than BMI. Further research is needed to assess the veracity of these results. There is a need to create adequate age and gender-specific cut-off points in order to produce specific WC percentiles for swedish children.

Keywords: body mass index; waist circumference; obesity

INTRODUCTION

Childhood obesity and overweight is considered to be a serious public health problem. Over the past two decades the prevalence of overweight school-aged children and adolescents have reached alarming numbers, and has been described by the World Health Organization (WHO) as a worldwide epidemic (WHO, 2006).

Although the prevalence of overweight is rising significantly in most parts of the world, it is dramatically higher in economically developed regions (Lobstein, 2004). This epidemic is of great concern since childhood obesity seems to pass through to adulthood resulting in an onset of obesity-related chronic disease in adult life, increasing morbidity and mortality (Berenson, 2012).

Also overweight children may have an increased risk for early cardiovascular diseases as well as additional problems such as hypertension, hyperinsulinemia, type 2 diabetes, social exclusion and depression (Lobstein, 2004) .

Prevalence of obesity

According to the WHO more than 1.4 billion people suffered from overweight in 2008, in which half billion where obese. As a consequence of this condition at least 2.8 billion people die each year (WHO 2012).

WHO data show that 40 million preschool children were overweight in 2008 (WHO 2012).

Data from the International Obesity Task Force report that ten per cent of the world´s school-aged are estimated to be carrying excess body fat (Lobstein, 2004).

In a recent study, regarding 11-year olds across Europe, using data from nine countries, *Yngve et al* reported that the prevalence of overweight ranged from 5.9% in the Netherlands to 17.7% in Portugal for girls and from 9.5% in Belgium to 26.5% in Portugal for boys (Yngve et al, 2008).

Although the prevalence of obesity in Sweden was, according to Neovius M, ‘still low from an international perspective’, the increase among children and adolescents in the recent decades is alarming (Neovius et al 2006).

In the collection of information regarding overweight prevalence in preparation for the Ministrial Conference on Counteracting Obesity in 2006, the WHO Regional Office for Europe produced a report that showed few countries had good, comparable and representative data to present on childhood overweight. Surveillance of overweight prevalence was therefore strongly recommended in the WHO report (Branca, Nikogosian et al, 2007). The WHO Regional Office for Europe thus initiated the Childhood Obesity Surveillance Initiative, COSI, a new programme for surveillance of overweight and obesity in schoolchildren.

The first data collection of COSI was carried out in the school year 2007/2008 and 13 countries from the region participated (Belgium, Bulgaria, Cyprus, Czech Republic, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Portugal, Slovenia and Sweden) (WHO Regional Office for Europe 2010). The second round of measuring, COSI II, was carried out in 2010 and in Sweden the data collection was carried out by the Karolinksa Institutet.

Body Mass Index and Waist Circumference

A critical issue to handle in attempting to establish the magnitude of the obesity problem is the lack of international consensus in relation to the methodology for defining overweight and obesity in children (Caroli, Wijnhoven et al. 2007)

Body Mass Index is commonly used to assess overweight and obesity. BMI is calculated by dividing weight in kilograms by height^2 in meters (Cole, 2002). In adults overweight is defined by a BMI ≥ 25 kg/m^2, and obesity defined by a BMI ≥ 30 kg/m^2 (WHO, 2006).

Once BMI varies with age and gender different definitions have to be used with children and adolescents (Neovius *et al*, 2006). Pediatric overweight is internationally defined by sex- and age-specific cut-offs (Cole *et al*, 2000). There are different cut-off points and the prevalence of unhealthy weight varies depending on which are used (de Onis *et al*, 2007; Wang *et al*, 2006).

Previous to 1977 the various growth charts in use were based on samples of children that were not population representative.

In order to fill that gap, the National Center for Health Statistics (NCHS) Growth Chart Task Force developed separated growth percentile curves for boys and girls (ages 2 to 18 years). The then called 1977 NCHS growth charts, were constructed with anthropometric data collected during the period 1963–74 in a series of three national health examination surveys (Kuczmarski *et al*, 2000).

CDC

In 1978 the Centers for Disease Control and Prevention (CDC) modified the 1977 NCHS growth curves to develop a set of curves approximating normal distributions that would allow the calculation of standard deviation scores for values above and below the median (Kuczmarski *et al*, 2000).

IOTF

In 2000, Cole *et al* provided a new definition of overweight and obesity in childhood based on international data used from six large nationally representative cross sectional surveys on growth (Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States) (Cole *et al*, 2000).

WHO

In 2007 WHO developed growth curves for weight-for-age, height-for-age and BMI-for-age for school-aged children and adolescents. The standards were created using data from the 1977 NCHS/WHO growth reference for 5 to 19 years (de Onis *et al*, 2007).

In this study it will be used the WHO Child Growth Standards.

Even though BMI is an important objective measure of nutritional status, it also has some limitations (Prentice, 2001), for instance it does not distinguish between body weight associated with muscle and body weight associated with fat (WHO, 2000).

Even though there are high correlations between BMI and total body fat and percent body fat (%BF), BMI is also correlated with fat free mass (FFM).

Throughout childhood increases of BMI are primarily driven by increases in FFM/stature^2 particularly in adolescent boys. Due to varying growth rates and maturity levels these relationships between BMI and the fat and fat-free mass components of the body are further complicated in this life stage (Maynard *et al*, 2001).

The distribution of the fat in the body and not only the amount of overall fatness is considered to be important to health implications (Gutin *et al*, 2007).

Abdominal distribution of the adipose tissue is considered a substantial risk factor for the development of the metabolic syndrome as studies show strong relationships between abdominal obesity and the disorders which are typically associated to this syndrome (Guran *et al*, 2003; Thompson, 2008).

Maffeis et al observed that a WC above the 90th percentile in children is more likely to be associated to multiple risk factors than a WC of less or equal to the 90th percentile (Maffeis, 2001).

According to McCarthy the obesity prevalence in the UK may have been underestimated owing to the fact that abdominal fatness measured by the WC has increased to a greater extent than overall fatness (McCarthy, 2006). Hence, measures of central obesity such as the WC may be superior in its ability to predict early signs of undesirable weight development compared with BMI (Kahn, Imperatore et al, 2005).

WC is an alternate measure of abdominal adiposity (Brambilla *et al*, 2006) and it is related to be a strong predictor of abdominal fat (Maynard *et al*, 2001). Within a given BMI category a larger WC increases the likelihood of having an unfavorable cardiovascular profile high levels of glucose and blood pressure as well as an increased risk of having the metabolic syndrome (Jansen *et al*, 2005).

Regardless of having a component of subcutaneous fat, WC correlates to metabolic risk factors in children (Savva, 2000) and may reflect differences in body composition that are not detected using BMI alone (McCarthy, 2003).

Presently, WC is oftentimes used as an indirect screening marker for abdominal obesity applied in epidemiological studies along with the BMI (Jansen *et al*, 2005).

The parameters for considering abdominal obesity in the developmental age are subject to constant debates. McCarthy *et al* (2001) considered WC and wais-to-height ratio to be more sensitive predictors of cardiometabolic complications than BMI. Also Brambilla *et al* (2006) found WC more useful than BMI in a study assessing visceral tissue in children and youth.

Although high WC values are frequently acepted to be the cause of metabolic risk factors, the WC cut-off values that would define abdominal obesity in the development age are still raises some controversy (Ostrowska Nawarycz, 2010).

In a 2008 systematic review of 120 studies, Ross *et al* identified 8 different protocols for WC measurement (Ross *et al*, 2008). In an effort to develop an international standard for measurement of WC, the need for the use of fixed sites (bony landmarks) of measurement was highlighted. Three protocols comply with the requirements:

- The superior border of the iliac crest – NIH (National Institute for Health) guidelines (NHI, 2000);
- Just below the lowest rib;
- Midway between lowest rib and iliac crest – WHO.

Ross *et al* did not find a substantial influence of WC measurement protocol on the relationship between WC and morbidity or mortality, however different studies have shown a profound influence of the measurement site on absolute WC values (Wang, 2003; Rudolf, 2007; Hitze, 2008). These discrepancies between protocols can be particularly relevant whilst trying to compare different studies.

The aim of this study is to ascertain if there is any significant difference in obesity and overweight prevalence in the sample, by utilizing both a WC percentile classification and a BMI classification (using the WHO cut-offs).

Since to date there is no WC percentile for Sweden this study will use the WC cut-off values from Germany (Scwandt *et al*, 2008).

Once WC percentiles have some variation from each country population the use of the WC percentile curves for german children may have some inborn error and therefore should be taken into account.

METHODS

The current study used data collected as part of the WHO European Childhood Obesity Surveillance Initiative, and used a research protocol prepared especially for this study (Wijnhoven, 2008).

Subjects

Subjects in this study are children aged 7 to 11 years evaluated with regards to the anthropometric variables of weight and height concerning the second phase of COSI (2010). COSI II survey was carried out by Karolinska Institutet from May-July on a sample in the greater Stockholm area. One thousand three hundrer and thirty-five (1335) children were included in COSI II.

COSI II included a family form sent to the parents of the child and an examiner form, filled in by the examiners at the date of the measuring. Children with missing family forms or who were absent at the day of measuring have been excluded. Children with inconsistent measuring values and missing variables were excluded from this study as they were impossible to interpret. The number of children included in the analisys is 1097, 590 boys and 507 girls.

The basic principles of confidentiality, privacy and objectivity were ensured throughout the process.

Sampling

Eighteen (18) different schools are included, 12 of them are located in Stockholm and providing 87,5% of the children included. The median income of the parents is 750,000 SEK (swedish crowns) and is more than 50% higher than the median for couples with children in Sweden. This, among other possible factors, means that it is very likely that the study sample is not representative for Sweden.

Antropometric data collection

All measurements at one school were performed on the same day. Heights, weights and waist circumferences of the sample were measured by trained personnel using calibrated equipment and a protocol common to all other participating countries. Examiners were instructed not to calculate BMI at the point of measurement.

Anthropometric measurements were be done in the mornings before lunch time following standardized procedures. Children were asked to go to the toilet before the measurements.

Height

Height was measured using SECA 214 stadiometers to the nearest 0.1 cm. The children were instructed to stand with their back against the vertical backboard, shoulders leveled, feet slightly apart and hands at the side. The child’s head as at the level with a horizontal line from the child’s ear canal to the lower border of the eye socket ran parallel to the base board with the child looking straight ahead and the back of the head, shoulder blades, buttocks, calves, and heels of the child were touching the backboard. The head board rested firmly on top of the child’s head so the hair was compressed (Wijnhoven, 2008).

Weight

Weight was measured using SECA 862 digital floor scale. The children were instructed to remove heavy clothing and to stand in the middle of the scale with their feet slightly apart. Measuring values were rounded off to nearest 100g (Wijnhoven, 2008)

BMI

BMI was calculated and each child was classified as ‘normal’, ‘pre-obese’ or ‘obese’ weight according to the WHO cut-offs (de Onis, 2007).

WC

Waist circumference was measured using special anthropometrics tapes (SECA 200 and 201) to the nearest 0.1 cm halfway between the iliac crest and the lowest rib. Measurements were taken at the end of a normal gentle expiration.

Statistical analysis

The data was analyzed using SPSS for Windows, v. 20.0. Independent t-tests were used to compare variables between genders. Pearson´s Chi-square analysis was used to analyse the association between classes for BMI and WC.

RESULTS

The sample included 1097 children, age 7-11. Age and anthropometric data is shown in table 1. Boys were significantly higher than girls (p-value 0.006), with no difference in weight (p-value 0.276). There were no differences in BMI (p-value 0.412) although boys had higher WC values (p-value 0.003). The BMI and WC increase gradually with age for both boys and girls.

Table1. Age and anthropometric data on 7 to 11 year old boys and girls (mean ± SD)

	Boys (n=590)	Girls (n=507)	All (n=1097)	P-value
Age (years)	8.9 ± 1.2	8.8 ± 1.2	8.9 ± 1.2	
Weight (kg)	33.1 ± 7.1	32.3 ± 7.2	32.7 ± 7.2	0.276
Height (cm)	138.5 ± 8.7	137.2 ± 9.2	137.9 ± 9.0	0.006
BMI (kg/m^2)	17.0 ± 2.3	17.0 ± 2.5	17.0 ± 2.4	0.412
WC (cm)	60.1 ± 6.3	58.9 ± 5.9	59.6 ± 6.1	0.003

The prevalence rates for overweight (pre-obese and obese) using the WHO cut-off values for the BMI ranged from 22.9% in boys to 17.8% in girls. 455 boys were classified as having normal weight (77.1 %) while 102 were pre-obese (17.3%) and 33 obese (5.6%). As for the girls 417 were classified as normal weight (82.2%), 72 pre-obese (14.2%) and 18 obese (3.6%). These results are shown in table 2.

Table2. Prevalence of pre-obesity and obesity by gender using the WHO cut-offs for the BMI.

		BMI Class		
		Normal **5th – 85th percentile**	**Pre-obese** **85th – 95th percentile**	**Obese** **≥ 95th percentile**
Boys	*n*	455	102	33
	% within gender	77,1%	17,3%	5,6%
Girls	*n*	417	72	18
	% within gender	82,2%	14,2%	3,6%
Total	*n*	872	174	51
	% of Total	79,5%	15,9%	4,6%

As presented in table 3, 94.1% of boys were classified with a normal WC, while 5.4% were classified as pre-obese and 0.5% obese. A similar tendency was verified in girls with 92.2% classified with a normal WC while 5.9% were pre-obese and 1.2% obese.

Table3. Prevalence of pre-obesity and obesity by gender using the German cut-offs for the WC.

		WC Class		
		Normal **WC < 90th percentile**	**Pre-obese** **WC ≥ 90th percentile**	**Obese** **WC ≥ 97th percentile**
Boys	*n*	555	32	3
	% within gender	94.1%	5.4%	0.5%
Girls	*n*	471	30	6
	% within gender	92.9%	5.9%	1.2%
Total	*n*	1026	62	9
	% of Total	93.5%	5.6%	0.8%

Figure 1 compares the prevalence of pre-obesity, obesity and normal weight using the BMI and WC cut-offs. The prevalence of pre-obesity and obesity was higher in all age groups when using the BMI.

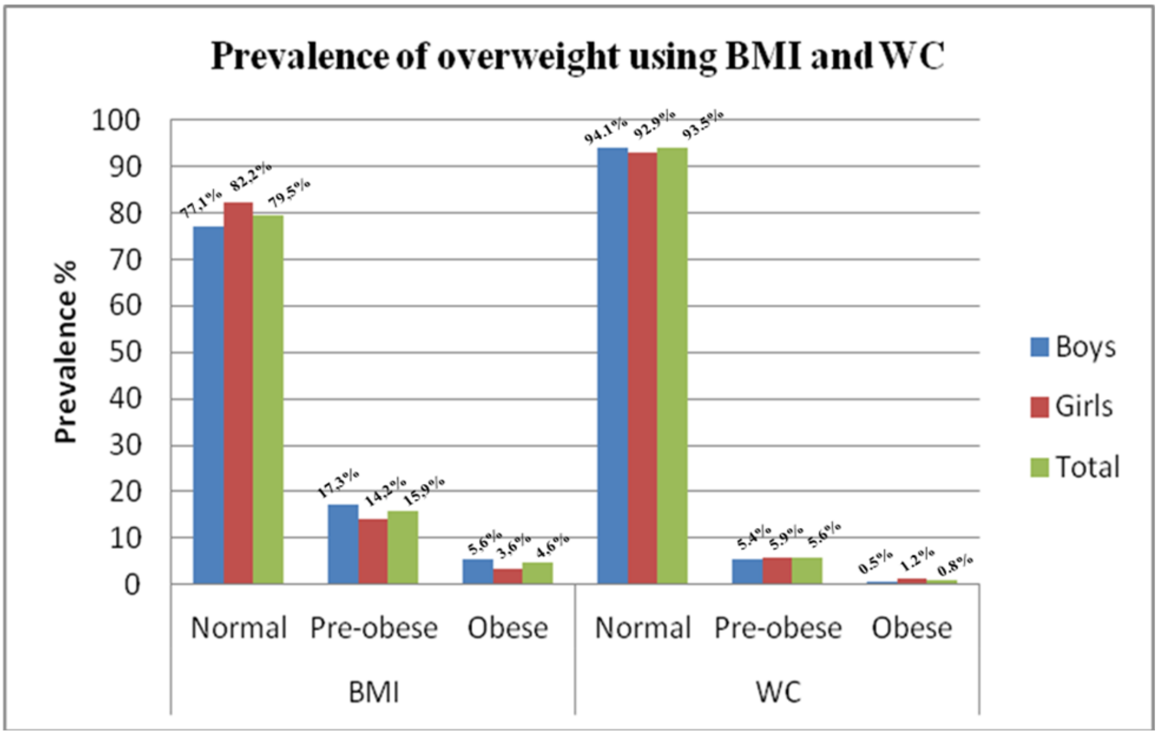

Figure1. Prevalence of pre-obesity and obesity using the WHO BMI cut-offs and the German WC cut-offs.

Figure 2 shows the percentage of cases that fall in the same class in both variables. 83% of the cases are classified in the same way by both indicators, meaning that both BMI and WC are normal, pre-obese or obese, while 17% of the children are classified differently using BMI or WC.

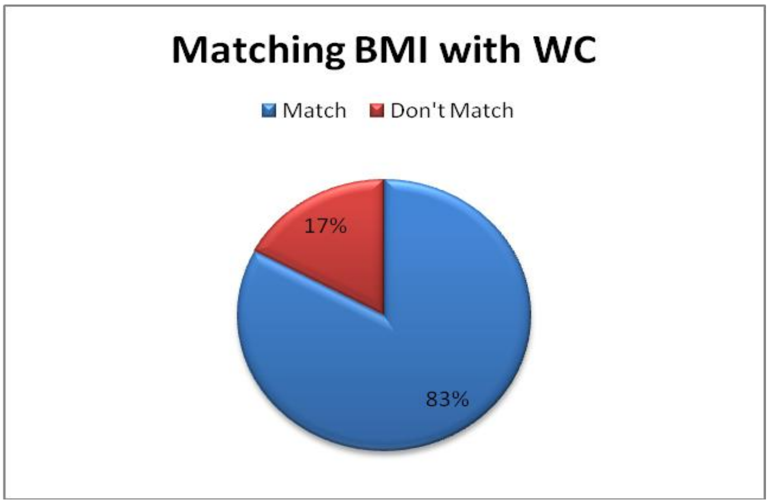

Figure2. Percentage of cases that fall in the same class in both variables.

As shown in figure 3 the combination of both disorders was present in 6.2% of the children from which 0.7% were classified as obese in both BMI and WC. 14% of the children had a WC percentile bellow 90th while being classified as pre-obese or obese with the BMI. On the other hand 0.3% was classified as pre-obese or obese in the WC while having a normal BMI. However 79.2% of the children had a normal classification in BMI and WC.

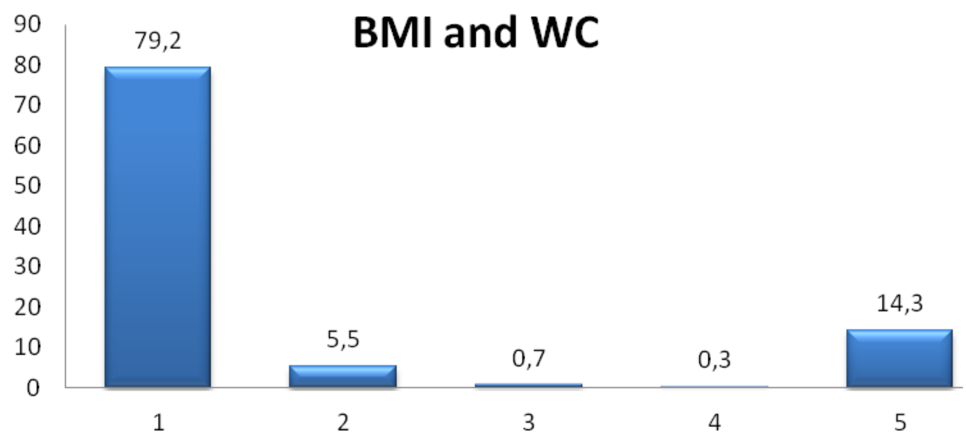

Figure2. Prevalence of combined waist circumference and body mass index (1: normal BMI and WC; 2: BMI and WC > 90th percentile; 3: BMI and WC>97th percentile; 4: BMI<90th and WC>90th percentile; 5: BMI>90th and WC<90th percentile).

DISCUSSION

In the current study two indices of fatness were examined separately, BMI and WC. The results for the WHO cut-offs for BMI showed that overweight (pre-obesity and obesity) was found in 22.9% of boys and 17.8% of girls. These findings are similar to the those reported by Neovius *et al* (Neovius *et al*, 2006) and higher to what reported by Ynve (Yngve et al, 2008).

Results for WC suggest a lower prevalence of overweight in both boys (5.9%) and girls (7.1%). However this indicator seems to revert the situation as the prevalence of overweight is thus higher in girls than boys.

When compared to the BMI, WC classification had a significantly lower prevalence of pre-obesity and obesity both in boys and girls. The reasons for these results are yet not clear and specific swedish percentiles may be necessary to clarify this matter.

When combining the prevalence of BMI with WC only 0.3% of the cases had a higher WC while having a normal BMI, though for a normal WC 14.3% of children had a high BMI classification.

The comparison between swedish and german children from 7-11 years of age enables to verify the differences in weight, height and WC for age. Swedish children are higher, heavier but have a smaller WC mean. This alone may justify the differences observed and therefore may misrepresent reality.

Although there exist risk predictor cut-offs for adults, only few specific cut- offs or even reference percentiles are available for children (Hirschler, 2005).

Children require WC separate cut-offs of sex-specific relative to age, height and the status of sexual maturity because of the normal increase in WC throughout childhood (Hatipoglu, 2008).

Age and specific WC percentiles have been developed for children and adolescents from a number of different countries such as UK (McCarthy, 2001), Spain (Moreno, 1999), the Netherlands (Fredriks *et al*, 2005), Turkey (Hatipoglu *et al*, 2008), Poland (Nawarycz, 2010), Germany(Schwandt, 2008) and USA (Fernandez, 2004).

Nevertheless when comparing national reference values several important matters should be taken in consideration. WC reference values may differ between countries and among different ethnic groups as genetic and environmental factors are likely to explain some of the variations in the WC phenotype (Fernandez, 2004).

Therefore comparisons among different studies require caution.

Since WC may be measured at different sites and percentile values calculated with different methods, international agreement as the measurement site is thus required in order to favor comparisons between percentile values from different populations.

Limitations

A selection bias may have been introduced if overweight and especially obese children’s parents opted out of the study or if the children were absent or refusing measurements. Furthermore, the children in this study are not representative for Sweden as the main part of the participants are from an urban area, Stockholm, and also due to the small size of the sample.

CONCLUSION

Further work is necessary to examine the correlation between waist circumference , body fatness, and morbidity in young people. Waist circumference should be routinely measured in schoolchildren as it is a simple estimator of abdominal obesity. There is needed more research to establish adequate age and gender-specific cut-off points in order to produce specific WC percentiles for swedish children.

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