Waist circumference is appropriate for quantifying body fat in university female students

Dorjana Zerbo Šporin
University of Primorska, dorjana.zerbosporin@zrs.upr.si

Abstract

Excessive body fat, especially central fat distribution, is a risk factor for many obesity-related diseases. The screening of individuals for health risks, using the available methods to determine body composition, is usually impractical for field work. The aim of this study was to evaluate a simple anthropometric method to identify obesity and related co-morbidity risk in university female students. The research validates the usefulness of waist circumference and the waist-to-hip circumference ratio to quantify total body fat instead of using a bioelectrical impedance analyser. Waist circumference demonstrates ($r = 0.79$) a highly positive linear correlation with total body fat mass; 4% of participants show a moderate risk for developing cardio-metabolic disorders and should be involved in therapeutic protocols; weight loss and physical activity intervention can be prescribed. We can conclude that waist circumference can be used instead of bioimpedance analysers to screen the population of young adult females and identify those who are at risk due to increased body fat or central fat distribution. It is not possible to estimate the amount of total body fat of young adult females from their waist-to-hip circumference ratio, but it remains a good predictor of health risk.

KEYWORDS: waist circumference, waist-to-hip circumference ratio, bioelectrical impedance analysis, body fat, young adult females

Introduction

An excessive amount of body fat is a risk factor for cardio-vascular and metabolic diseases, high blood pressure, bone and muscle disorders and specific types of cancers, such as colon and breast cancer (Blinc & Bresjanac 2005; Kuk et al. 2006; Warburton et al. 2006).

The amount of body fat is usually quantified by assessing gross body composition, body fat mass (BFM) and fat-free mass (FFM) (Heyward & Stolarczyk 1996; Lee & Gallagher 2008). A regression equation, derived from skinfolds (Zerbo & Štefančič, 2004) and an anthropometrical five-way fractionation method (Tomazo Ravnik 1996) have been used previosly to estimate BFM of Slovene female students. The screening of individuals at health risk, using the available methods to accurately determine body composition with greater accuracy, is generally impractical for field work. It is therefore desirable to use convenient methods for estimating

ANTHROPOLOGICAL NOTEBOOKS 20 (2): 145–153.
ISSN 1408-032X

body fat, e.g. using selected anthropometric parameters (Lee & Gallagher 2008). Many research studies focused on identifying which specific aspects of obesity are significant predictors of eventual development of a cardio-metabolic risk. A central pattern of body fat distribution, particularly an increased amount of visceral fat, is an independent risk factor (Bergman et al. 2011; Evans et al. 2012; Kuk et al. 2006; Lee & Gallagher 2008; Lee et al. 2008). Anthropometric measurements such as waist circumference (WC) and waist-to-hip circumference ratio (WHR) are strongly correlated with the quantity of visceral fat, so they are reliable predictive factors for central obesity-related diseases (Evans et al. 2012; Kravos 2005; Malina 1996). The amount of fat on the trunk influences the concentration of the circulating visfatin, the pro-inflammatory mediator that contributes to co-morbidity (Jurdana et al. 2013).

Maintaining an appropriate body weight and waist circumference significantly contributes to health promotion and disease prevention. Regular physical activity and healthy eating behaviour are the most important protective factors (Blinc & Bresjanac 2005; Lee et al. 2010; Warburton et al. 2006). Behavioural intervention on eating habits and physical activity practice in youth may contribute to the development of healthy adult lifestyles, helping reduce chronic disease incidence (Koster et al. 2009; Hallal et al. 2006; Perry et al. 1989).

Based on these premises, this study validates the usefulness of WC and WHR in female students for quantifying body fat rather than using the bioelectrical impedance method. The aim was to apply a simple screening method, able to identify obesity and related co-morbidity risk from readily obtainable anthropometrical parameters. Individuals with elevated risk should be educated about the importance of maintaining an appropriate body weight and waist circumference in young adult age for the long-term prevention of cardio-metabolic disorders.

Subjects and methods

Subjects

A total of 169 female students, in average 22 years old, from various faculties of the University of Ljubljana were anthropometrically examined. The participants only engaged in recreational sports activities. The research was carried out at the Department of Biology, Biotechnical Faculty in Ljubljana, Slovenia. All the participants voluntarily participated in the study. Informed consent was obtained from all participants. The research was conducted in accordance with the ethical principles of the Helsinki Declaration.

Protocol

All measurements were taken by same examiner in the morning. The environment in which the measurements have been carried out was quiet, properly illuminated and thermally neutral. The participants were wearing usual light indoor clothing.

Anthropometric measurements

Waist circumference (WC) was estimated halfway between the costal edge and the iliac crest on the side and between the processus xyphoideus and umbilicus in the front (Tran & Weltman 1989). Hip circumference (HC) was taken at the greatest circumference around the buttocks (Lohman 1981). Circumferences were measured twice with a flexible inextensible tape to a 0.1 cm accuracy and the mean was used. The waist-to-hip circumference ratio (WHR) was

simply calculated by dividing the waist with the hip circumference (Heyward & Stolarczyk 1996). A cut-off point of 80 cm for WC was used for identifying individuals with moderate health risk and a critical value of 88 cm or more for individuals with high risk for cardiometabolic disorders linked to central obesity distribution type (Rotar-Pavlič 2008).

Bioelectrical impedance analysis

A gross body composition was determined by using the bioelectrical impedance method (BIA). Body fat mass (BFM) and a percentage of body fat (%BF) were assessed by the Tanita TBF-305 bioelectrical impedance analyser (Tanita Corporation, Arlington Heights, IL) and the data were analysed with the software provided by the manufacturer. A high correlation ($r^2 = 0.95$, $p < 0.001$) was observed between the body composition estimated by TBF-305 and dual energy x-ray absorptiometry which suggests that TBF - 305 may be used as a tool in health assessment (Rubiano, Nunez & Heymsfield 1999).

Impedance was measured in the accordance with the principles of the BIA method protocol; 12 hours before measurement, participants were not allowed to drink alcohol or other beverages except water, they were not allowed to take diuretics and not to engage in any intensive physical exercise or visit a sauna. A moderate meal had to be consumed at least three hours before testing. Before impedance measuring, all subjects were asked to empty their bladders (Nunez 1998).

Statistical analysis

Selected variables were tested for normality with the Kolmogorov-Smirnov test. Descriptive statistics such as minimal (*Min*) and maximal (*Max*) value, mean (M) and standard deviation (*SD*), were determined for all variables. All data values are presented as *M*±*SD*. Pearson's correlation analyses were performed to determine potential correlations between anthropometric variables and body fat mass derived from bioelectrical impedance. The correlation with $r \geq 0.26$ and a *p*-value of less than 0.01 was taken as statistically significant. All the statistical analyses were performed by using the SPSS software package.

Results

As shown in Table 1, female students from the University of Ljubljana in average have a waist circumference of 69.3 cm and waist-to-hip circumference ratio of 0.7, while their mean body fat mass was 13.7 kg, which in average presents 22% body weight as fat.

Table 1: Descriptive statistic for anthropometric parameters of 169 female students

Parameter	Min	Max	M±SD
Age (years)	19.0	29.0	22.0±2.55
Waist Circumference (cm)	60.3	103.0	69.3±5.73
Hip Circumference (cm)	84.3	121.5	97.3±6.52
Waist-to-Hip Ratio	0.6	0.9	0.7± 0.04
Body fat mass (kg)	2.7	54.4	13.7±5.90
% Body Fat	5.6	53.9	22.1±5.78

Legend: Min - the lowest value, Max - the highest value, M±SD-mean ± standard deviation

Waist circumference demonstrates (Table 2) a highly positive linear correlation with body fat mass ($r = 0.79$) and the percentage of body fat ($r = 0.73$), estimated by using the bioelectrical impedance method. WC reflects higher BFM and %BF, so a larger waist circumference also means a greater amount of total body fat, not only abdominal fat. WC can explain 69% variance for BFM ($r^2 = 0.69$) in female students (Figure 1).

Table 2: Pearson's correlation coefficients(r) for anthropometrical and obesity parameters in female students

Parameter	Body fat mass (kg)	% Body Fat
Waist Circumference (cm)	0.79*	0.73*
Waist-to-Hip ratio	0.04	0.08

*$r \geq 0.26$; $p < 0.01$

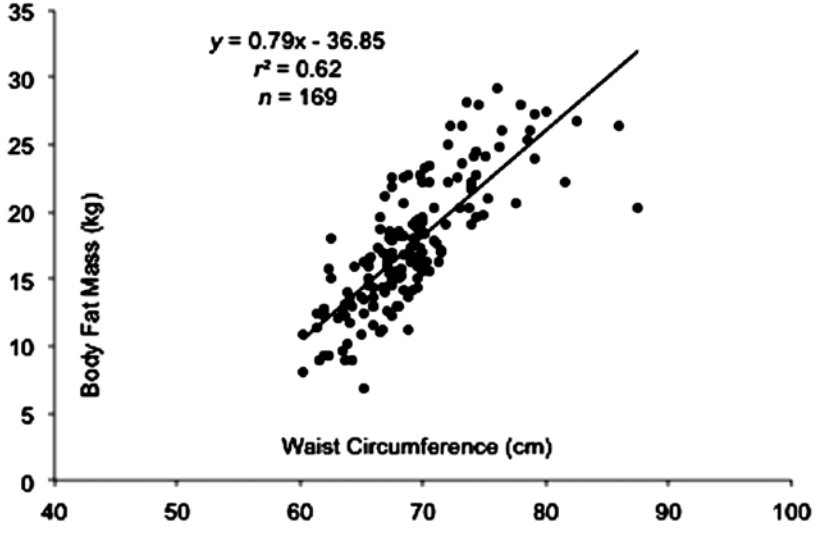

Figure 1: Linear positive regression of waist circumference and body fat mass in female students

A weak correlation ($r = 0.04$, $r^2 = 0.002$) was found between waist-to-hip circumference ratio and body fat mass (Table 2, Figure 2), suggesting that it is not possible to estimate total body fat of young adult females from WHR.

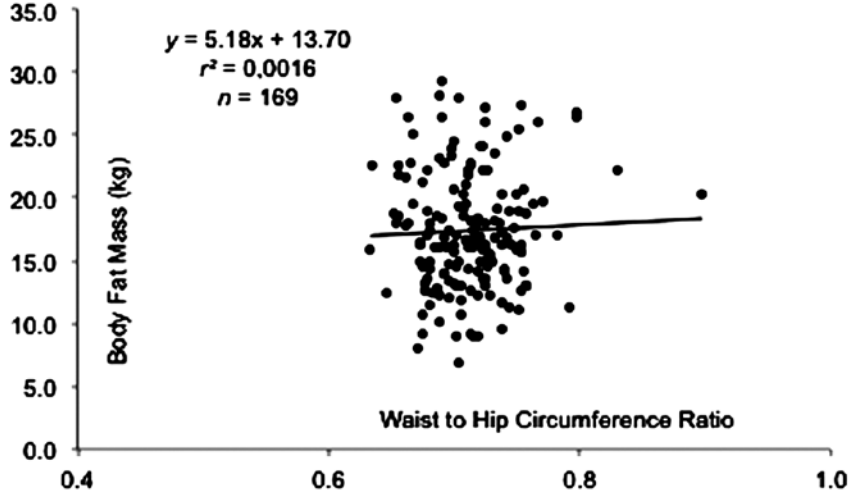

Figure 2: No significant relationship for body fat mass and waist-to-hip circumference ratio in female students

Waist circumference could also be used for determining the risk degree for cardio-metabolic disorders, associated with an excessive amount of visceral fat (Rotar-Pavlič 2008). In this context, it was determined that 4% of examined participants show a critically elevated value for WC (>80 cm) and a moderate risk for developing cardio-metabolic disorders. No female students included in the study showed a high cardio-metabolic risk (Figure 3).

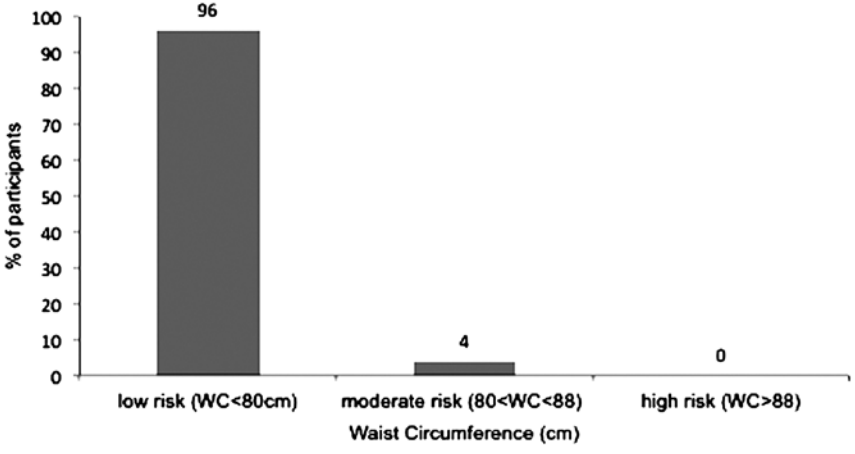

Figure 3: Distribution of female students in categories of low, moderate and high risk for cardio-metabolic disorders

Discussion

Obesity is a public health problem that has become epidemic on a global scale (Chan & Woo 2010). It is estimated that more than half of adults aged 35–65 living in Europe are either overweight or obese, defined by the body mass index. The prevalence of obesity in Europe is probably 10–20% in men and 15–25% in adult women (Seidell & Flegal 1997). In Slovenia, 36.7% of adults aged 25 to 64 are overweight, and 15% are obese (Zaletel-Kragelj, Eržen & Fras 2004). Even the proportions of overweight and obese Slovenian children and adolescents were almost steadily growing from 1991 to 2011 (Kovač, Jurak & Leskošek 2012).

Measuring body composition is usually in response to the need to describe either deficiencies or excesses of a component that is thought or known to be related to health risk. In conditions such as obesity, the levels of body fat allow for clinical diagnoses with implications for formulating appropriate interventions (Kuk et al. 2006).

The screening of individuals for health risks, using the available methods to accurately determine body composition, is generally impractical for field use. It is therefore desirable to have available simple methods that can accurately estimate body composition (Lee & Gallagher 2008).

For female students from the University of Ljubljana, two indices for quantifying body fat instead of direct measurements of body composition with bioelectrical impedance analysers were examined. As a result, a strong, significant positive linear correlation ($r = 0.79$, $r^2 = 0.69$) between waist circumference and body fat mass measured with BIA (Table 2, Figure 1) suggests the possibility of indirectly estimating BFM from WC at least within selected group of young adult Slovenian females. Waist circumference could explain a 69% variance for body fat mass (Figure 1). Our findings correspond to the findings of Wang et al. (2003) who found close relation of WC with body fat mass ($r^2 = 0.77$) and the percentage of body fat ($r^2 = 0.66$). A larger waist circumference means a greater amount of total body fat and is useful for a rapid determination of the degree of obesity.

The increased waist circumference not only reflects total fatness, but also abdominal fatness. Recent findings indicate that WC is a reliable marker of health risk, since increased abdominal fat amount predicts obesity-related cardio-metabolic co-morbidity (Bergman et al. 2011; Evans et al. 2012; Janssen et al. 2004; Kuk et al. 2006; Lee & Gallagher 2008; Lee et al. 2008). Usually a cut-off point of 80 cm for WC is used for identifying adult females with moderate health risk and the critical value of 88 cm or more for individuals with high risk for cardio-metabolic disorders linked to central obesity distribution type (Rotar-Pavlič 2008). In the presented sample, female students are not exposed to high cardio-metabolic risk (Figure 3); 4% of the examined participants show a moderate risk for developing cardio-metabolic disorders and should be immediately involved in therapeutic protocols; weight loss and physical activity intervention can be prescribed.

Such approach provides the possibility of a quick overview of larger samples, in the laboratory and in the field. Circumferences are easy to obtain because they are non-invasive and inexpensive although anthropometric data sometimes suffer from low accuracy and reproducibility (Stolk et al. 2013). Therefore, as in the present study, reliable anthropometry has to be performed by a single trained and experienced examiner.

For female students, a weak correlation between waist-to-hip circumference ratio and body fat mass was found (Figure 2). The same has been shown for university students by Montero et al. (2010). The findings suggest that it is not possible to estimate total body fatness of young adult females from WHR. The waist-to-hip circumference ratio remains a good predictor of health risk linked to central obesity type (Evans et al. 2012; Kravos 2005; Malina 1996). According to the classification of Bray & Gray (1988), the female students examined in the current study, with a mean WHR of 0.7, in average belong to the group with a low cardio-metabolic health risk. Similarly, average WHR values (0.75) for young adult females aged 18 to 24 years were determined by Dobbelsteyn et al. (2010). A larger hip-than-waist circumference is typical for young adult females and reflects a gynoid fat distribution type, essential for successful fertilisation and pregnancy (Malina, 1996). According to WHR, 5% of Slovenian female students belong to the group with an increased cardio-metabolic risk due to the specific body fat distribution (Zerbo Šporin 2013).

Conclusions

Within the group of young adult Slovenian females, it is possible to indirectly estimate total body fat from waist circumference ($r = 0.79$, $r^2 = 0.69$) instead of direct measurements with the Tanita TBF-305 bioimpedance analyser. Larger waist circumference also means a greater amount of total body fat and is useful for rapid determination of the degree of obesity for larger samples in the laboratory and in the field. Waist circumference is easy to obtain as a non-invasive and inexpensive anthropometrical parameter. Measurement protocols for body circumferences are much simpler than for bio-impedance and can be very reliable if the technicians are well trained and experienced. Waist circumference can be used as an independent measurement to identify those who are at risk due to either increased body fat mass or central fat distribution. Four per cent of examined participants show a moderate risk for developing cardio-metabolic disorders and should be immediately involved in therapeutic protocols; weight loss and physical activity intervention can be prescribed. It is not possible to estimate the amount of total body fat of young adult females from waist-to-hip circumference ratio, but it remains a good predictor of health risk linked to central obesity type. The present sample, with a mean waist-to-hip circumference ratio of 0.7, belongs to the group of a low cardio-metabolic health risk, typical for gynoid fat distribution type of young adult women.

Acknowledgements

I would like to thank my colleagues Marija Štefančič and Tatjana Tomazo-Ravnik for their professional support. Many thanks to all participants.

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Povzetek

Prekomerna količina telesnega maščevja, še posebej v predelu trebuha, je dejavnik tveganja za pojav številnih, z debelostjo povezanih bolezni. Razpoložljive metode za določanje telesne sestave in prepoznavanje posameznikov s povečanim tveganjem za zdravje, so za izvajanje meritev na terenu manj primerne. Namen raziskave je bil ovrednotiti možnost opredelitve debelosti in z njo povezanega tveganja za obolevnost študentk, s preprosto, antropometrično metodo. Raziskava preverja ali sta obseg pasu in razmerje med obsegom pasu in bokov primerna za vrednotenje debelosti in ali lahko nadomestita določanje telesne sestave z analizatorji bioelektrične impedance. Obseg pasu je s količino celotnega telesnega maščevja pomembno povezan (r = 0,79) in tako uporaben parameter za prepoznavanje obolevnosti izpostavljenih mladih odraslih žensk, bodisi zaradi povečane količine telesnega maščevja ali njegove centralne porazdelitve. 4% pregledanih študentk kaže zmerno tveganje za razvoj bolezni srca in ožilja ter motenj presnove. Prepoznane posameznice je potrebno usmeriti v preventivne programe za znižanje telesne mase z izbiro ustrezne diete in programa vadbe. Razmerje med obsegom pasu in bokov ni primerno za vrednotenje zamaščenosti mladih odraslih Slovenk, vendar ostaja dober pokazatelj tveganja za zdravje, povezanega s centralnim tipom debelosti.

KLJUČNE BESEDE: obseg pasu, razmerje med obsegom pasu in bokov, analiza bioeletričnega upora, telesno maščevje, mlade odrasle ženske

CORRESPONDENCE: DORJANA ZERBO ŠPORIN, University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technology, Glagoljaška 8, SI-6000 Koper, Slovenija. E-mail: dorjana.zerbosporin@zrs.upr.si.