Article **ECORFAN-Bolivia Journal**
December 2017 Vol. 4 No. 7 34-41

# Anthropometric indicators that best estimate adiposity: a systematic review

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Received July 17, 2017; Accepted December 28, 2017

**Abstract**

To estimate adiposity, a good anthropometric indicator should be objective, valid, reliable, capable in detecting health risk and offer results of interventions by the change in body composition. Given the variety of possible indicators, it is important to establish which are the most used and validated; so the objective of this systematic review was to identify the anthropometric indicators that best estimate adiposity in young adults. A systematized search was made in PubMed, ScienceDirect, Scopus and Cochrane Library, with the descriptors anthropometry, anthropometric indicators, adiposity, obesity, validity, dual x-ray, adult and plethysmography. Methodological quality of the articles was evaluated and those who appraised the validity of anthropometric indicators against an image gold standard, were taken into account. The relationship between body mass index, waist circumference and body adiposity index was studied in the 4 included articles, determining that the first two are considered the best anthropometric indicators to estimate adiposity

**Anthropometric indicators, validation, adiposity, adults**

**Citation:** GÁLVEZ-CUENCA, Liz Anel, ORTIZ-RODRÍGUEZ, Briseidy, CARRASCO-LEGLEU, Claudia E., CANDIA-LUJÁN Ramón, DE LEÓN, Lidia G. Anthropometric indicators that best estimate adiposity: A systematic review. ECORFAN Journal-Bolivia 2017, 4-7: 34-41.

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## Introduction

Anthropometric indexes usually refer to proportions of body measurements, which are given an interpretation, hence that body weight acquires a better meaning when it relates to age or size of the individual, than when expressed alone. Some indicators are useful for assessing body composition as part of an individual's physical performance or nutritional status or in the detection of health risks (WHO, 1995).
Body mass index (BMI) is one of the most widely used anthropometric indicators for its low cost and simplicity of calculation of excess weight and its use at an international level was accepted by the WHO in adult individuals since 1995 (Rosales, 2012)

Strong criticism of the BMI for its variation in age, gender, and ethnicity, and failure to distinguish between fat and lean mass despite their relationship with cardiometabolic diseases (Eknoyan, 2008; Nutt, 2015; Garrow & Webster, 1985) allowed the emergence of other indexes such as waist / hip (WHR), or waist / height (WHtR) that despite its correspondence with fat accumulation in the abdominal area, have not been characterized by effectively identifying some risk factor for health (Huxle, Mendis, Zheleznyakov, Reddy & Chan, 2010). On the other hand, waist circumference (WC) is recognized as an indicator of central adiposity and proven as a metabolic risk factor, although it also neglects other regions of accumulation of adipose tissue and does not quantify total body fat (Lean, Han & Morrison, 1995; Pérez, Gálvez & Miranda Pérez, 2009).

The anthropometric variables have been used in prediction equations for the estimation of fat percentage, with the inconvenience of errors related to the compressibility of skin and subcutaneous tissue, as well as to estimate a fixed relationship between internal and external adiposity, among other things (Pretice & Jebb, 2001).

Recently the body adiposity index (BAI) has been satisfactorily validated against modern imaging methods, although it does not properly determine the fatty tissue content since its formula includes only the perimeter of hip in relation to height (Pan American Health Organization, 2000). On the contrary, more sophisticated equipment such as computerized axial tomography (CAT), magnetic resonance imaging (MRI) or dual X-ray absorptiometry (DEXA), which estimate adipose tissue with great precision, have served as gold standards for the validation of anthropometric indicators, but their use is limited in large-scale studies because of their high costs (Demmer, et al., 2016; Hames, Anthony, Thornton & Goodpaster, 2014).

A good anthropometric indicator should adequately reflect the problem, which in this case is the content of body adiposity; and in view of the variety of parameters, it is important to establish which of those used in clinical practice meet their objective, which are reliable to detect the risks and which facilitate the integral diagnosis of adiposity to be used in the prevention of related pathologies. Therefore, the objective of this systematic review was to identify the anthropometric indicators that best estimate adiposity in young adults.

ISSN:2410-4191

## Metodology

### Search strategy

The electronic databases consulted were PubMed, ScienceDirect, Scopus and Cochrane Library. We searched for articles related to the identification of validated anthropometric indicators that best estimate adiposity in young adults with the descriptors anthropometry, anthropometric indicators, adiposity, obesity, validity, dual x-ray, adult and plethysmography, in English and Spanish, related to the identification of validated anthropometric indicators that best estimate adiposity in young adults delimited from January 2010 to December 2016.

### Studies selection

Included were original studies evaluating the validity, correlation and/or concordance of anthropometric indicators against a gold standard of imaging in young adult males and females. Those studies done in children or with some associated pathology were excluded.

A total of 727 articles with established descriptors were identified. After reading and analyzing the abstracts, 699 articles were excluded because they did not meet the inclusion criteria. Of the remaining 28 documents, 24 were discarded because they were repeated in the databases; so that after full reading, four articles were included for this study (n = 4). Figure 1 shows the process of selecting articles.

### Search strategy

In the electronic databases PubMed, ScienceDirect, Scopus and Cochrane Library we searched for articles with the descriptors anthropometry, anthropometric indicators, adiposity, obesity, validity, dual x-ray, adult and plethysmography, related to the identification of anthropometric indicators validated that best estimate adiposity in young adults, in English and Spanish, limited to the period from January 2010 to December 2016.

### Studies selection

Included were original studies evaluating the validity and/or correlation and/or concordance of anthropometric indicators against a gold standard of imaging in young adult males and females. We exclude those studies done in children, adolescents and older adults, or with some aggregate pathology.

A total of 727 articles were obtained with the descriptors established, identified by the titles of interest. After the reading and analysis of the abstracts, 699 articles were excluded because they did not meet the inclusion criteria, since the analyzes were done in children or older adults, or with some type of aggregate disease. Of the remaining 28 documents, 24 were discarded because they were repeated in the databases; so only after full reading, only four articles were included for this study (n = 4). Regarding the use of a gold standard for validation, only the use of DEXA in young adults was identified. (See Figure 1).

ISSN:2410-4191

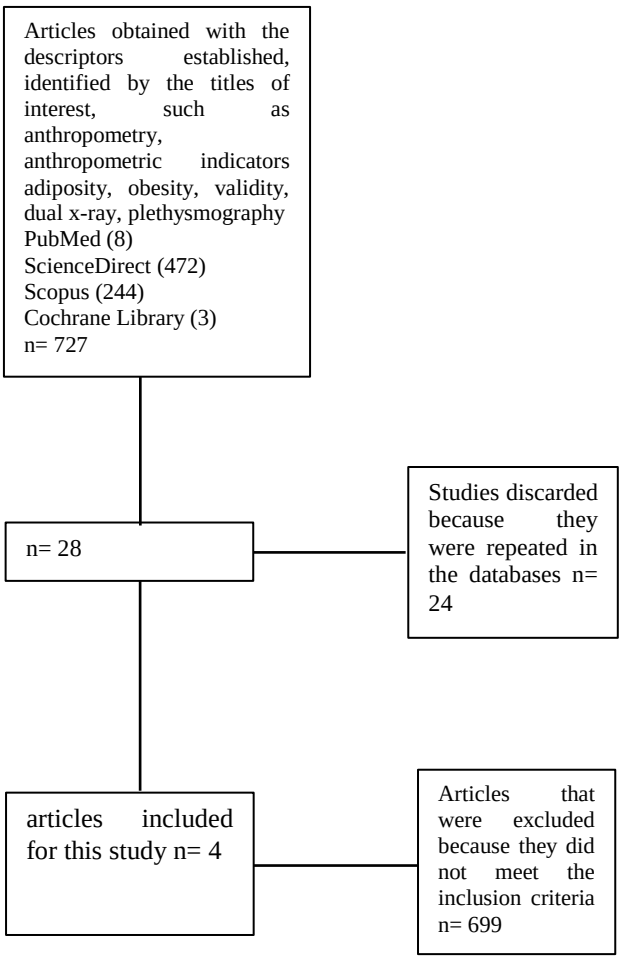


**Figure 1** Studies selection process

## Quality assessment

The quality of included studies was determined by the List of Downs and Black, an instrument comprising 27 items divided into 5 measurement subscales. According to the type of studies used here, 11 items were taken regarding the timely reporting of the methodological process, the validity of the sample and the results presented. The studies with the 11 positive items were considered of good methodological quality.

## Results

The anthropometric indicators that have been most validated to estimate adiposity in young adults (Table 1) are BMI, WHR and BAI. DEXA was identified as the reference method. In all studies Pearson's correlation was used for statistical analysis; in terms of methodological validity the total of articles were of good quality with 11 positive items for each according to the List of Downs & Black.

Sun, Vam Dam, Spiegelman, Heymsfield, Willett & Hu, 2010, reported the validation of BMI and WHR, as well as the correlation of these with triglycerides, cholesterol, glucose, insulin and C-reactive protein. The sample analyzed in this review corresponded to n = 3,960 of which were males with n = 2,049 and females n = 1,911, were also adults classified by gender, race and age, statistical analysis for the present systematic review were taken from the data corresponding to men and women between 20 and 39 years of age, presenting in women a r = 0.92 and in men r = 0.95 compared to the comparison of BMI and percentage of fat by DEXA. Regarding the correlation of WHR with DEXA, the values were r = 0.95 in men and r = 0.93 in women. It was concluded that both BMI and WHR are valid adiposity indicators against the measurements obtained by the DEXA.

In order to find also the relationship between BMI, WHR and adiposity data offered by DEXA, (Kim, et al., 2014) with data from the Fourth and Fifth National Health and Nutrition Survey of Korea, 18,198 subjects were analyzed between men and women of different age groups, of which, for the purposes of the present review, data were collected from 5,843 men and women from 19 to 39 years old.

ISSN:2410-4191

A positive correlation was obtained between the percentage of fat obtained by DEXA and WHR with r = 0.72 for men and r = 0.63 for women. While, with BMI in men it was r = 0.71 and in women r = 0.70, concluding that both BMI and WHR reflect body fat.

In 2011, Bergman et al., with the purpose of counteracting some of the limitations of BMI proposed BAI; the formula is BAI = [(HC, in cm)/((h, in m)1.5 )$^{-18}$)] where:

WC = hip circumference in centimeters

h = height in meters

The equation was tested on 1,733 Mexican-American subjects. The results of this study showed a positive correlation between BAI and the percentage of body fat estimated by DEXA with r = 0.85, concluding that this indicator estimates adiposity directly.

Yu et al., in 2015 in order to test whether BAI is a better indicator than BMI and WC in Chinese adults, these three indicators were contrasted against DEXA. The age of the sample evaluated was 18 to 65 years old, corresponding to n = 5,726, of which 872 were men and 4,854 women. The results of the correlation between BMI and DEXA were, in men with r = 0.66 and r = 0.77 in women; a correlation between WC and DEXA found r = 0.71 and r = 0.70 in men and women respectively; for BAI r = 0.44 in males and r = 0.64 in females. The authors concluded that the BMI and WC are better indicators of adiposity in Chinese population than the BAI.

| Autohr(s) | Sample | Indicador validado | Results | Observations |
|---|---|---|---|---|
| Sun et al., (2010) | n=31,136 | BMI<br>WC | BMI<br>M<br>(r= 0.92)<br>F (r= 0.95)<br><br>CC<br>M<br>(r= 0.95)<br>F<br>(r= 0.93) | For this review only young adult data were analyzed |
| Bergman Et al., (2011) | n=1,733 | BAI | r = 0.85 | The results are from the sample total. |
| Kim et al (2014) | n=18,198 | BMI<br>WC | BMI<br>M<br>(r= 0.64)<br>F (r= 0.68)<br>CC<br>M<br>(r= 0.67)<br>F<br>(r= 0.63) | For this review only data from young adults was analyzed |
| Yu et al. (2015) | n=5726 adults<br>n=2425 children | BMI<br>WC<br>BAI | BMI<br>M (r=0.66)<br>F (r= 0.77)<br>CC<br>M<br>(r =0.71)<br>F<br>(r = 0.70)<br>BAI<br>M<br>(r = 0.44)<br>F (r= 0.64) | For this review, only data from adults was analyzed |
| BMI=body mass index, WC=Waist Circunference, BAI=body adiposity index, DEXA=dual X-ray absorptiometry, M=Male, F=Female, *r*=Pearson Correlation | | | | |

**Table 1** Articles analyzed in this review

## Discussion

Because the location and body distribution of fat is important because of its contribution to disease development (Vague, 1947, 1957), it has been necessary to explore the validity of other anthropometric indicators used to estimate adiposity, such as WHR, WC and BAI .

The WHR has lost utility because in many individuals the same ratio between the two circumferences is maintained despite the increase in weight. On the other hand, in spite of the different sites of measurement of WHR, this parameter retains high correlation with central obesity.

ISSN:2410-4191

Selecting the best indicator involves taking the results it provides, such as criteria that refer to objectivity, validity and reliability; to the cut-off points established for it; the data for the prediction of risk factors and the result of the interventions applied to a subject (WHO, 1995). The article by John J. Himes in 1995, which was part of a document issued by the Pan American Health Organization, describes as anthropometric indicators for obesity and distribution of body fat to BMI, relative weight, sum of skinfolds, the circumferences of the body, the relationships between them and the prediction equations of total body fat. But at the time of matching these indicators, the result was poor to identify populations with higher adiposity.

According to the above, it is likely that the only anthropometric indicators that comply with these principles are BMI and WC, so in the present review, only those were identified with those criteria.

The BAI recently proposed, its own name and methodology of validity, coincided with the search features proposed here, so it was also taken into account, however it is still necessary to clearly define their respective cutoff points.

One of the advantages offered by DEXA is the determination of total body fat and segmented by anatomical regions, the results are obtained in kilograms (absolute weight) and percentage of fat (%F). The study by Sun et al. Determined that both BMI and WC have validity against DEXA despite differences between the ages, sex and race of the sample studied. The DEXA is not able to distinguish visceral or subcutaneous fat so that in that study did not establish a correlation at this level. In Kim et al., in the Korean population, the total adiposity measured by DEXA was obtained in absolute weight (kg) and %F and segmented in body regions: head, arms, legs and trunk. Both BMI and WC had a good correlation with DEXA and even more in women, but at an older age, this ratio decreased. It should be taken into account that this sample was only in a single population type and ethnic characteristics marked differences in the distribution and accumulation of body fat, even the study did not present the data of abdominal adiposity by DEXA, which is fat which more cardiovascular risk represents.

For its part, the BAI with a high validity against DEXA in Mexican and African American population, makes it specific for this type of population, leaving aside the white race. This latter fact was ratified by Yu et al., when evaluated in Chinese population, finding that it correlates in a lower proportion against DEXA.

Although new studies have validated the BAI and the results indicate that it can be a good indicator, differences are observed in terms of age, gender, in people with some type of aggregate pathology or in sports practices, so their use may be limited.

ISSN:2410-4191

## Conclusion

Although the BMI is not able to distinguish between fat mass and lean mass, and WC is used for the estimation of abdominal adiposity, these two have proven to be the best anthropometric indicators to estimate adiposity due to its high correlation with direct methods like the DEXA. Since the location and body distribution of fat predisposes to the development of chronic non-transmissible diseases of high global prevalence, it is important to identify their distribution, which makes it necessary to explore the validity of other anthropometric indicators that can be used to estimate adiposity.

## References

Bergman, R. N., Stefanovsky, D., Buchanan, T. A., Summer, A. E., Reynolds, J. C., Sebring, N. G., y otros. (2011). A Better Index of Body Adiposity. *Obesity , 19*, 1083-1089.

Demmer, D. L., Beilin, L. J., Hands, B., Burrows, S., Cox, K. L., Pennell, C. E., y otros. (2016). Dual Energy X Ray Absorptiometry Compared with Anthopometry in Relation to Cardio-Metabolic Risk Factors in a young Adults Population: Is the Gold Standard Tarnished? *PLOS ONE, 11* (9), 1-11.

Eknoyan, G. (2008). Adolphe Quetelet (1796-1874) the average man and indices of obesity. *Nephology Dialysis Transplatation* , 47-51.

Garrow, J. S., & Webster, J. (1985). Quetelet's index (W/H2) as a measure of fatness. *International journal of obesity, 9* (2), 147-153.

Hames, K. C., Anthony , S. J., Thornton, J. C., y Goodpaster, B. H. (2014). Body composition analyses by air displacement plethysmography in adults ranging from normal weight to extremely obese. *Obesity , 22* (4), 1078-1084.

Huxley, R., Mendis, S., Zheleznyakov, E., Reddy, S., & Chan, J. (2010). Body mass index, waist circumference and waist; hip ratio as predictors of cardiovascular risk a review of the literature. *European journal of clinical nutrition, 64* (1), 16-22.

Kim, S. G., Ko, K. D., Hwang, I. C., Suh, S. H., Kay, S., Caterson, I., y otros. (2014). Relationship between indices of obesity obtained by anthropometry and dual-energy X ray absorptiometry:The Fourth and Fifth Korea National Health and Nutrition Examination Survey (KNHAVES IV and V, 2008-2011). *Obesity y Research & Clinical Practice, 9*, 478-498.

Lean, M., Han, T., & Morrison, C. (1995). Waist circumference as a measure for indicating need for weight management. *British medical journal, 15* (311), 158-161.

Norton, K., y Olds, T. (1996). *Anthropometrica.* University of New South Wale Press.

Nuttal, F. Q. (2015). Body mass index obesity, BMI and Health: A Critical Review. *Nutrition Today , 50* (3), 117-128.

WHO. (1995). El estado físico: uso e interpretación de la antropometría: informe de un cómite de expertos de la WHO. *Organización Mundial de la Salud* , 5-39.

Organización Panamericana de la Salud. (2000). Indicadores antropométricos de la obesidad: aspectos epidemiologicos y de salud pública para su establecimiento y empleo. En *La obesidad en la pobreza: un nuevo reto para la salud pública.* Washington, EUA: PAHO Scientific Publication 570.

ISSN:2410-4191

Pérez, L. M., Gálvez, J. U., y Miranda Pérez, M. (2009). Validación de índices antropométricos alternativos como marcadores de riesgo cardiovascular. *Endocrinología y nutrición , 56* (9), 439-446.

Pretice, A. M., y Jebb, S. A. (2001). Beyond body mass index. *Obesity reviews , 2*, 141-147.
Rosales, R. Y. (2012). Antropometría en el diagnóstico de pacientes obesos; una revisión. *Nutrición Hospitalaria, 26* (6), 1803-1809.

Sun, Q., Vam Dam, R. M., Spiegelman, D., Heymsfield, S. B., Willett, W. C., y Hu, F. B. (2010). Comparison of Dual-Energy X Ray Absorptiometric and Anthopometric Measures of Adiposity in Relation to Adiposity-Related Biologic Factors. *American journal epidemiology, 172* (12), 1442-1454.

Vague, J. (1957). The degree or masculine differentiation of obesities a factor determining predisposition to diabetes, atherosclerosis gout, and uric calculous disease. *The american journal of clinical nutrition , 4* (1), 20-34.

Vague, J. (1974). Sexual differentiation a factor affecting the forms of obesity. *La presse medicale , 30*, 339-340.

Yu, Y. M., Liu, H., Shanchun, Z. M., Walker, S. O., Bartell, T. M., & Wang, X. M. (2015). Body mass index and waist circumference rather that body adiposity index are better surrogates for body adiposity in a chinese population. *Nutrition in clinical practice , 30* (2), 247-282.

ISSN:2410-4191