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Research Article

Correlation of waist-height index with total fat mass in obese and overweight patients

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Background: Excess total body fat causes low-grade systemic inflammation that precedes cardiometabolic damage. Plycometry is a widely accepted method for measuring total body fat, but not all physicians are trained to do it. The waist-to-height ratio is simpler to assess and has been recognized as a predictor of cardiovascular risk, but not as an indicator of total body fat. This study evaluated whether plycometry can be substituted by this ratio, and thus make an early intervention on systemic inflammation without having to be trained in plycometry.

Methods: Cross-sectional study based on a clinical trial of 40 patients who underwent a 14-week weight loss intervention. As part of the evaluations, weight, height, waist circumference and total body fat were obtained, which are the variables analyzed in this study. Pearson's correlation test was performed in duplicate: before and after the intervention. In all cases a $p<0.05$ was considered significant.

Results: The waist-to-height ratio correlated moderately with total body fat (R=0.7) before the intervention. At the end of the intervention the correlation increased to strong (R=0.8). When stratifying by body mass index grades, a trend of higher correlation was observed in the body mass index group between 25 and 26.9 kg/m^2 (0.7 before and 0.85 after the intervention, respectively).

Conclusions: The waist-to-height ratio is not a substitute for plycometry, but it can be useful in predicting a low-grade systemic inflammatory state, especially in patients with a body mass index under 27 kg/m^2. Further research is needed to assess the cutoff point at which low-grade systemic inflammation begins, so that more accurate information can be provided for intervention based on waist-to-height ratio.

Keywords: *waist-height ratio, total fat mass, BMI, cardiometabolic risk, obesity*

Introduction

Cardiovascular diseases are the leading causes of death in the world (Woodruff et al., 2024). These diseases are preceded by metabolic conditions such as diabetes and fatty liver disease, which arise because of persistent insulin resistance. Insulin resistance responds to a state of low-grade inflammation that is caused by total fat mass (TFM) excess (Koenen, 2021; Al-Chalabi et al., 2024). This means that detection and treatment of TFM excess may prevent the onset of metabolic diseases and thus cardiovascular morbidity and mortality (Mambrino et al., 2023), especially when intervening at a body mass index (BMI) between 25 and 26.9 kg/m^2, since 27 is the overweight degree at which metabolic abnormalities often begin to appear (WHO, 2004). There are two methods for estimating TFM, plycometry and bioimpedance. Plycometry consists of the measurement of strategic fat folds over the body and, using some equations, it is possible to estimate TFM percentage (Marfell-Jones et al., 2006). Bioimpedance measures the amount of water in the body and, by difference, estimates the percentage of TFM (Jossinet, 2005; Ward & Brantlov, 2023). Comparing both, the most accurate is plycometry (Gallardo et al., 2012), and the health professional trained to perform it is nutritionist, however a great number of patients go to the physician and not to the nutritionist for initial health care (SA, 2008). The physician is not trained to perform plycometry but may estimate wais-to-height ratio (WHtR). WHtR is an anthropometric parameter that estimates the ratio of waist circumference to height to define the presence of abdominal obesity (also known as central or truncal obesity), which is established at 0.5 or more, while if it is below than 0.5, abdominal obesity is not considered to be present (Vasquez et al., 2010). Its estimation requires knowledge of the patient's height and waist circumference, measurements that are very easy to obtain by anyone with a stadiometer and a tape measure. WHtR has gained recognition as a good abdominal obesity indicator (Khoury et al., 2013; Alshamiri et al.), but not as TFM predictor. This study aims to answer whether WHtR can be used as a replacement for plycometry to predict cardiometabolic risk in early stages and thus improve the quality of life of the population.

Materials and Methods

Cross-sectional study derived from a clinical trial in which the effect of different types of milk on TFM loss was evaluated during 14 weeks in patients with obesity and overweight in a private nutritional care clinic in the State of Mexico, Mexico in 2021 (Merchant & Guerrero, 2022). As part of the anthropometric measurements in the original study, weight, height, waist circumference, and TFM measured by plycometry were obtained, variables that were used for the analysis of this study (height with waist circumference allows WHtR to be calculated, and with weight allows BMI to be calculated). TFM was measured in percentage and converted to kilograms (kg) according to the following equation:

TFM (kg) = (Total weight x TFM percentage) / 100.

Pearson test was performed to assess the correlation (R) of WHtR with TFM for all patients and stratifying by BMI. This test was performed in duplicate: before and after the intervention. To compare R values by BMI ranges, a two-sample F-test for variances was performed. In all cases a $p<0.05$ was considered as a minimum to consider statistical significance.

Results

Forty patients with an TFM between 23.2 and 56.57 kg before starting the intervention were analyzed, and after the intervention they reached between 21.72 and 50.55 kg (-2.38 kg, $p>0.001$). BMI changed from 31.91 ±4.59 kg/m^2 (minimum: 25.22) to 29.59 ±4.49 kg/m^2 (minimum 23.15). For WHtR the change was -0.04 ($p>0.05$), as it resulted in 0.649 ±0.07 and 0.605 ±0.07 before and after the study (Table 1).

Table 1. Changes in TFM and WHtR before and after 14 months of weight loss intervention

Parameter	Media ± S.D.				p
	Before	min, max	After	min, max	
TFM (kg)	36.94 ±8.31	23.20, 56.57	34.56 ±7.73	21.72, 50.55	<0.001
BMI (kg/m^2)	31.91 ±4.59	22.5, 39.83	29.59 ±4.49	23.15, 38.42	<0.001
WHtR	0.649 ±0.07	0.52, 0.79	0.605 ±0.07	0.48, 0.74	>0.05

TFM: total fat mass, WHtR: waist-height ratio. S.D. standard deviation. P: significance. min: minimum. max: maximum.

An overall correlation of 0.67 ($p<0.001$) was found between WHtR and TFM before the intervention. After the intervention it was 0.82 ($p<0.001$) (figure 1).

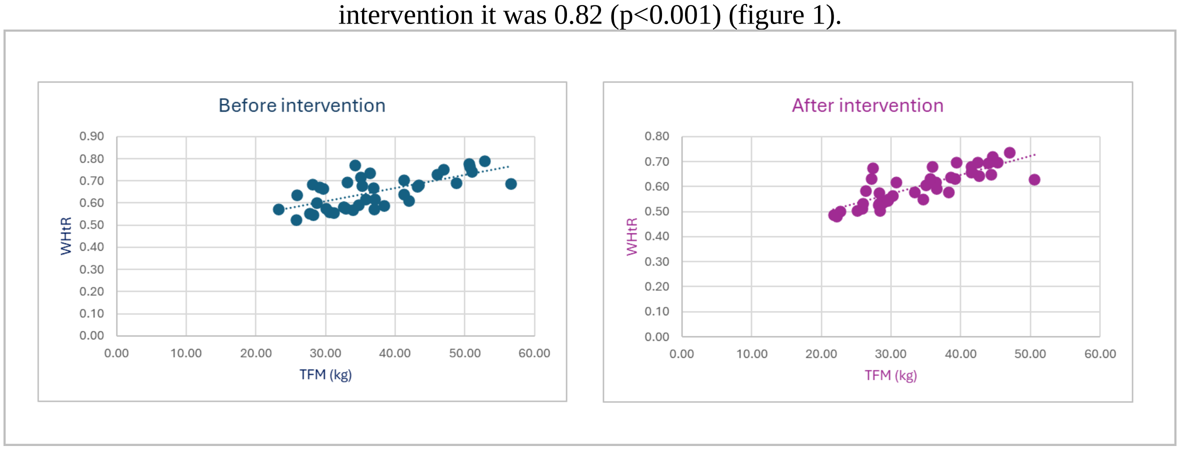

Figure 1. Correlation of WHtR with TFM before and after the intervention

When stratifying by BMI, the correlation was maintained in all strata, being more marked for 25 to 26.9 kg/m^2 group both before and after the intervention (R=0.70 and 0.85, respectively, p<0.001) (table 2). In all cases the correlation was stronger after the intervention.

Table 2. Correlation of WHtR with FMT before and after the intervention according to BMI

BMI (kg/m^2)	Correlation of WHtR with TFM (kg)		p
	Before	After	
Global	0.68	0.81	<0.001
23 - 24.9	NA	0.78	NA
25 - 26.9	0.70	0.85	<0.001
27 - 29.9	0.69	0.83	<0.001
30 - 34.9	0.66	0.81	<0.001
35 - 39.9	0.67	0.81	<0.001

BMI: body mass index. WHtR: waist-height ratio. TFM: total fat mass, P: significance.

No significant difference (p=0.32) was found when analyzing the variance in correlations between BMI strata.

Discussion

WHtR showed a significant correlation with TFM in obese and overweight patients undergoing weight loss treatment. The correlation was higher after patients lost 2.36 kg of TFM, suggesting that after weight loss abdominal mass is reduced in greater proportion than in the rest of the body, which means a great clinical advantage, because abdominal obesity is the type of obesity most associated with cardiovascular diseases (Borlaug & Reddy, 2016). Moreover, a slightly higher correlation was observed when BMI is 25 to 26.9 kg/m^2, which is a great advantage, since a great number of patients start to show metabolic abnormalities at 27 kg/m^2 (Lee & Dixon, 2017). Addressing this factor provides an excellent opportunity to influence timely weight loss treatment prior to cardiometabolic alterations. By reducing TFM the inflammatory state is reduced, insulin resistance is improved, metabolism can be controlled, and cardiovascular damage can be prevented (Zhang et al., 2021). Al incidir en la obesidad temprana se disminuye el estado inflamatorio, se revierte la resistencia a la insulina, se controla el metabolismo y se previene el daño cardiovascular. Plycometry is the most widely accepted method for assessing TFM, but not all physicians are trained to perform it. Although the correlation was not perfect but moderate to high, the findings of this study show that WHtR is useful for predicting TFM excess when plycometry is not available. This means that physicians receiving patients approaching a health professional for the first time may measure WHtR and determine a risk of cardiometabolic damage even before it occurs. However, the correlation was less than 1, meaning that, although statistically significant, clinically WHtR does not replace plycometry in the measurement of TFM, so physicians should be trained on plycometry, or refer the patient to a nutritionist, so that better health care can be provided to the patient according to his or her risk. WHtR measurement is so simple that it can be performed by the patient himself/herself at home, without having to visit a nutritionist or physician, so that an information and awareness campaign for the general population can prevent damage even earlier than a medical consultation.

Conclusion

Although correlation was not perfect in any of cases, WHtR is advantageous for detecting patients at risk of cardiometabolic disease when a more efficient method for TFM assessment is not available. A limitation of this study is that no indicators of systemic inflammation are available to associate WHtR with different inflammation degrees. Further studies are desirable to determine the WHtR cutoff point at which low-grade systemic inflammation begins, so that more accurate information can be provided to the population.

Author contributions

The author designed the protocol, executed the study, analyzed the data and reports the results

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AI usage declaration

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Conflict of interest

The author declares no confilict of interests.

Ethics approval

The original clinical trial was approved by the Ethics Committee of the Universidad Internacional Iberoamericana, recorded in minute No. CR-103 dated March 26, 2021.

Consent to participate

Patients who participated in the original clinical trial signed an informed consent previously approved by the cited Ethics Committee.

Consent to publish

Patients who participated in the original clinical trial signed an informed consent previously approved by the cited Ethics Committee.

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