

# Anthropometric markers in relation to postprandial hyperinsulinemia in middle-aged adults

## Abstract

Our objective was to evaluate the relationship between postprandial hyperinsulinemia with three anthropometric markers of adiposity; body mass index (BMI), waist hip ratio (WHR) and body fat percentage (BFP). We carry out a retrospective observational study reviewed medical records of 752 patients who attended outpatient endocrinology, no previous diagnosis of metabolic disease, but with a family history of metabolic risk in the period 2012 to 2014. We collected demographic, anthropometric measurements (BMI, WHR, and BFP) and postprandial insulin values (quartiles 1, 2, 3 and 4) between 30 to 60 minutes into oral glucose tolerance test. For testing the association between anthropometric measurements and postprandial insulin quartiles, we use a univariate and multivariate multinomial logistic regression model. The measure of association is presented as relative prevalence ratio (PR) with confidence intervals (CI) at 95%.

The mean age was 37.5 years  $\pm$  14.8 and 66% of the participants were women. In the univariate analysis using quartile 1 as references, quartiles 3 and 4 were associated with BMI, WHR and BFP. In multivariate analysis, quartiles 3 and 4 remained associated with markers of adiposity. BMI; PR=1.15, 95% CI (1.10 to 1.22) and PR=1.25, 95% CI (1.19 to 1.32) for quartiles 3 and 4; respectively. WHR; PR=3.25, 95% CI (2.17 to 4.87) and PR=5.85, 95% CI (3.76 to 9.10) for quartiles 3 and 4 respectively. BFP; PR=1.09, 95% CI (1.05 to 1.12) and PR=1.14, 95% CI (1.10 to 1.18) for quartiles 3 and 4; respectively.

In conclusion, the diagnosis of obesity must be carried out using the combination of measures of adiposity in order to evaluate the total fat content and distribution of body fat.

**Keywords:** hyperinsulinism, insulin resistance, body mass index, waist-hip ratio, body fat distribution, obesity

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**Abbreviations:** BFP, body fat percentage; BMI, body mass index; CI, confidence intervals; IR, insulin resistance; IQR, interquartile range; OGTT, oral glucose tolerance test; PR, prevalence ratios; Ref, reference; SD, standard deviation; DM2, type 2 diabetes mellitus; WHR, waist-hip ratio

## Introduction

Insulin is an anabolic hormone par excellence, have an important role in regulating glucose metabolism, stimulates lipogenesis, diminishes lipolysis, and increases amino acid transport at the cellular level. Hyperinsulinemia or insulin resistance (IR) engages the vascular and metabolic pathophysiology, triggering a series of mechanisms including inflammation, endothelial dysfunction and vasoconstriction, which predisposes insulin resistant individuals to accelerated atherosclerosis and thrombosis.<sup>1,2</sup> Therefore, the current IR is recognized as a risk factor for developing type 2 diabetes mellitus (DM2), atherosclerosis, cardiovascular events, cerebrovascular disease, hypertension, non-alcoholic fatty liver, polycystic ovarian syndrome and certain forms of cancer.<sup>3</sup>

The central or abdominal obesity is more strongly linked to IR and cardiovascular disease than peripheral fat deposits.<sup>4-6</sup> It has been found that subjects with fat distribution predominantly in the upper body are insulin resistant compared to subjects with fat predominance of lower body. Similarly, it has been demonstrated in women with predominantly higher obesity, hyperinsulinemia increased in fasting and oral glucose tolerance test.<sup>7-10</sup>

The anthropometric measures such as body mass index (BMI) can define whether a person is underweight, overweight or obese. Other anthropometric measurements such as waist-hip ratio (WHR) try to reflect the distribution of central fat. However, these measures have limitations, since it does not determine the composition and distribution of muscle mass and fat mass. Currently, the bioimpedance method has become increasingly used in clinical practice, being the most appropriate tool for measuring body fat percentage (BFP) and muscle mass.<sup>11,12</sup>

Because insulin resistance is a key element in the genesis of metabolic diseases and their recognition for test glucose tolerance is not economically accessible to the whole population, the objective of this study was to evaluate the relationship of postprandial hyperinsulinemia with three markers anthropometric adiposity in middle-aged adults with no history of diabetes mellitus or other endocrine disorder.

## Materials and methods

We conducted a retrospective observational study reviewed medical records of 752 patients who attended outpatient endocrinology at our institution during the years 2012 to 2014. None of the patients had previous medical history of metabolic disease, but had a family history of risk metabolic (hypertension, DM2, cardiovascular disease, stroke and cancer). Patients attended consulted for recurrent chronic nonspecific symptoms (weight gain, fatigue, migraine, constipation, hair loss, acne, constipation).

Our inclusion criteria were participants over 18 years of age, of both sexes, without prior history of metabolic, endocrine diseases or immunosuppression. We excluded pregnant women and if participants have fasting glucose values above 126 mg /dL. All participants must be tested for oral glucose tolerance test (OGTT) and electrical bioimpedance.

We collected from medical records demographic variables and anthropometric measures such as BMI, WHR and BFP. An endocrinologist conducted anthropometric measurements during outpatient care. We use the weight and height to calculate BMI and WHR was obtained by measuring with a tape the waist circumference up to the last floating rib and hip circumference at the level of buttocks. The BFP was obtained by electrical bioimpedance. We collected insulin values between 30 and 60 minutes into the OGTT and insulin postprandial values were categorized into quartiles: quartile 1, quartile 2, quartile 3 and quartile 4, respectively. We also collected the values of thyroid hormones. The separation between anthropometric measurements and laboratory values should not exceed thirty days.

Continuous variables were represented as means with standard deviation (SD) or as medians with interquartile range (IQR) if the distribution was skewed. Categorical variables are presented as frequencies and percentages. To compare continuous variables between quartiles of postprandial insulin used analysis of variance while for variables with skewed distribution we used the Kruskal-Wallis test. Chi square test was used to compare categorical variables between quartiles of postprandial insulin. The correlation between

anthropometric measures and postprandial insulin was assessed with Pearson test ( $r$ ) and scatter plots. The association between anthropometric measurements and postprandial insulin quartiles was assessed with univariate and multivariate multinomial logistic regression. The variables used to adjust the multivariate model were age, sex, thyroid hormones. Quartile 1 was used as the reference category in all multinomial regression models. The measure of association is presented as relative prevalence ratios (PR) with their respective confidence intervals (CI) at 95%. Analyses were performed using the statistical package STATA version 12.1 (Statacorp, TX, USA).

## Results

The mean age was 37.5 years  $\pm$  14.8 and 66% of the participants were women. The mean BMI, WHR and BFP was 27.9 kg / m<sup>2</sup>  $\pm$  5.5; 0.94 cm.  $\pm$  0.06; and 36.9 %  $\pm$  7.9, respectively. Similarly, the median fasting insulin was 12.5  $\mu$ IU / mL (IQR 7.7 to 18.5) and median postprandial insulin was 88.2  $\mu$ IU/mL (IQR 54.2 to 143.6). The range of values of postprandial insulin was quartile 1: 4.9 to 54.1  $\mu$ IU/mL; quartile 2: 54.2 to 88  $\mu$ IU/mL, quartile 3: 88.4 to 143.6  $\mu$ IU/mL and quartile 4: 143.7 to 586  $\mu$ IU/mL. Table 1 shows the clinical characteristics of the participants across quartiles.

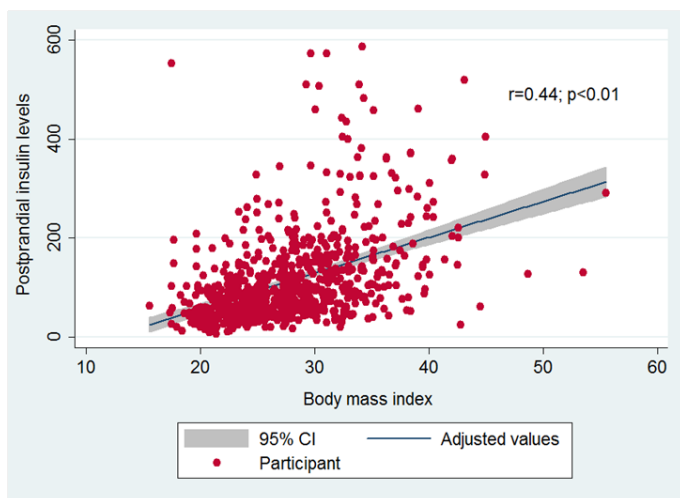
The correlation between postprandial insulin and BMI, WHR and BFP was  $r = 0.44$ ,  $p < 0.01$ ;  $r = 0.35$ ,  $p < 0.01$ ;  $r = 0.20$ ,  $p < 0.01$ ; respectively. The correlation between anthropometric measures and postprandial insulin are presented in Figures 1–3.

**Table 1** Characteristics of participants across postprandial insulin quartiles

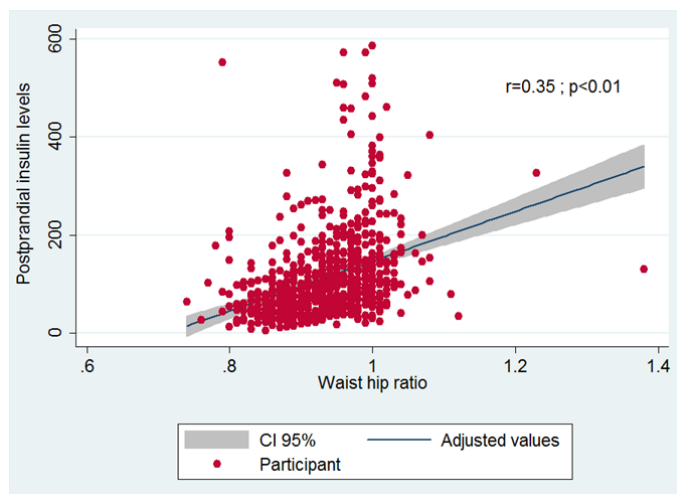
Characteristics	Quartile 1	Quartile 2	Quartile 3	Quartile 4	p Value
	N=188	N=188	N=188	N=188	
Age (years)	34.3 $\pm$ 14.2	37.6 $\pm$ 15.9	38.3 $\pm$ 14.4	39.7 $\pm$ 14.5	<0.01
Male	44 (17.5)	51 (20.2)	64 (25.4)	93 (36.9)	<0.01
Fasting Insulin	7.2 ( 5.4 a 10)	9,9 (7.2 a 13)	14 (10 a 20)	23 (16 a 34)	<0.01
Postprandial Insulin	39 (31 a 47)	69 (62 a 78)	106 (97 a 124)	198 (163 a 271)	<0.01
Fasting Glucose	89.2 $\pm$ 26.8	90.3 $\pm$ 11.1	92.1 $\pm$ 13.5	96.2 $\pm$ 11.3	<0.01
Postprandial Glucose	105 $\pm$ 49.8	123 $\pm$ 39.4	142 $\pm$ 41.8	164 $\pm$ 43.8	<0.01
BMI	25.3 $\pm$ 4.3	26.4 $\pm$ 4.6	28.6 $\pm$ 5.1	31.5 $\pm$ 5.7	<0.01
WHR	0.91 $\pm$ 0.05	0.92 $\pm$ 0.06	0.95 $\pm$ 0.06	0.97 $\pm$ 0.06	<0.01
BFP	34.6 $\pm$ 8.1	36.1 $\pm$ 8.4	37.9 $\pm$ 7.3	39.0 $\pm$ 7.1	<0.01
Free Triiodothyronine (ng/dL)	3.2 $\pm$ 0.5	3.2 $\pm$ 0.6	3.3 $\pm$ 1.4	3.3 $\pm$ 0.5	0.22
Free Thyroxine (ng/dL)	1.2 $\pm$ 0.2	1.2 $\pm$ 0.2	1.2 $\pm$ 0.3	1.1 $\pm$ 0.2	0.03
Log Thyroid-Stimulating Hormone (mIU/L)	2,5 (1,6 a 3,7)	2,6 (1,7 a 3,7)	2,6 (1,7 a 3,4)	2,6 (1,9 a 3,7)	0.72

**Abbreviations:** BFP, body fat percentage; BMI, body mass index; WHR, waist hip ratio

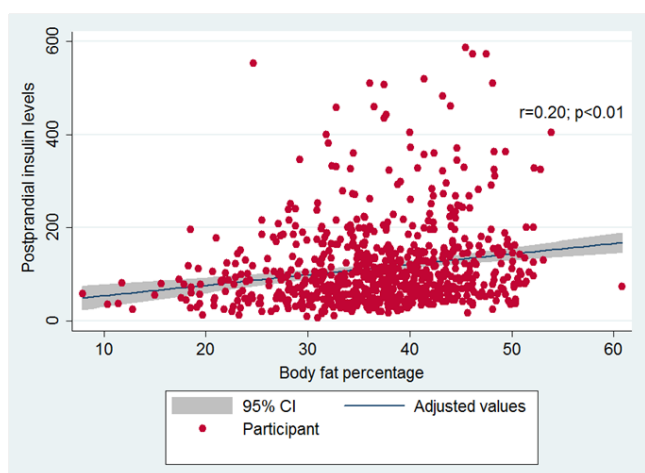
Mean  $\pm$  standard deviation; number (percentage): Median (interquartile range).



**Figure 1** Scatter plot between body mass index of and postprandial insulin.



**Figure 2** Scatter plot between waist-hip ratio and postprandial insulin.



**Figure 3** Scatter plot between body fat percentage and postprandial insulin.

Univariate logistic regression model multinomial of BMI and postprandial insulin quartiles using quartile 1 as references, shows that for each 1 unit increase in BMI, the risk of being in quartile 2 of postprandial insulin is PR=1.06, 95% CI (1.01 to 1.12) and this difference was statistically significant ( $p = 0.01$ ). Also, for each 1 unit increase in BMI, the risk of being in the postprandial insulin quartile 3 is PR=1.17, (CI 95% (1.12 to 1.23) and this difference was statistically significant ( $p < 0.01$ ). Similarly, for each 1 unit increase BMI, the risk of being in the quartile 4 of postprandial insulin is PR=1.29, CI 95% (1.23 to 1.36) to be in quartile 1 of postprandial insulin and this difference was statistically significant ( $p < 0.01$ ). In multivariate analysis the differences remained statistically significant for comparisons between quartile 1 with quartiles 3 and 4. Thus, for each 1 unit increase of BMI, the risk of being in the quartile 3 of postprandial insulin is PR=1.15, 95% CI (1.10 to 1.22), and the risk of being in the quartile 4 of postprandial insulin is PR=1.25, 95% CI (1.19 to 1.32). Table 2 shows the crude and adjusted multinomial logistic regression model between BMI and postprandial insulin quartiles.

Univariate multinomial logistic regression between WHR and postprandial insulin quartiles using quartile 1 as references, shows that for each 0.1 unit increase of WHR, the risk of being in quartile 2 of postprandial insulin is PR = 1.60; 95% CI (1.13 to 2.30) and this difference was statistically significant ( $p = 0.01$ ). Similarly, for every 0.1 unit increase in WHR, the risk of being in quartile 3 of postprandial insulin is PR=3.61, 95% CI (2.47 to 5.29) and this difference was statistically significant ( $p < 0.01$ ). Also, for every 0.1 units increased in WHR, the risk of being in the quartile 4 of postprandial insulin is PR=7.30, 95% CI (4.82 to 11.09) and this difference was statistically significant ( $p < 0.01$ ). In multivariate analysis the differences remained statistically significant for comparisons quartile 1 with quartiles 3 and 4. Thus, for every 0.1 units increased in WHR, the risk of being in quartile 3 of postprandial insulin is PR=3.25, 95% CI (2.17 to 4.87), and the risk of being in the quartile 4 of postprandial insulin is PR=5.85, 95% CI (3.76 to 9.10). Table 3 shows the crude and adjusted multinomial logistic regression model between WHR and postprandial insulin quartiles.

Univariate multinomial logistic regression model of BFP and postprandial insulin quartiles using quartile 1 as references, displays that for each 1 unit increase in the BFP, the risk of being in quartile 3 of postprandial insulin is PR=1.06, 95 % CI (1.03 to 1.08) and this difference was statistically significant ( $p < 0.01$ ). Also, for each 1 unit increase in the BFP, the risk of being in quartile 4 of postprandial insulin is PR=1.08, CI 95% (1.05 to 1.11) and this difference was statistically significant ( $p < 0.01$ ). There was no difference between quartile 2 and quartile 1. In multivariate analysis the differences remained statistically significant for comparisons between quartile 1 and the other quartiles. Thus, for each 1 unit increase in the BFP, the risk of being in quartile 2 of postprandial insulin is PR=1.03, CI 95% (1.00 to 1.06), the risk of being in quartile 3 postprandial insulin is PR=1.09, 95% CI (1.05 to 1.12), and the risk of being in the quartile 4 of postprandial insulin is PR=1.14, 95% CI (1.10 to 1.18) than being in quartile 1 of postprandial insulin respectively. Table 4 shows the crude and adjusted multinomial logistic regression model between BFP and postprandial insulin quartiles.

**Table 2** Multinomial logistic regression model between body mass index and postprandial insulin quartiles

Variable	Crude PR (IC 95%)	P value	Adjusted PR (IC 95%)	P value
Quartile 1	Ref	--	Ref	--
Quartile 2				
BMI	1.06 (1.01 a 1.12)	0.01	1.05 (0.99 a 1.10)	0.07
Age (years)	1.02 (1.00 a 1.05)	0.03	1.01 (0.99 a 1.03)	0.19
Male	1.23 (0.77 a 1.96)	0.39	1.16 (0.70 a 1.95)	0.56
Free triiodothyronine (ng/dL)	0.84 (0.57 a 1.25)	0.40	0.97 (0.62 a 1.53)	0.90
nFree thyroxine (ng/dL)	0.57 (0.20 a 1.61)	0.29	0.61 (0.16 a 2.39)	0.48
Log thyroid-stimulating hormone (mIU/L)	1.06 (0.82 a 1.38)	0.66	0.98 (0.73 a 1.31)	0.89
Quartile 3				
BMI	1.17 (1.12 a 1.23)	<0.01	1.15 (1.10 a 1.22)	<0.01
Age (years)	1.02 (1.01 a 1.04)	0.01	1.01 (0.99 a 1.03)	0.19
Male	1.69 (1.74 a 2.66)	0.02	1.11 (0.66 a 1.84)	0.70
Free triiodothyronine (ng/dL)	1.24 (0.88 a 1.75)	0.21	1.07 (0.71 a 1.62)	0.75
Free thyroxine (ng/dL)	1.29 (0.58 a 2.88)	0.53	1.35 (0.34 a 5.31)	0.67
Log thyroid-stimulating hormone (mIU/L)	0.98 (0.76 a 1.27)	0.90	0.99 (0.74 a 1.34)	0.97
Quartile 4				
BMI	1.29 (1.23 a 1.36)	<0.01	1.25 (1.19 a 1.32)	<0.01
Age (years)	1.03 (1.01 a 1.04)	<0.01	1.01 (0.99 a 1.03)	0.25
Male	3.20 (2.06 a 4.99)	<0.01	2.08 (1.23 a 3.53)	<0.01
Free triiodothyronine (ng/dL)	1.22 (0.87 a 1.72)	0.25	1.49 (0.93 a 2.38)	0.09
Free thyroxine (ng/dL)	0.25 (0.08 a 2.30)	0.01	0.13 (0.03 a 0.56)	<0.01
Log thyroid-stimulating hormone (mIU/L)	1.16 (0.88 a 1.52)	0.29	0.98 (0.71 a 1.36)	0.93

**Abbreviations:** BMI, body mass index; CI, confidence interval; PR, prevalence ratio; Ref, reference.

**Table 3** Multinomial logistic regression model between waist-hip ratio and postprandial insulin quartiles

Variable	Crude PR (IC 95%)	P Value	Adjusted PR (IC 95%)	P Value
Quartile 1	Ref	--	Ref	--
Quartile 2				
WHR*	1.60 (1.13 a 2.30)	0.01	1.45 (0.99 a 2.13)	0.06
Age (years)	1.02 (1.00 a 1.05)	0.03	1.00 (0.99 a 1.03)	0.25
Male	1.23 (0.77 a 1.96)	0.39	1.18 (0.71 a 1.96)	0.53
Free triiodothyronine (ng/dL)	0.84 (0.57 a 1.25)	0.40	0.97 (0.62 a 1.51)	0.90
nFree thyroxine (ng/dL)	0.57 (0.20 a 1.61)	0.29	0.57 (0.15 a 2.22)	0.42
Log thyroid-stimulating hormone (mIU/L)	1.06 (0.82 a 1.38)	0.66	0.97 (0.73 a 1.31)	0.86
Quartile 3				
WHR*	3.61 (2.47 a 5.29)	<0.01	3.25 (2.17 a 4.87)	<0.01
Age (years)	1.02 (1.01 a 1.04)	0.01	1.00 (0.99 a 1.02)	0.42
Male	1.69 (1.74 a 2.66)	0.02	1.21 (0.74 a 1.99)	0.45
Free triiodothyronine (ng/dL)	1.24 (0.88 a 1.75)	0.21	1.09 (0.74 a 1.62)	0.67
Free thyroxine (ng/dL)	1.29 (0.58 a 2.88)	0.53	1.09 (0.28 a 4.24)	0.90
Log thyroid-stimulating hormone (mIU/L)	0.98 (0.76 a 1.27)	0.90	0.99 (0.74 a 1.34)	0.96
Quartile 4				
WHR*	7.30 (4.82 a 11.09)	<0.01	5.85 (3.76 a 9.10)	<0.01
Age (years)	1.03 (1.01 a 1.04)	<0.01	1.00 (0.99 a 1.02)	0.61
Male	3.20 (2.06 a 4.99)	<0.01	2.67 (1.60 a 4.45)	<0.01
Free triiodothyronine (ng/dL)	1.22 (0.87 a 1.72)	0.25	1.60 (1.01 a 2.51)	0.04
Free thyroxine (ng/dL)	0.25 (0.08 a 2.30)	0.01	0.08 (0.02 a 0.36)	<0.01
Log thyroid-stimulating hormone (mIU/L)	1.16 (0.88 a 1.52)	0.29	0.99 (0.72 a 1.37)	0.97

**Abbreviations:** CI, confidence interval; PR, prevalence ratio; Ref, reference; WHR, waist hip ratio

\*transformed WHR/0.1

**Table 4** Multinomial logistic regression model between body fat percentage and postprandial insulin quartiles

Variable	Crude PR (IC 95%)	P Value	Adjusted PR (IC 95%)	P Value
Quartile 1	Ref	--	Ref	--
Quartile 2				
BFP	1.02 (0.99 a 1.04)	0.07	1.03 (1.00 a 1.06)	0.04
Age (years)	1.02 (1.00 a 1.05)	0.03	1.01 (0.99 a 1.03)	0.19
Male	1.23 (0.77 a 1.96)	0.39	1.71 (0.97 a 3.03)	0.06
Free triiodothyronine (ng/dL)	0.84 (0.57 a 1.25)	0.40	0.95 (0.60 a 1.50)	0.83
Free thyroxine (ng/dL)	0.57 (0.20 a 1.61)	0.29	0.56 (0.14 a 2.16)	0.40
Log thyroid-stimulating hormone (mIU/L)	1.06 (0.82 a 1.38)	0.66	0.95 (0.71 a 1.28)	0.76
Quartile 3				
BFP	1.06 (1.03 a 1.08)	<0.01	1.09 (1.05 a 1.12)	<0.01
Age (years)	1.02 (1.01 a 1.04)	0.01	1.01 (0.99 a 1.03)	0.14
Male	1.69 (1.74 a 2.66)	0.02	3.13 (1.79 a 5.51)	<0.01
Free triiodothyronine (ng/dL)	1.24 (0.88 a 1.75)	0.21	1.09 (0.73 a 1.64)	0.68
Free thyroxine (ng/dL)	1.29 (0.58 a 2.88)	0.53	0.89 (0.23 a 3.43)	0.87
Log thyroid-stimulating hormone (mIU/L)	0.98 (0.76 a 1.27)	0.90	0.93 (0.69 a 1.25)	0.62
Quartile 4				
BFP	1.08 (1.05 a 1.11)	<0.01	1.14 (1.10 a 1.18)	<0.01
Age (years)	1.03 (1.01 a 1.04)	<0.01	1.01 (0.99 a 1.03)	0.14
Male	3.20 (2.06 a 4.99)	<0.01	10.4 (5.75 a 8.81)	<0.01
Free triiodothyronine (ng/dL)	1.22 (0.87 a 1.72)	0.25	1.57 (0.99 a 2.48)	0.06
Free thyroxine (ng/dL)	0.25 (0.08 a 2.30)	0.01	0.06 (0.01 a 0.26)	<0.01
Log thyroid-stimulating hormone (mIU/L)	1.16 (0.88 a 1.52)	0.29	0.88 (0.64 a 1.21)	0.44

**Abbreviations:** BFP, body fat percentage; CI, confidence interval; PR, prevalence ratio; Ref, reference.

## Discussion

The main finding of our study was the presence of association between the three indicators of adiposity; body mass index, waist-hip ratio and body fat percentage; with the upper quartiles of postprandial insulin in a large population of undiagnosed diabetes mellitus and other metabolic disorders. This finding strengthens the importance of measurements of adiposity in future prevention of type 2 diabetes mellitus during clinical practice.

Obesity is a modifiable risk factor on which we can intervene, mainly in populations at risk for cardiometabolic diseases. The distribution of body fat is associated with cardiovascular events by its close relationship with the pathophysiology of IR. Although, the

use of BMI is widespread to measure overweight and obesity, the BMI might underestimate the prevalence of both conditions, due to excess body fat despite having a normal BMI. Thus, normal weight based on BMI <25 kg/m<sup>2</sup> may be at risk of metabolic syndrome, cardiometabolic alterations and even higher mortality if they have a high BFP. A study has shown that men with normal weight in the highest tertile of BFP (> 23% body fat) were 4 times more likely to have metabolic syndrome and had a higher prevalence of DM2, hypertension, dyslipidemia and disease cardiovascular compared with men in the lowest tertile. Normal-weight women in the highest tertile of BFP (> 33% body fat) were 7 times more likely to have metabolic syndrome. Although more studies are needed to confirm these results, it is clear that individuals with normal weight based on BMI may need

a more detailed classification to better define their cardiometabolic risk associated with adiposity. Given the possibility of sub-diagnose patients with excess body fat by BMI; the combination of other anthropometric measures (BFP or WHR) in conjunction with the assessment of cardiometabolic risk factors is desirable in routine medical practice.<sup>13,14</sup>

In our results we show that quartile 4, and then quartile 3 of postprandial insulin are those with strongest association with adiposity obtained with any of the three anthropometric measures. Those participants that BMI was associated with quartile 3 had an average post prandial BMI of 28.6 kg/m<sup>2</sup>, which is considered as overweight, while those in quartile 4 had an average BMI 31.5 kg/m<sup>2</sup>, value considered obese. However, there is a definition of obesity based on the values of BFP > 25% for men and > 35% for women.<sup>15</sup> We postulate according to the revision made, BMI underestimates adiposity because some people could be obese based on their BFP. Obesity “hidden” in this group of patients would be characterized by being normal-weight or overweight as BMI, an average 0.92 waist hip ratio and a higher BFP to 25% in males and 33% females.<sup>16,17</sup> It will require an extension of our study to prove that patients with normal BMI may have a hidden postprandial hyperinsulinemia, which may have an association with the BFP coupled with WHR.

Observing our results also appreciate the value of fasting insulin amount does not differ much between quartile 3 and quartile 4, however when the postprandial insulin is measured, the value between quartile 3 and quartile 4 doubles. Therefore, we emphasize the importance of measuring postprandial insulin in those participants with risk factors and suspicion of the presence of hyperinsulinemia by BMI, WHR or BFP altered, as would greater contribution to the diagnosis of hyperinsulinemia in this population apparently healthy.

Our study has limitations, including the use of information from medical records; however strict quality control of the data was carried in order to avoid measurement bias. Another limitation is that our study was conducted in one medical center, thus the results are not entirely extrapolated to the general population, however, has been conducted in a large number of participants with which it ensures adequate statistical power to test our hypothesis study.

## Conclusion

In conclusion, we found association between measures of adiposity and upper quartiles of postprandial insulin apparently healthy population. Since BMI cannot differentiate between muscle and fat, there would be individuals with moderate overweight or obese preserved more muscle mass and lean subjects with lack of muscle mass and increased body fat; whereupon they may be at high risk of cardiovascular disease and DM2. It is for this reason that we recommend in routine clinical practice the complementary use of other measures of adiposity to additional BMI such as WHR and BFP.

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None.

## Conflicts of interest

The author declares there is no conflict of interest.

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