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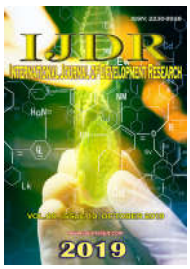

RESEARCH ARTICLE OPEN ACCESS

NUTRITIONAL STATUS, INSULIN RESISTANCE AND CYTOKINE BIOMARKERS: PRINCIPAL COMPONENT ANALYSIS APPROACH

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ABSTRACT

The study explored the clustering of risk factors and associations between nutritional status, biochemical parameters, insulin resistance, and cytokine biomarkers in rural and industrial workers. A cross-sectional study with 71 individuals, 41 women and 30 men. The following variables were used: gender, age, body mass index, waist circumference, total cholesterol, HDL-c, LDL-c, triglycerides, fasting glycemia, visceral fat area, fat percentage, TyG, Visceral Adiposity Index (VAI), Lipid Accumulation Product (LAP), cytokines (IL-6, IL-1β, IL-8, TNF-α, and IL-10). An exploratory factorial analysis and ANOVA were performed. Five factors explained the variation of the data. Factor 1 was related to overweight, obesity and visceral fat; factor 2 with insulin resistance, factor 3 with cytokines and fasting glycemia, factor 4 with lipid profile and factor 5 with TNF-α and IL-10. Differences were found in gender ($p = 0.023$), BMI ($p \leq 0.001$) and work sector ($p = 0.038$). The study identified risk factors for cardiovascular and metabolic diseases in the factors, with differences in sex, BMI and the work sector.

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INTRODUCTION

The high prevalence of overweight and obesity is a growing public health problem worldwide and is linked to more deaths than underweight. In 2016, more than 1.9 billion adults were overweight, about 39% of adults were overweight and 13% were obese (WHO, 2018). In Brazil, according to the Survey Surveillance of Risk Factors and Protection for Chronic Diseases by telephone survey (Vigitel), conducted in 26 state capitals and the Federal District, the frequency of overweight was 52.3%, being higher in men (60.4%) than women (45.9%) and the frequency of obese adults was 17.0%, being higher in men (18.0%) than women (16,2%) (BRASIL, 2017). Anthropometric measurements and indices have been used to define overweight and obesity based on fat distribution including body mass index (BMI), waist circumference (WC), waist-hip ratio and waist-height ratio among others. Increasing BMI is a major risk factor for noncommunicable diseases and is also a leading cause of cardio metabolic death in Brazil (OTTO *et al.,* 2016).

Other anthropometric measurements such as WC and waist / hip ratio (WHR) are significantly associated with metabolic syndrome, the development of insulin resistance, dyslipidemia, increased blood pressure, diabetes, and stroke (JUNGAND CHOI, 2014; BADARUDDOZA *et al.,* 2015). In addition to these routine anthropometric measures, new adiposity and insulin resistance indices have been proposed in the last decade and are being tested in different populations and pathologies. These include VAI (Visceral Adiposity Index), TyG (the product of the serum triglyceride concentration and fasting glycemia) and LAP (Lipid Accumulation Product), which are considered as easy tools to clearly mirror adipose tissue dysfunction as effective markers, because they are effective markers of early identification of insulin resistant individuals and the associated cardiometabolic risk (DU *et al.,* 2014; MIRMIRAN *et al.,* 2014; AMATO AND GIORDANO, 2014). Increased adipose tissue promotes unregulated production or secretion of bioactive substances (including chemokines, cytokines, and hormones), which trigger chronic

low-grade inflammation. This adipocyte dysfunction results in increased secretion of proinflammatory cytokines, such as interleukin 6 (IL-6), interleukin 1β (IL-1β), interleuna 8 (IL-8), tumor necrosis factor (TNF-α).), due to hypertrophied adipocytes of subcutaneous adipose tissue and visceral adipose, being increased in overweight and obese individuals, while secretion of anti-inflammatory adipokines (interleukin IL-10, omentin and adiponectin) seems to be suppressed (AROOR *et al.,* 2013 ; SCHMIDT *et al.,* 2015). Circulating levels of inflammatory markers are elevated in obese individual and correlated with BMI, total body fat and abdominal fat and also with VAI index. This inflammatory condition has been referred to as metabolic inflammation (SUGANAMI *et al.,* 2012; BRINKLEY *et al.,* 2012; AMATO *et al.,* 2014). Anthropometric and physiological risk factors are correlated with each other and are equally responsible for the risk of metabolic and cardiovascular complications. In recent years, Principal Component Factor Analysis (AFCP) has been used to identify the clustering of risk factors for metabolic syndrome and cardiovascular disease. It is a multivariate exploratory approach used to identify common variation among the analyzed variables, aiming to extract independent factors among the interrelated ones, reducing the dataset dimensionality and detecting the main source of inherent variation among the investigated variables (BADARUDDOZA *et al.,* 2015; PANAZZOLO *et al.,* 2012). Given the above, the objective of this study was to explore the clustering of risk factors and associations between nutritional status, biochemical parameters, insulin resistance and cytokine biomarkers in rural and industrial workers.

MATERIALS AND METHODS

Study population: This is across-sectional study, whose inclusion criteria were individuals over the age of 18, being industrial workers and rural / agribusiness workers, who previously participated in the projects "New Approaches in Biodynamics for Diagnosing and Prevention of Obesity and Co morbidity in Workers" and the "Screening of Overweight-Related Risk Factors in Agro-Industry Workers Using New Health Information and Analytical Technologies"at the University of Santa Cruz do Sul. Individuals using hypoglycemic, hypocholesterolemic oranti-inflammatory medicine were excluded from the sample. The collections were performed at the Physical Activity Laboratory (LAFISA) of the University of Santa Cruz do Sul (UNISC), in the city of Santa Cruz do Sul. The study sample consisted of 71 individuals, 41 females (22 from agriculture and 19 from industry) and 30 males (22 from agriculture and 8 from industry).

Instruments and procedures: Demographic data (age, gender) were obtained through a standardized questionnaire. In the anthropometric assessment weight and height were measured using the anthropometric scale (Welmy SA, Santa Barbara do Oeste, Brazil), on a scale of 0.1 kg for weight and for the height, a 2-meter anthropometer, divided into centimeters, subdivided into millimeters. The subjects were barefoot, wearing light clothes, positioned in the center of the equipment, in an upright posture, with both feet together, and upper limbs relaxed along the body, BMI (kg / m²) was calculated by weight (in kilograms) divided by height squared (in meters). The waist circumference was measured with the individual standing on both feet and with the upper limbs relaxed along the body, using a flexible metric measuring tape with the subject in a standing position and observing the Heyward (2013) criteria, measured at the midpoint between the lower and upper costal edges, of the iliac crests in a perpendicular plane. Visceral fat area (VFA) and body fat percentage (% G) were estimated by electrical bioimpedance using the octopolar multi-frequency analyzer (In-Body 720; Biospace, Seoul, South Korea). The evaluations followed the protocol indicated by the manufacturer. The subjects' blood collection was performed by venipuncture at the Exercise Biochemistry Laboratory of the University of Santa Cruz do Sul after twelve hours of fasting. We collected 10 mL of blood in the brachial vein by a trained professional. Serum lipids total cholesterol (TC), HDL-cholesterol (HDL-c), LDL-cholesterol (LDL-c), triglycerides (TG) as well as fasting blood glucose (GLI) were evaluated by serum samples (EDTA /Fluoride), respectively, in the Miura 200 automated equipment (ISE, Rome, Italy) using commercial kits from Kovalent (Kovalent do Brazil).

Cytokine levels (IL-6, IL-1β, IL-8, TNF-α, and IL-10) were measured in serum samples using the Human Cytokine Magnetic 10 plex Custom Kit (Invitrogen Life Technologies, USA) and System MAGPIX® (Luminex, USA) according to the manufacturer's instructions. The VAI, LAP and TyG index were calculated using the following formulas: VAI: Men: [WC / 39.68 + (1.88 x BMI)] × (TG / 1.03) × (1.31 / HDL); Women: [WC / 36.58 + (1.89 × BMI)] × (TG / 0.81) × (1.52 / HDL), where TG and HDL levels are expressed in mmol / L (AMATO *et al.,* 2010). Regarding the LAP: Men: [WC (cm) - 65] × [TG (mmol / L)]; Women: [CC (cm) - 58] × [TG (mmol / L)] (KAHN, 2005). While the TyG index was calculated as the Ln [fasting triglycerides (mg / dl) x fasting glucose (mg / dl) / 2], being Ln (natural logarithm) (SIMENTAL-MENDIA *et al.,* 2008; GUERRERO-ROMERO *et al.,* 2010). Statistical analyzes were performed using the Statistical Package for Social Sciences (SPSS) software version 23.0 for Windows (IBM, Armonk, NY, USA). Normality was tested using the Shapiro-Wilk test. Data were submitted to descriptive statistics, with values presented as mean + standard deviation. Student's t-test for independent samples was used to compare groups for variables with normal distribution, and for variables with non-normal distribution, the Mann-Whitney test was used.

The principal component factor analysis methodology was applied. The Kaiser-Mayer-Olkin (KMO) method was estimated, and Bartlett's sphericity test was applied to measure the quality of correlations between variables, where $p < 0.05$ indicates the appropriateness of principal component analysis on chosen variables. The number of components was maintained based on factors identified with eigenvalues 1 or more, and Varimax rotation performed to obtain a set of independent and better interpretable components. The first major component or factor 1 is a linear combination of the individual variables that are associated with the maximum variance in the data among all possible linear combinations, while the following factors explain the maximum amount of variance not explained by the preceding one. The factors were interpreted based on the loads that relate the variables to the components. With loads greater than 0.4 being used to identify the variables that make up a component, as shown in Badaruddoza, Kumar and Kaur (2015). Since the main components are derived variables, each individual included in the study has a score (scores) related to each factor. Then, each subject was grouped, based on these scores, by gender, BMI

classes (i.e. appropriate weight if BMI <24.9 kg / m², overweight if BMI> 25 and <29.9 kg / m² and obese if BMI> 30 kg / m²) and the work sector. Differences between these groups were tested by 3-way analysis of variance (ANOVA), where p values <0.05 were considered statistically significant. The ANOVA assumptions were analyzed and validated. This study was approved by the Research Ethics Committee (CEP) of the University of Santa Cruz do Sul / UNISC, under protocol number: 1.432.389. Participants were included by adherence after signing the Informed Consent Form.

RESULTS

Seventy-one individuals participated in the study, 30 (42.3%) males, with a mean age of 47 ± 11 years and 41 (57.7%) females with a mean age of 42 ± 11 years. Regarding the economic sector to which they were allocated, 22 (73.3%) men worked in agriculture/ agroindustry and 8 (26.7%) in industry; and 22 (53.7%) women in agriculture / agroindustry and 19 (46.3%) in industry. Regarding BMI, among males, 18 (60%) individuals were overweight and 3 (10%) were obese and among females 11 (26.8%) individuals were overweight and 13 (31.7%) were obese. Table 1 shows the anthropometric characteristics, fasting lipid profile and blood glucose, insulin resistance indices and cytokine biomarkers in means and standard deviation (SD) of the study population, divided by gender. Significant differences were found between genders in WC, % G, AGV, GLI, TG and VAI.

Table 1. Comparison of anthropometric characteristics, lipid profile, fasting glucose, insulin resistance indices and cytokine biomarkers by sex

Variáveis	Men n=30 (42,3%)	Womem n=41 (57,7%)	*P*
BMI (kg/m²)	26,55[24,61-27,81]	25,70[23,08-31,30]	0,917
WC (cm)	91,05[85,20-94,60]	81,40[74,00-89,95]	0,003
%G	22,30[17,65-25,63]	32,40[25,10-43,60]	<0,001
VFA (cm²)	82,60[57,73-98,60]	95,80[68,30-140-60]	0,040
GLI (mg/dL)	93,00[85,00-100,50]	87,00[75,00-94,00]	0,023
CT (mg/dL)	189,97±40,24	196,24±39,80	0,516
HDL-c (mg/dL)	54,47±12,49	56,02±13,60	0,625
LDL-c (mg/dL)	117,10±32,70	114,52±34,56	0,752
TG (mg/dL)	78,40[55,48-108,15]	103,00[69,50-175,40]	0,017
TyG	4,46±0,27	4,57±0,31	0,090
VAI	0,76[0,60-1,15]	1,41[0,83-2,65]	0,001
LAP	22,33[12,26-33,66]	27,16[16,59-49,03]	0,181
IL-1β (pg/ml)	0,01[0,01-1,49]	0,22[0,01-1,56]	0,321
IL-6 (pg/ml)	0,66[0,37-1,42]	0,50[0,30-0,71]	0,068
IL-8 (pg/ml)	9,58[5,92-16,54]	8,83[5,44-16,87]	0,789
IL-10 (pg/ml)	2,69[2,16-3,58]	2,44[1,41-3,14]	0,065
TNF-α (pg/ml)	0,20[0,02-0,97]	0,20[0,01-1,77]	0,919

SD = Standard Deviation; BMI (Body Mass Index) described in Kg / m²; WC (waist circumference, in centimeters); % G (body fat percentage); VFA (Area of visceral fat in cm²); CT (total cholesterol) HDL-c (HDL cholesterol) LDL-c (LDL cholesterol), TG (triglyceride) and GLI (fasting glucose) rates reported in mg / dL. TyGindex (the product of the serum triglyceride concentration and fasting glycemia); VAI (Visceral Adiposity Index); LAP (lipid accumulation product); IL-1β (interleukin 1β); IL-6 (interleukin 6); IL-8 (interleukin 8); IL-10 (interleukin 10) and TNF (tumor necrosis factor α), described in pg / ml. The t-test for independent samples, mean results (± standard deviation) and the Mann-Whitney test, median results [interquartile ranges], were applied for a gender comparison, considering p <0.05 (5%) significant.

The principal component factorial analysis resulted in five factors that had eigenvalues greater than 1 and represented 79, 88% of the total variance of the model (Table 2). Factor 1 was composed of 6 variables that presented loads higher than the cutoff value, explaining 29,30% of the variation, showing a strong relationship between BMI, AGV, CC, % G, LAP and GLI. Factor 2 comprised the variables TG, VAI, TyG and LAP, which showed a strong relationship between them, explaining 17, 72% of the variation. LAP was present in factor 1 and factor 2, but presented a stronger factor load in factor 2. Still in this factor, HDL was associated with the variables, but inversely, negatively. Factor 3 presented the variables IL-8, IL-6, IL-1β and GLI, with a strong association, contributing 12, 69% of the variation. GLI presented higher factor loading in this factor, expressing a greater relation with cytokines than with the variables that made up factor 1.

Table 2. Factor loadings of anthropometric variables, lipid profile, fasting glucose, insulin resistance indices and cytokine biomarkers related to each major component

Variables	Facto 1	Facto 2	Facto 3	Facto 4	Facto5
BMI (kg/m²)	**0,953**	0,071	-0,051	-0,063	0,088
FV (cm²)	**0,938**	0,149	-0,059	0,083	0,103
WC (cm)	**0,864**	0,031	0,101	0,051	-0,104
%G	**0,768**	0,220	-0,172	0,010	0,186
TG (mg/dL)	0,087	**0,961**	-0,046	0,110	-0,055
VAI	0,053	**0,958**	-0,088	-0,104	-0,008
TyG	0,260	**0,871**	0,004	0,250	-0,187
LAP	0,600	**0,732**	0,027	0,035	-0,069
HDL (mg/dL)	0,042	**-0,523**	0,176	0,492	-0,004
IL-8 (pg/ml)	-0,042	-0,021	**0,895**	-0,064	0,092
IL-6 (pg/ml)	0,027	-0,141	**0,813**	-0,076	0,195
IL-1β (pg/ml)	-0,164	-0,022	**0,650**	0,018	0,240
GLI(mg/dL)	0,404	0,049	**0,462**	0,187	-0,312
CT (mg/dL)	0,054	0,171	-0,036	**0,975**	0,029
LDL-c (mg/dL)	0,006	0,013	-0,093	**0,918**	0,057
TNF-α (pg/ml)	0,024	-0,109	0,286	0,016	**0,869**
IL-10 (pg/ml)	0,164	-0,075	0,169	0,084	**0,821**
Variation explained%	**29,30**	**17,72**	**12,69**	**12,27**	**7,90**
Variation accumulated %	**29,30**	**47,02**	**59,71**	**71,98**	**79,88**

SD = Standard Deviation; BMI (Body Mass Index) described in Kg / m²; WC (waist circumference, in centimeters); % G (body fat percentage); VFA (Area of visceral fat in cm²); CT (total cholesterol) HDL-c (HDL cholesterol) LDL-c (LDL cholesterol), TG (triglyceride) and GLI (fasting glucose) rates reported in mg / dL. TyG index (the product of the serum triglyceride concentration and fasting glycemia); VAI (Visceral Adiposity Index); LAP (lipid accumulation product); IL-1β (interleukin 1β); IL-6 (interleukin 6); IL-8 (interleukin 8); IL-10 (interleukin 10) and TNF (tumor necrosis factor α), described in pg / ml. Factorial analysis of principal components; Varimax rotation method with Kaiser normalization. Bold numbers represent variables with factorial load> 0.4.

Explaining 12, 27% of the variation, factor 4 is defined by the relation of the lipid profile variables as TC, LDL-c and HDL-c, the latter now positively. Factor 5 was composed by the variables TNF-α and IL-10, representing 7,9% of the variation. In the analysis of variance from the grouping according to gender, BMI and work sector of the scores generated by the principal component factorial analysis, a difference between the work sector was observed in factor 1 (p = 0,038), group working in agriculture significantly larger than the average working in industry. There was also a difference in BMI (p <0,001), being the mean of the group with obesity significantly higher than the average of overweight and adequate weight. The average score in the overweight group was also significantly higher than the average score in the appropriate weight group. It was found, in factor 2, a statistically significant difference between the means of the sexes (p = 0,023), being the female average significantly higher than the male average. As for factor 3, composed by cytokines (IL-8, IL-6, IL-1β) and GLI, an interaction was found between sex and the work sector (p = 0,028). The average male gender had a significantly higher score than the female average. In factor 4, there was a significant difference in the 3 analysis groups, but without any interaction between them. There was a difference in gender (p = 0,038), with the female average score significantly higher than the male average score and there was a difference in the labor sector (p = 0,046), with a significantly

higher average agricultural sector than the female average industry. There was also a difference in BMI (p = 0,01) and the mean overweight was significantly higher than the other groups (adequate weight and obesity), in contrast, the other groups did not differ in the mean. The analysis of factor 5 scores did not indicate differences in the means between the groups in this model (p = 0,767).

DISCUSSION

This study explored the clustering of risk factors and associations between nutritional status, biochemical parameters, insulin resistance, and cytokine biomarkers in rural and industry workers. It is one of the few that examined the associations between sex, BMI classes and the work sector, based on the scores of the main component factors, characterizing it as a methodological innovation. For this, we sought, through factor analysis of principal components with orthogonal rotation, to reduce 17 inter-correlated variables in groups of independent factors, identifying five factors. The main component named factor 1 was heavily loaded with variables related to overweight, obesity and visceral fat (BMI, AGV, WC, % G), and explained the maximum variance found (29, 3%), incorporating the largest sources of variation within of a data set. The factors subsequent to the first major component (factor1) and orthogonal to it are progressively smaller, explaining the major sources of variation in each factor. The second factor (factor 2), composed by the insulin resistance variables (TG, VAI, TyG and LAP) and factor 3, which included the cytokine variables (IL-8, IL-6, IL-1β) and together explained 30, 62% of the variation.

Factor 4 was defined by the relation of the lipid profile variables and factor 5 composed of the variables TNF-α and IL-10, representing a total of 20, 17% of the variation. Comparable to our findings, Badaruddoza, Kumar, and Kaur (2015) attempting to determine significant cardiovascular risk factors by analyzing principal component factors in 1827 individuals, 911 Indian men and 916 women from three generations, also identified that factor 1 It was heavily loaded with obesity-related factors (BMI, WC, waist / hip ratio, and skin fold thickness) across all generations and in both sexes, recognizing obesity as an independent predictor of cardiovascular morbidity and mortality. Panazzolo *et al*. (2012)by exploring trends and associations between micro vascular function and classic clinical measures often used in a cardio metabolic setting, 189 female subjects identified in the main component 1 a strong relationship between BMI, WC, systolic and diastolic BP, insulin levels, TG, C-reactive protein and also a strong association between HDL-c, but inversely. This component was designated by the authors as a component of abdominal obesity and insulin resistance, clinically expressed as metabolic syndrome. In our study, factor 2 was the one that presented variables and indices of insulin resistance (TG, VAI, TyG and LAP) followed by factor 3, which included the proinflammatory cytokine variables (IL-8, IL-6, IL-1β) and fasting blood glucose. With weight gain, and the consequent excessive storage of triglycerides in adipocytes induces changes in adipose tissue (adipocyte insulin resistance and increased production of TNF-α, IL-6 and various other adipocytokines), which are associated with diabetes mellitus, hypertension and diabetic dyslipidemia (AMATO *et al.,* 2014). Indexes such as TyG, VAI and LAP have shown high sensitivity for recognizing insulin resistance. Moreover, VAI and LAP indices are sensitive markers of visceral obesity. Increased TyG index has been associated with type 2 diabetes in metabolically healthy and unhealthy obese and non-obese individuals, regardless of BMI. VAI and LAP are considered superior markers of insulin resistance because they incorporate lipid variables (TG and HDL-c) and adiposity status (BMI and WC) when compared with lipid proportions (DU *et al.,* 2014; NAVARRO-GONZÁLEZ *et al.,* 2016).

Traditional lipid ratios, such as CT / HDL-c, LDL-c / HDL-c, and TG / HDL-c, are consistently associated with metabolic syndrome and are considered more effective than isolated lipid measurements in detecting insulin resistance (KIMM *et al.,* 2010; DU *et al.,* 2014). In our research, lipid profile variables appeared in factor 4, followed by insulin resistance factor 2 and factor 3 for proinflammatory cytokines (IL-8, IL-6, IL-1β) and GLI. The VAI and LAP are more efficient than TG / HDL-c ratio in recognizing insulin resistance, as they reflect abdominal obesity and visceral fat, which is strongly correlated with insulin resistance. These indices may be favorable for recognizing insulin resistance in non-diabetic people and for identifying diabetes or cardiovascular risk (DU *et al.,* 2014; ER *et al.,* 2016). Guo et al. (2016) identified that the prevalence of metabolic syndrome in adults living in rural, low-income areas of Xinjiang was higher than China's national level and that LAP and VAI were effective indicators for screening, with LAP being the index, more sensitive to identify men and women with metabolic syndrome. Brinkley et al. (2012) used factor analysis to identify inflammatory factors and examine their associations with adiposity in 424 elderly men and women at risk of disability who participated in the LIFE-P study in the United States found that the IL-1 receptor antagonist 1 (IL-1ra) and IL-6 had higher loads on the second factor (which included IL-1ra and IL6 C-reactive protein), BMI, WC, body mass and total fat were independently associated with factor 2. Adipose tissue hypertrophy is accompanied by the secretion of various proinflammatorychemokines and cytokines such as IL-1, IL-6, IL-8 and TNF-α, which are involved in interrupting insulin signaling and promoting insulin resistance. IL-6 and IL-8 levels are elevated in the presence of overweight and obesity, the development of insulin resistance, the development of atherosclerosis and the increased risk of arterial plaque formation. In addition, increased serum triglyceride levels are associated with increased proinflammatory cytokines, including IL-6 levels as well as TNFα, and are negatively correlated with serum HDL-c levels in healthy subjects (JUNG AND CHOI, 2014; VAN BEEK *et al.,* 2014; ZAGOTTA *et al.,* 2015).

The present study model also identified differences after grouping the variables in gender, BMI and work sector. Significant differences were found regarding gender in factor 2 and factor 4, with female mean scores significantly higher than male ones. Factor 3, composed by cytokines (IL-8, IL-6, IL-1β) and GLI, presented an interaction between sex and the work sector, with the male mean scores being significantly higher than the female, in the industrial sector. Badaruddoza et al. (2011) in a study of 616 individuals (350 men and 266 women), also observed that there was a difference between genders in factor loading in the analysis of principal component factors. Factor 1 was identified as lipid in men and blood pressure in women, factor 2 was identified as obesity in men and lipid in women, and factor 3 was identified as blood pressure in men and obesity in women. Furthermore, BMI and WC were associated with 2 factors in men and women and

contributed to a considerable risk. In our study, significant differences were found in factor 1 regarding BMI, with the obesity group's mean score significantly higher than the average overweight score and adequate weight and the average overweight scores significantly greater than the mean score of the appropriate weight group. In factor 4, the overweight group's mean score was significantly higher than the other groups (adequate weight and obesity), with no difference in the mean scores between the other groups. As for the work sector, significant differences were found in factor 1 and factor 4, with averages scores of those working in agriculture significantly higher than the averages scores of those working in industry. However, the research has some limitations, due to the cross-sectional nature of this analysis, not allowing conclusions about a causal effect between adiposity, insulin resistance and proinflammatory cytokines. Although a considerable number of inflammatory markers have been evaluated, our results should be interpreted with caution given the size of the sample, which may have limited the detection of significant associations, particularly in men. However, a large number of covariates were considered when evaluating the association between the components. Our study examined a cluster of inflammatory biomarkers and how they relate to anthropometric variables and insulin resistance indices. Studying changes in body composition, TyG, VAI, and LAP indices and inflammatory biomarkers over time may contribute to partially overcome this possible bias. These findings highlight the importance of the global approach to risk assessment and underline the need for further studies to elucidate a defined set of markers that can provide a better characterization of the underlying inflammatory state, determining exactly which markers are most important, and how these different metabolic and cardiovascular risk factors interact over time in the development of clinical disease.

Final consideration

The present principal component factorial analysis found that factor 1 was carried by the variables of overweight, obesity and visceral fat, followed by insulin resistance factors and inflammatory cytokines, considered risk factors for cardiovascular and metabolic diseases. After grouping, based on factor scores, differences in gender, BMI and work sector were found.

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Conflict of interests

The authors have no conflicts of interest.

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