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Assessment of cardiometabolic status in 5.994 german mechanics

Evaluación del estado cardiometabólico en 5.994 mecánicos alemanes

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Abstract

Introduction: Cardiometabolic disorders encompass a number of pathological processes that are highly prevalent especially in the developed world and are related to socioeconomic status.
Material and methods: Descriptive and cross-sectional study in 5994 German mechanics in which different indicators of obesity and overweight, insulin resistance scales, fatty liver and liver fibrosis scales and atherogenic indices were determined.
Results: Overall, 62.5% of German mechanics are obese or overweight, 27.3% have high blood pressure, 42% have high cholesterol, 22.7% have blood glucose above 100 mg/dl, a high percentage of metabolic syndrome (15.8% if NCEP-ATPIII criteria are applied, 25.2% if JIS criteria are applied), 11.3% have a high risk of insulin resistance and 23.3% a high risk of fatty liver disease.
Conclusions: The level of cardiometabolic risk among mechanics can be considered moderate-high and increases with age.

Keywords: Obesity, metabolic syndrome, dyslipidemia, insulin resistance, fatty liver.

Resumen

Introducción: Las alteraciones cardiometabólicas engloban una serie de procesos patológicos altamente prevalentes especialmente en el mundo desarrollado y que guardan relación con el nivel socioeconómico.
Material y métodos: Estudio descriptivo y transversal en 5994 mecánicos alemanes en los que se determinan diferentes indicadores de obesidad y sobrepeso, escalas de resistencia a la insulina, escalas de hígado graso y fibrosis hepática e índices aterogénicos.
Resultados: Globalmente el 62,5% de los mecanicos alemanes presentan obesidad o sobrepeso, el 27,3% hipertensión arterial, el 42% hipercolesterolemia, el 22,7% glucemia superior a 100 mg/dl, un alto porcentaje de síndrome metabólico (15,8% si aplicamos los criterios NCEP-ATPIII, y el 25,2% si los criterios aplicados son los JIS), el 11,3% presentan un alto riesgo de resistencia a la insulina y el 23,3% un alto riesgo de enfermedad de hígado graso.
Conclusiones: El nivel de riesgo cardiometabólico entre los mecánicos se puede considerer moderado-alto y se va incrementando con la edad.

Palabras clave: Obesidad, síndrome metabólico, dislipemia, resistencia a la insulina, hígado graso.

Introduction

Cardiometabolic risk refers to the probability that a person is likely to suffer cardiovascular alterations if he or she has at least one risk factor such as obesity, high LDL cholesterol, high triglyceride or low HDL levels, arterial hypertension, insulin resistance, smoking or a sedentary lifestyle[1]. Each of these factors alone is already dangerous, but when a combination of them occurs, the risk of a cardiovascular event increases considerably. The World Health Organization (WHO) estimates that cardiometabolic diseases cause around 30% of deaths worldwide[2].

People who are overweight are at increased risk of cardiovascular disease because weight affects the way insulin acts in the body[3]. Insulin helps control blood glucose, cholesterol and triglyceride levels. Weight gain makes insulin more ineffective which causes our body to not respond properly. When the body is resistant or less susceptible to insulin, there is an accumulation of glucose in the blood, which is known as insulin resistance and can eventually lead to diabetes mellitus. It is also known that arterial hypertension is more frequent in people with insulin resistance.

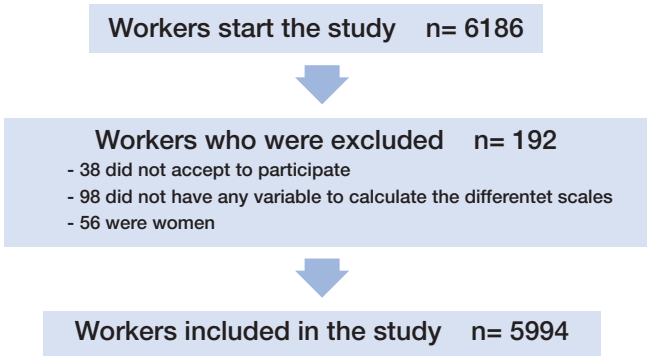
In Germany[4] 37% of deaths are due to cardiovascular diseases and 3% to diabetes-related processes, so that the highest percentage of deaths in our country is related to cardiometabolic problems.

The aim of our study was to determine the prevalence of cardiometabolic disorders in a group of mechanics working in Germany.

Methods

A descriptive, cross-sectional study was performed in 6.186 german mechanics workers between January 2019 and December 2020. 192 of them were excluded (38 for not agreeing to participate, 98 for lacking any of the parameters necessary to calculate the different cardiovascular risk scales, and 56 were women), leaving 5.994 mechanics. See flow chart in **figure 1**.

Figure 1: Flow chart of the study participants.



Inclusion criteria

- Age between 18 and 69 years.
- Give consent to participate in the study and the use of the data for epidemiological purposes.
- Were man.

Anthropometric, clinical and analytical determinations were carried out by the healthcare professionals of the different occupational health units that participated in the study, after standardizing the measurement techniques.

The following parameters were included in the assessment:

Weight (in kg) and height (in cm) are determined with a SECA model 700 scale and a SECA 220 measuring rod. Abdominal waist circumference (in cm) is measured with a SECA model 200 tape measure. For the waist-to-height ratio (WtHR), the cut-off point is set at 0.50[5]. Blood pressure is measured in the decubitus supine position with a calibrated OMRON M3 automatic sphygmomanometer and after a 10-minute rest period. Three determinations are made at one minute intervals, obtaining the mean of the three hypertension is considered when the values are equal/higher than 140 mmHg systolic or 90 mmHg diastolic blood pressure or if the worker is receiving antihypertensive treatment[6]. Blood glucose, total cholesterol and triglycerides are determined by peripheral venipuncture after fasting for at least 12-hour. Glycemia, total cholesterol and triglycerides are determined by automated enzymatic methods. HDL is determined by precipitation with dextran sulfate Cl2Mg and LDL is calculated using the Friedewald formula (provided that triglycerides are less than 400 mg/dl). All the above values are expressed in mg/dl.

Friedewald' formula: LDL-c= total cholesterol –HDL-c– triglycerides/5

The following are considered altered values: 200 mg/dL for cholesterol, 130 mg/dL for LDL and 150 mg/dL for triglycerides or if they are under treatment for any of these analytical alterations[7] .

Blood glucose values are classified according to the criteria of the American Diabetes Association[8] and are considered to be diabetes at 126 mg/dL or if they are receiving hypoglycaemic treatment.

BMI is calculated by dividing weight by height in meters squared. Obesity is considered to be 30 kg/m^2 or more.

We use to estimate the percentage of body fat: CUN BAE9 (Clínica Universitaria de Navarra Body Adiposity Estimator).

-44,988 + (0.503 x age) + (10.689 x gender) + (3.172 x BMI) – (0.026 x BMI^2) + (0.181 x BMI x gender) – (0.02 x BMI x age) – (0.005 x BMI^2 x gender) + (0.00021 x BMI^2 x age) where Male = 0 Female = 1
Other indicators related to overweight and obesity:
Visceral adiposity index (VAI)[10]

Females:

$$VAI = \left(\frac{WC}{36,58 + (1,89 \times BMI)}\right) \times \left(\frac{TG}{0,81}\right) \times \left(\frac{1,52}{HDL}\right)$$

Males:

$$VAI = \left(\frac{WC}{39,68 + (1,88 \times BMI)}\right) \times \left(\frac{TG}{1,03}\right) \times \left(\frac{1,31}{HDL}\right)$$

Body roundness index[11] (BRI) = 364.2-365.5x$\sqrt{1-[(waist/(2\pi)2)/(0.5 \times height)2]}$
Body Surface Index (BSI)[12]. BSA is calculated using the DuBois formula where w (weight) represents weight in kg and h (height) represents height in cm.

$$BSA = w^{0,425} * h^{0,725} * 0,007184$$

$$BSI = \frac{WEIGHT}{\sqrt{BSA}}$$

Conicity index (CI)[13]

$$\frac{\text{waist circumference (in metres)}}{0,109} \times 1 \sqrt{\frac{\text{Weight (in kilogram)}}{\text{Height (in metres)}}}$$

Body shape index (ABSI)[14]

$$ABSI = \frac{WC}{BMI^{2/3} \times height^{1/2}}$$

Other indicators related to cardiovascular risk:
Triglyceride glucose index[15]
TyGindex = LN (TG [mg/dl] × glycaemia [mg/dl]/2).
METS-IR[16]. LN (2 x blood glucose +Triglicerides) x BMI/ LN (HDL-c). Se considera riesgo alto de RI a partir de 50.
Cardiometabolic index (CMI)[17]
WtHR/(Triglycerides/HDL-c)

Metabolic syndrome was determined using three models:

a) NCEP ATP III (National Cholesterol Educational Program Adult Treatment Panel III), which considers metabolic syndrome when three or more of the following factors are present: waist circumference is greater than 88cm in women and 102 in men; triglycerides >150 mg/dl or specific treatment for this lipid disorder; blood pressure >130/85 mm Hg; HDL <40 mg/dl in women or <50 mg/dl in men or specific treatment is followed, and fasting blood glucose >100 mg/dl or specific glycaemic treatment.

b) The International Diabetes Federation (IDF) model[18], which considers the presence of central obesity necessary, defined as a waist circumference of >80 cm in women and >94 cm in men, in addition to two of the other factors mentioned above for ATP III (triglycerides, HDL, blood pressure and glycemia).

c) The JIS model[19], which follows the same criteria as NCEP ATPIII but the waist circumference cut-off points start at 80 cm in women and 94 cm in men.

Atherogenic dyslipidemia (AD)[20] is characterized by high triglyceride concentrations (>150 mg/dL), low HDL (<40 mg/dL in men and <50 mg/dL in women) and normal or slightly elevated LDL. If LDL values are high (>160 mg/dl) we speak of lipid triad (LT).

Fatty liver scales include:

Fatty liver index (FLI)[21]

$$FLI = (e^{0.953*\log_e(\text{triglycerides}) + 0.139*BMI + 0.718*\log_e(GGT) + 0.053*\text{waist circumference} - 15.745}) / (1 + e^{0.953*\log_e(\text{triglycerides}) + 0.139*BMI + 0.718*\log_e(GGT) + 0.053*\text{waist circumference} - 15.745}) \times 100$$

BARD score[22] BMI ≥ 28 1 point, AST/ALT ≥ 0,8 2 points, type 2 diabetes mellitus 1 point. Cutoff to high risk 2 points

Lipid accumulation product (LAP)[23]
- Men: (waist (cm) - 65) x (triglycerides (mMol)).
- Women: (waist (cm) - 58) x (triglycerides (mMol))

The different atherogenic indices have different cutoff points[24]: Total cholesterol/HDL-c index: low risk: < 5 in men and < 4.5 in women; moderate risk: between 5 and 9 in men and between 4.5 and 7 in women; and high risk: > 9 in men and > 7 in women. LDL-c/HDL-c ratio: low risk: < 3 and high risk ≥ 3. Triglycerides/HDL-c ratio is considered high risk from 3%. Cholesterol-HDL-c index: high risk as from 130.

A smoker is considered to be any person who has regularly consumed at least 1 cigarette/day (or the equivalent in other types of consumption) in the last month, or has quit smoking less than 12 months ago.

Statistical analysis

A descriptive analysis of the categorical variables was performed, calculating the frequency and distribution of responses for each of them. For quantitative variables, the mean and standard deviation were calculated, and

for qualitative variables, the percentage was calculated. The bivariate association analysis was performed using the chi2 test (with correction of Fisher's exact statistic when conditions required so). The statistical analysis was performed with the SPSS 27.0 program, with an accepted statistical significance level of 0.05.

Ethical aspects

The study was approved by the Clinical Research Ethics Committee. All procedures were performed in accordance with the ethical standards of the institutional research committee and with the 2013 Declaration of Helsinki. All patients signed written informed consent documents prior to their participation in the study.

Results

Table I shows the anthropometric, sociodemographic, analytical and clinical characteristics of the 5994 mechanics. A total of 32.9% were smokers. All age groups were similarly represented.

Table II shows the mean values of the different cardiometabolic indicators analyzed in the study: overweight and obesity indicators (BMI, WtHR, BSI, BRI, ABSI, VAI, CI, CUN BAE), insulin resistance scales (TyG index, METS-IR), fatty liver and liver fibrosis scales (FLI, BARD score, LAP) and atherogenic indices.

Table III shows a bivariate analysis of the different scales related to cardiometabolic disorders in the different age groups. All the scales show a progressive worsening of the values obtained with increasing age.

Table I: Characteristics of the 5994 German mechanics.

Mechanics n=5994	Mean (SD)
Age (years)	39.4 (11.3)
Height (cm)	174.4 (6.7)
Weight (kg)	81.5 (14.7)
Waist (cm)	85.9 (10.7)
Systolic blood pressure (mmHg)	127.4 (15.2)
Diastolic blood pressure (mmHg)	77.2 (10.7)
Total cholesterol (mg/dl)	193.3 (38.8)
HDL-c (mg/dl)	50.6 (8.0)
LDL-c (mg/dl)	118.6 (36.9)
Triglycerides (mg/dl)	122.0 (76.1)
Glycaemia (mg/dl)	93.0 (19.9)
ALT (U/L)	32.0 (18.1)
AST (U/L)	24.5 (14.9)
GGT (U/L)	36.3 (45.8)
	n (%)
18-29 years	1357 (22.6)
30-39 years	1776 (29.6)
40-49 years	1553 (25.9)
50-69 years	1308 (21.8)
Non smokers	4023 (67.1)
Smokers	1971 (32.9)

Table II: Mean values of antrhopometric and cardiometabolic parameters in German mechanics.

Mechanics n=5994	Mean (SD)
Body mass index	26.8 (4.5)
Waist to height ratio	0.49 (0.06)
Body surface index	57.9 (7.9)
Body roundnes index	3.3 (1.1)
Body shape index	0.073 (0.01)
Visceral adiposity index	7.2 (6.0)
Conicity index	1.16 (0.09)
CUN BAE	25.5 (6.7)
TyG index	8.5 (0.6)
METS-IR	39.3 (8.4)
AI Total cholesterol/HDL-c	3.9 (1.1)
AI Triglycerides/HDL-c	2.6 (1.9)
AI LDL-c/HDL-c	2.4 (1.0)
AI Total cholesterol-HDL-c	142.7 (40.8)
Cardiometabolic index	1.3 (1.1)
Lipid accumulation product	31.4 (31.7)
Fatty liver index	37.2 (27.4)
BARD scoring	1.7 (1.1)

Table III: Prevalence of high values of antrhopometric and cardiometabolic parameters in German mechanics by age.

	18-29 years n= 1357 % (95% CI)	30-39 years n= 1776 % (95% CI)	40-49 years n= 1553 % (95% CI)	50-69 years n= 1308 % (95% CI)	Total n= 5994 % (95% CI)	p-value
Waist to height ratio >0.50	31.3 (30.2-32.4)	38.9 (37.8-40.0)	45.5 (44.5-46.5)	47.0 (46.9-48.1)	40.7 (40.2-41.2)	<0.0001
Overweight BMI	31.7 (30.6-32.8)	39.2 (38.1-40.3)	47.8 (46.8-48.8)	49.5 (48.4-50.6)	42.0 (41.5-42.5)	<0.0001
Obesity BMI	11.6 (10.6-12.6)	19.1 (18.1-20.3)	24.7 (23.7-25.8)	26.8 (25.7-27.9)	20.5 (20.0-21.0)	
Overweight CUN BAE	26.8 (25.7-27.9)	34.3 (33.3-35.3)	27.7 (26.7-28.7)	17.5 (16.4-18.6)	27.2 (26.5-27.5)	<0.0001
Obesity CUN BAE	25.9 (24.8-27.0)	42.5 (41.5-43.5)	65.2 (64.2-66.2)	79.4 (78.3-80.5)	52.7 (52.2-53.2)	
Hypertension	13.9 (12.9-14.9)	17.5 (16.6-18.4)	31.3 (30.3-32.3)	49.8 (48.7-51.0)	27.3 (26.8-27.8)	<0.0001
Total cholesterol ≥ 200 mg/dl	15.0 (14.0-16.0)	36.8 (35.8-37.8)	57.6 (56.6-58.6)	58.5 (57.4-59.6)	42.0 (41.5-42.5)	<0.0001
LDL-c ≥ 130 mg/dl	13.9 (12.8-14.9)	30.8 (29.8-31.8)	51.3 (50.3-52.3)	55.0 (53.9-56.1)	37.6 (37.1-38.1)	<0.0001
Triglycerides ≥ 150 mg/dl	12.5 (11.5-13.5)	21.2 (20.2-22.3)	30.5 (29.5-31.6)	32.7 (31.6-33.8)	24.2 (23.7-24.7)	<0.0001
Glycaemia 100-125 mg/ml	10.5 (9.5-11.5)	14.7 (13.8-15.6)	23.1 (22.1-24.1)	31.7 (30.6-32.8)	19.6 (19.1-20.1)	<0.0001
Glycaemia > 125mg/dl	0.7 (0.5-0.9)	1.6 (1.3-2.0)	2.4 (2.0-2.8)	8.5 (7.6-9.4)	3.1 (2.7-3.5)	
Metabolic syndrome NCEP-ATPIII criteria	4.4 (3.7-5.1)	9.2 (8.5-9.9)	19.4 (18.4-20.4)	32.3 (31.2-33.4)	15.8 (15.3-20.3)	<0.0001
Metabolic syndrome IDF criteria	5.2 (4.5-5.9)	9.7 (9.0-10.4)	16.0 (15.0-17.0)	16.1 (15.0-17.2)	11.7 (11.2-12.2)	<0.0001
Metabolic syndrome JIS criteria	9.9 (9.0-10.8)	16.9 (15.9-17.9)	30.0 (29.0-31.0)	46.7 (45.6-47.8)	25.2 (24.7-25.7)	<0.0001
Atherogenic dyslipidemia	2.5 (2.0-3.0)	4.4 (3.8-5.0)	10.0 (9.0-11.0)	13.6 (12.5-14.7)	7.4 (7.0-7.8)	<0.0001
Lipid triad	0.4 (0.3-0.6)	1.0 (0.7-1.3)	3.4 (3.3-3.5)	4.0 (3.2-4.8)	2.2 (1.9-2.5)	<0.0001
AI Total cholesterol/HDL-c moderate-high	3.0 (2.5-3.5)	9.7 (9.0-10.5)	21.3 (20.3-22.3)	30.3 (29.2-31.4)	15.7 (15.2-16.2)	<0.0001
AI Triglicerides/HDL-c high	12.3 (11.3-13.3)	21.2 (20.2-22.2)	32.1 (31.1-33.1)	39.1 (38.0-40.2)	25.9 (25.4-30.4)	<0.0001
AI LDL-c/HDL-c high	7.2 (6.3-8.1)	17.3 (16.3-18.3)	35.5 (34.5-36.5)	44.7 (43.6-45.8)	25.7 (25.2-26.2)	<0.0001
AI Total cholesterol-HDL-c	30.9 (29.8-32.0)	56.5 (55.5-57.5)	77.9 (76.7-78.7)	78.9 (78.8-80.0)	61.1 (60.6-61.6)	<0.0001
Lipid accumulation product high	22.1 (21.0-23.2)	32.7 (31.7-33.7)	43.1 (42.1-44.1)	44.8 (43.7-45.9)	35.6 (35.1-36.1)	<0.0001
METS-IR high	5.5 (4.8-6.3)	10.5 (9.7-11.2)	14.6 (13.6-15.6)	16.0 (15.0-17.1)	11.3 (10.8-11.8)	<0.0001
TyG index high	12.2 (11.2-13.2)	22.1 (21.1-23.1)	34.3 (33.3-35.3)	42.7 (41.6-42.8)	27.5 (27.0-28.0)	<0.0001
Fatty liver index high risk	12.8 (11.8-13.8)	20.9 (19.9-21.9)	29.6 (28.6-30.6)	29.9 (28.8-31.0)	23.3 (22.8-23.9)	<0.0001

The last column shows the overall prevalence of altered values for all the scales, with the most striking values being 20.5% obesity and 42% overweight, 27.3% arterial hypertension, 42% hypercholesterolemia, 22.7% of blood glucose above 100 mg/dl, a high percentage of metabolic syndrome (15.8% if we apply the NCEP-ATPIII criteria, and 25.2% if the criteria applied are JIS), 11.3% present a high risk of insulin resistance and 23.3% a high risk of fatty liver disease.

Discussion

In our study, we can consider that the cardiometabolic risk obtained in the group of mechanics by applying the different scales included in the study can be considered moderately high. A clear increase in this risk is observed with increasing age.

Our results are consistent with those obtained by the authors of the French RECORD[25] study which analysed data from 4.360 workers where BMI, waist circumference, blood pressure, lipid profile, and blood glucose were assessed. The conclusion of the study was that the most disadvantaged sectors of the workforce performed worse on all cardiometabolic scales. A Colombian study[26] conducted in a metal-mechanic company showed much higher prevalences of metabolic syndrome than ours, namely 41%. Other studies[27,28], also conducted in mechanics, showed prevalences of metabolic syndrome similar to ours.

Translated with www.DeepL.com/Translator (free version) As strong points, we would highlight the large sample size, almost 6.000 mechanics, and the large number of scales used, which has allowed us to determine the cardiometabolic risk of this group with greater reliability.

As limitations, we found that the study was only carried out in men, as women were excluded due to their small number (specifically 56) and in a specific country, which may make it difficult to extrapolate the results to other geographical areas.

Conclusion

The cardiometabolic risk of German mechanics can be considered moderate-high, especially considering the very low average age of the population studied, mainly due to high prevalence of overweight-obesity, dyslipidemia, arterial hypertension, metabolic syndrome and high risk of insulin resistance and fatty liver.

Interests conflict

The researchers declare that they have no conflict of interest.

References

1. Morales G, Balboa-Castillo T, Muñoz S, Belmar C, Soto A, Schifferli I, et al. Association between cardiometabolic risk factors, physical activity and sedentariness in Chilean university students. Nutr Hosp 2017;34(6):1345-52

2. Maldonado Villalón JA, Carranza Cervantes CA, Ortiz González MJ, Gómez Alonso C, Cortés-Gallegos NL. Prevalencia de factores de riesgo cardiometabólico en estudiantes universitarios de la región centro-occidente, en la Universidad Michoacana de San Nicolás de Hidalgo, México. Rev. Mex. Cardiol . 2013; 24(2): 76-86.

3. Ye J. Mechanisms of insulin resistancein obesity. Front Med 2013;7(1):14-24

4. Organización Mundial de la Salud - ENT Perfiles de países, 2018. Available at: https://www.who.int/nmh/countries/deu_es.pdf

5. Luengo-Pérez LM, Urbano-Gálvez JM, Pérez-Miranda M. Validación de índices antropométricos alternativos como marcadores del riesgo cardiovascular. Endocrinol Nutr 2009;56(9):439-46

6. James PA, Oparil S, Carter BL, Cushman, WC, Dennison-Himmelfarb CH, Handler J. Evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA 2014;311(5):507-20.

7. Mach F, Baigent C, Catapano AL, Koskinas KC, Casula M, Badimon L. ESC Scientific Document Group. 2019 ESC/EAS Guidelines for the management of dyslipidaemias: lipid modification to reduce cardiovascular risk. Eur Heart J 2020;41(1):111-88.

8. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care 2010;33(Suppl 1):S62-9

9. Gómez-Ambrosi J, Silva C, Catalán V, Rodríguez A, Galofré JC. Escalada J. Clinical usefulness of a new equation for estimating body fat. Diabetes Care 2012;35(2):383-8.

10. Amato M, Giordano C, Galia M, Criscimanna A, Vitabile S, Midiri M. Visceral Adiposity Index A reliable indicator of visceral fat function associated with cardiometabolic risk. Diabetes Care 2010;33(4):920-2

11. Rico-Martín S, Calderón-García JF, Sánchez-Rey P, Franco-Antonio C, Martínez-Álvarez, M, & Sánchez-Muñoz-Torrero, JF. (2020). Effectiveness of body roundness index in predicting metabolic syndrome: A systematic review and meta-analysis. Obes Rev.;21(7): e13023

12. Shirazu I, Sackey THA, Tiburu EK, Mensah YB, Forson A. The use of Body Surface Index as a Better Clinical Health indicators compare to Body Mass Index and Body Surface Area for Clinical Application. Int. J. S. Res. Sci. Engg. Technol 2018; 4(11): 131-6

13. Andrade MD, Freitas MC, Sakumoto AM, Pappiani C, Andrade SC, Vieira VL. Association of the conicity index with diabetes and hypertension in Brazilian women. 2016;60(5):436-42.

14. Bertoli S, Leone A, Krakauer NY, Bedogni G, Vanzulli A. Redaelli VI. Association of Body Shape Index (ABSI) with cardio-metabolic risk factors: A cross-sectional study of 6081 Caucasian adults. PLoS One 2017; 25;12(9):e0185013.

15. Unger G, Benozzi SF, Peruzza F, Pennacchiotti GL. Triglycerides and glucose index: A useful indicator of insulin resistance. Endocrinol Nutr 2014;61(10):533-40

16. Bello-Chavolla OY, Almeda-Valdes P, Gomez-Velasco D, Viveros-Ruiz T, Cruz-Bautista I, Romo-Romo A, et al METS-IR a novel score to evaluate insulin sensitivity, is predictive of visceral adiposity and incident type 2 diabetes. Eur J Endocrinol 2018;178(5):533-44

17. Wakabayashi I, Daimon T. The "cardiometabolic index" as a new marker determined by adiposity and blood lipids for discrimination of diabetes mellitus. ClinChim Acta 2015;438:274-8.

18. Zimmet P, Alberti KG, Serrano-Ríos M. A new International Diabetes Federation worldwide definition of the metabolic syndrome: the rationale and the results. Rev Esp Cardiol 2005 ;58(12):1371-6.

19. Cabrera-Roe E, Stusser B, Cálix W, Orlandi N, Rodríguez J, Cubas-Dueñas I. Concordancia diagnóstica entre siete definiciones de síndrome metabólico en adultos con sobrepeso y obesidad. Rev Peru Med Exp Salud Publica 2017;34(1):19-27.

20. Bestehorn K, Smolka W, Pittrow D, Schulte H, Assmann G. Atherogenic dyslipidemia as evidenced by the lipid triad: prevalence and associated risk in statin-treated patients in ambulatory care. Curr Med Res Opin 2010; 26:2833-9

21. Bedogni G, Bellentani S, Miglioli L, Masutti F, Passalacqua M, Castiglione A. The Fatty Liver Index: a simple and accurate predictor of hepatic steatosis in the general population. BMC Gastroenterol 2006; 6:33.

22. Ruffillo G, Fassio E, Alvarez E, Landeira G, Longo C, Dominguez N, et al. Comparison of NAFLD fibrosis score and BARD score in predicting fibrosis in nonalcoholic fatty liver disease. J Hepatol 2011;54(1):160-3

23. Chiang JK, Koo M. Lipid accumulation product: a simple and accurate index for predicting metabolic syndrome in Taiwanese people aged 50 and over. BMC Cardiovasc Disord 2012;12:78

24. López González ÁA, Rivero Ledo YI, Vicente Herrero MT, Gil Llinás M, Tomás Salvá M, Riutord Fe B. Índices aterogénicos en trabajadores de diferentes sectores laborales del área mediterránea española. Clin Investig Arterioscler. 201;27(3):118-28

25. Lewin A, Thomas F, Pannier B, Chaix B. Work economic sectors and cardiovascular risk factors: cross-sectional analysis based on the RECORD Study. BMC Public Health. 2014 Jul 24;14:750.

26. Agredo-Zúñiga RA, García-Ordoñez ES, Osorio C, Escudero N, López-Albán CA, Ramírez-Vélez R. Obesidad abdominal y ausentismo por causa médica en una empresa de la industria metalmecánica en Cali, Colombia. Rev Peru Med Exp Salud Publica 2013;30(2):251-5.

27. Martínez EG, Gutierrez AM. Metabolic Syndrome and Body Composition measurements in Blue-Collar Workers from a Metal-Mechanic Factory in Soledad. Preliminary Report. Salud Uninorte. Barranquilla (Col) 2017;33(1):1-6

28. 22. Suárez-Ortegón MF, Arbeláez A, Mosquera M, Ramírez-Vélez R, Aguilar-De Plata C. Evaluation of the relationship between self-reported physical activity and metabolic syndrome and its components in apparently healthy women. Biomédica. 2014;34:60-66.