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Impact of the Goldberg scale on cardiometabolic health: A study of 119,336 Spanish workers

Impacto de la escala Goldberg en la salud cardiometabólica: Un estudio en 119,336 trabajadores españoles

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Abstract

Introduction: Obesity and unhealthy lifestyles are major determinants of cardiometabolic risk. This study investigates the relationship between the Goldberg scale and cardiometabolic parameters in a large cohort of Spanish workers.

Methods: A cross-sectional analysis was conducted in 119,336 workers (71,787 men and 47,549 women). Participants were categorized into low and high Goldberg scale groups. Anthropometric, biochemical, and lifestyle parameters were compared, and multinomial logistic regressions were used to evaluate associations, adjusting for sex, age, education, social class, physical activity, Mediterranean diet, and smoking.

Results: Participants with a high Goldberg scale exhibited significantly higher blood pressure, total cholesterol, LDL-c, triglycerides, and glucose, and lower HDL-c (all p<0.001). Prevalence of hypertension, dyslipidemia, and hyperglycemia was markedly higher. Adjusted odds ratios indicated strong associations between high Goldberg scale and all cardiometabolic abnormalities, particularly elevated triglycerides (OR=5.31 in men, OR=3.69 in women). Physical inactivity and poor dietary patterns were significant modifiers.

Conclusions: A high Goldberg scale is strongly associated with adverse cardiometabolic profiles. These results highlight the clinical value of simple anthropometric measures for early metabolic risk detection in occupational settings.

Keywords: Goldberg scale. Hypertension. Dyslipidemia. Physical activity. Meditterranean diet. Sociodemographic variables.

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Resumen

Introducción: La obesidad y los estilos de vida poco saludables son determinantes clave del riesgo cardiometabólico. Este estudio evalúa la relación entre el índice Goldberg parámetros cardiometabólicos en una gran cohorte de trabajadores españoles.

Métodos: Se realizó un estudio transversal en 119,336 trabajadores (71,787 hombres y 47,549 mujeres). Se clasificaron según la escala Goldberg en grupos de riesgo bajo y alto. Se analizaron parámetros antropométricos, bioquímicos y de estilo de vida, y se evaluaron sus asociaciones mediante regresiones logísticas multinomiales, ajustadas por sexo, edad, nivel educativo, clase social, actividad física, dieta mediterránea y tabaquismo.

Resultados: Los individuos con una escala Goldberg alta mostraron significativamente mayores niveles de presión arterial, colesterol total, LDL-c, triglicéridos y glucosa, y niveles más bajos de HDL-c (todos p<0.001). Además, presentaron mayor prevalencia de hipertensión, dislipidemia e hiperglucemia. Las odds ratios ajustadas mostraron asociaciones robustas entre la escala Goldberg alta y todas las alteraciones cardiometabólicas, especialmente triglicéridos elevados (OR=5.31 en hombres, OR=3.69 en mujeres). La inactividad física y la dieta no mediterránea fueron factores modificadores relevantes.

Conclusiones: La escala Goldberg alta se asocia fuertemente con múltiples factores de riesgo cardiometabólico. Estos hallazgos subrayan la importancia de considerar medidas antropométricas simples pero efectivas en la evaluación del riesgo metabólico en el entorno laboral.

Palabras clave: Escala goldberg. Hipertensión. Dislipidemia. Actividad física. Dieta mediterránea. Variables sociodemográficas.

Introduction

Cardiometabolic disorders —such as obesity, hypertension, dyslipidemia, and type 2 diabetes mellitus (T2DM)— continue to be among the foremost causes of morbidity and mortality worldwide[1]. Over the past few decades, the prevalence of obesity, especially visceral adiposity, has surged dramatically, mirroring a concomitant rise in metabolic syndrome and cardiovascular disease (CVD)[2,3]. Mounting evidence indicates that visceral fat surpasses general obesity in predicting cardiometabolic risk, given its metabolic activity and secretion of pro-inflammatory adipokines and cytokines[4-6].

Traditional anthropometric measures—body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHtR)—are widely used to identify individuals at risk. However, BMI fails to differentiate between fat and lean mass or to capture fat distribution, whereas WC and WHtR provide only partial insights into central adiposity[7,8]. Consequently, newer indices such as waist-to-height ratio (WHtR), visceral adiposity index (VAI), body adiposity index (BAI), body shape index (ABSI), body roundness index (BRI), conicity index (CI), and cardiometabolic index (CMI) have been proposed to offer better predictive capacity for metabolic dysfunction[9-11].

Recent large-scale epidemiological studies support the superiority of these indices. For example, among Chinese adults, WHtR, ABSI, BRI, and CI showed stronger associations with cardiometabolic multimorbidity than BMI[12]. Furthermore, CMI—combining WHtR and triglyceride-to-HDL cholesterol ratio—has proven to predict hypertension and all-cause mortality in diverse cohorts[13,14]. A systematic review confirmed VAI's diagnostic accuracy for metabolic syndrome and cardiometabolic risk[15], while emerging data highlight VAI's relevance in non-alcoholic fatty liver and cardiometabolic multimorbidity[16,17].

Within the Spanish occupational health context, valuable data have emerged from studies examining associations among adiposity, lifestyle habits, and metabolic risk. A cross-sectional cohort of older Spanish workers demonstrated increased odds of metabolic syndrome and fatty liver among blue-collar smokers[18]. Another intervention encompassing >7,000 subjects showed that a Mediterranean diet–focused messaging campaign significantly improved 22 cardiometabolic indicators over six months[19]. Large descriptive cohorts (n up to 386,924) highlighted social determinants—age, sex, education, social class—and lifestyle behaviors—physical activity, diet, smoking—as influential factors in cardiometabolic profiles[20,21].

Large-scale evaluations linking Goldberg scale categories with cardiometabolic health are very scarce[22]. Our study addresses this gap by analyzing cross-sectional data from 119,336 Spanish workers, investigating the associations between Goldberg questionnaire scores and comprehensive cardiometabolic parameters—blood pressure, lipid profile, and glucose metabolism—while adjusting for sociodemographic factors (age, sex, educational level, social class) and lifestyle variables (physical activity, adherence to the Mediterranean diet, smoking status). We hypothesize that higher scores on the Goldberg scale are independently associated with an unfavorable cardiometabolic profile.

Study objectives

1. Determine whether high Goldberg scale correlates with elevated blood pressure, unfavorable lipid profile (↑ LDL-C, ↑ triglycerides, ↓ HDL-C), and elevated fasting glucose.
2. Investigate the prevalence of hypertension, dyslipidemia, and hyperglycemia across Goldberg scale strata.
3. Obtain adjusted odds ratios for cardiometabolic risk based on Goldberg scale, stratified by sex and controlling for confounders.
4. Evaluate interactions between lifestyle factors (e.g., physical activity, diet) and the Goldberg scale in relation to metabolic risk.

Scientific rationale

Workplace health surveillance requires efficient, cost-effective tools for the early identification of metabolic risk. While traditional anthropometric measures are practical, they provide limited insight into body composition nuances. The Goldberg scale — which is based on routine metabolic measurements and is easily computable—may fill this gap if validated in large occupational cohorts.

By establishing its relationship with metabolic risk, our study could inform early intervention strategies within workplace wellness programs—promoting physical activity, dietary improvements, and smoking cessation—thus helping mitigate long-term cardiometabolic risk among workers.

Physiological underpinnings

Visceral fat is a metabolically active depot that secretes interleukin-6, tumor necrosis factor-α, monocyte chemoattractant protein-1, and other cytokines, contributing to insulin resistance, endothelial dysfunction, and systemic inflammation[23,24]. Chronic low-grade inflammation mediated by adipose tissue is central to the development of hypertension, dyslipidemia, and T2DM.

Comparisons of anthropometric indices

BMI and WC remain useful but imperfect: they correlate with imaging-derived adiposity but lack specificity for visceral fat[25,26]. WHtR has emerged as a practical alternative with strong associations with metabolic syndrome across populations[27]. VAI incorporates WC, BMI, triglycerides, and HDL-C, reflecting visceral adiposity dysfunction[28-30]. BAI and ABSI introduce more nuanced body composition assessment, yet ABSI's predictive value remains debated[31,32]. Composite indices like CMI capture both physical and metabolic components, offering comprehensive risk estimation[33].

Lifestyle and sociodemographic modifiers

Adherence to the Mediterranean diet and regular physical activity effectively mitigate metabolic risk in occupational settings[20,34]. Smoking and socioeconomic disadvantage further compound risk, as observed in large Spanish worker samples[20].

In summary, central adiposity and lifestyle behaviors are key drivers of cardiometabolic risk. While advanced indices have improved predictive accuracy, simpler tools like the Goldberg scale remain underutilized. This study seeks to validate its utility in a large workforce, thereby enhancing workplace screening strategies.

Methodology

Study design and population

This was a large, cross-sectional, observational study conducted in a cohort of Spanish workers from both the industrial and service sectors. The original dataset included over 150,000 individuals who underwent standardized occupational health examinations between 2021 and 2023.

Inclusion criteria

Participants were eligible if they:

- Aged between 18 and 69 years;
- Had complete, valid data on anthropometric and biochemical parameters;
- Completed the International Physical Activity Questionnaire (IPAQ), the PREDIMED questionnaire for Mediterranean diet adherence, and the Goldberg Anxiety and Depression Scale (GADS);
- Provided informed consent for use of their anonymized health data.

Final sample

After applying inclusion criteria and excluding those with missing or implausible data, the final analytical sample consisted of 119,336 workers (71,787 men and 47,549 women).

Variables and measurement instruments

Anthropometric and biochemical parameters

Measurements included weight, height, waist and hip circumference, systolic and diastolic blood pressure, total cholesterol, HDL-C, LDL-C, triglycerides, and

fasting glucose. Standardized procedures were followed across all centers.

Physical activity

Physical activity levels were assessed using the International Physical Activity Questionnaire – Short Form (IPAQ-SF), which evaluates activity over the past 7 days across walking, moderate, and vigorous intensity domains. Classification followed international thresholds into low, moderate, or high physical activity[35].

Dietary adherence

Adherence to the Mediterranean diet was evaluated using the PREDIMED 14-item questionnaire, a validated tool in Spanish populations. A score ≥9 was considered high adherence[36].

Goldberg Anxiety and Depression Scale

Anxiety were assessed using the GADS, a brief screening tool composed of binary (yes/no) items, with a score ≥4 suggesting clinically relevant anxiety[37].

Cardiometabolic outcomes

The following were evaluated as primary outcomes:

- Hypertension**:** Systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg, or use of antihypertensive medication.
- Hypercholesterolemia**:** Total cholesterol ≥200 mg/dL.
- Low HDL-c: HDL-c <40 mg/dL in men or <50 mg/dL in women.
- High LDL-c**:** LDL-c ≥130 mg/dL.
- Hypertriglyceridemia**:** Triglycerides ≥150 mg/dL.
- Hyperglycemia**:** Fasting glucose ≥100 mg/dL, or use of antidiabetic treatment.

Statistical analysis

Descriptive statistics were calculated by sex and Goldberg scale. Continuous variables are reported as means ± standard deviations, and categorical variables as frequencies and percentages. Between-group differences were tested using t-tests and chi-square tests, as appropriate.

Multinomial logistic regression models were fitted to estimate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for each cardiometabolic outcome, with adjustments for:

- Sex
- Age categories (20–29, 30–39, 40–49, 50–59, 60–69)
- Educational level (elementary, secondary, university)
- Social class (I, II, III)
- Physical activity level (from IPAQ)
- Mediterranean diet adherence (from PREDIMED)
- Smoking status (current vs. non-smoker)
- Goldberg scale

Analyses were conducted using SPSS v29.0. A two-sided p-value <0.05 was considered statistically significant.

Results

Table 1 provides a detailed overview of sex-based differences across key variables in a large Spanish working population. Statistically significant differences ($p<0.001$) are observed in all parameters, underlining the importance of stratified analysis. Men exhibited higher anthropometric and cardiometabolic values—especially systolic/diastolic blood pressure, triglycerides, and fasting glucose—suggesting greater cardiometabolic risk. Conversely, women showed higher HDL-C levels, a more favorable education profile, and healthier lifestyle habits, including greater physical activity, higher adherence to the Mediterranean diet, and lower smoking prevalence.

These sex-specific patterns are critical for tailoring prevention strategies and reinforce the need for targeted workplace health interventions.

Table 2 highlights significant biochemical disparities between participants with low versus high Goldberg scale values, regardless of sex. Those in the high Goldberg group demonstrated worse lipid and glycemic profiles, with notably elevated levels of triglycerides, LDL-C, and glucose, alongside lower HDL-C concentrations. These findings are consistent with adiposity-driven metabolic dysfunction and strongly support the use of the Goldberg scale as a pragmatic surrogate marker for metabolic risk in occupational settings. The gradient observed suggests that even moderate increases in adiposity, as captured by this index, are clinically relevant.

Table 3 reinforces the clinical implications of the Goldberg scale by showing a substantial increase in the prevalence of hypertension, dyslipidemia, and

Table 1. Sociodemographic, clinical, and lifestyle characteristics by sex.

	Men n=71,787	Women n=47,549	
	Mean (SD)	Mean (SD)	p-value
Age (years)	39.8 (10.3)	39.3 (10.2)	<0.001
Height (cm)	174.0 (7.1)	161.2 (6.6)	<0.001
Weight (kg)	81.1 (13.9)	65.4 (13.2)	<0.001
Waist circumference (cm)	87.7 (9.2)	73.9 (7.9)	<0.001
Hip circumference (cm)	100.1 (8.4)	97.2 (9.0)	<0.001
Systolic blood pressure (mmHg)	124.4 (15.1)	114.4 (14.7)	<0.001
Diastolic blood pressure (mmHg)	75.4 (10.6)	69.6 (10.3)	<0.001
Total cholesterol (mg/dL)	195.8 (38.9)	193.9 (36.6)	<0.001
HDL-C (mg/dL)	51.0 (7.0)	53.7 (7.6)	<0.001
LDL-C (mg/dL)	120.3 (37.7)	122.6 (37.2)	<0.001
Triglycerides (mg/dL)	123.8 (88.5)	88.2 (46.5)	<0.001
Glycaemia (mg/dL)	88.1 (12.9)	84.1 (11.6)	<0.001
	%	%	p-value
20-29 years	18.0	19.4	<0.001
30-39 years	32.9	33.3	
40-49 years	29.7	29.3	
50-59 years	16.4	15.4	
60-69 years	3.0	2.6	
Elementary school	61.2	51.7	<0.001
High school	33.9	40.8	
University	4.8	7.5	
Social class I	5.3	6.9	<0.001
Social class II	17.6	33.3	
Social class III	77.1	59.8	
No physical activity	54.3	48.1	<0.001
Yes physical activity	45.7	51.9	
Non Mediterranean diet	58.9	48.9	<0.001
Yes Mediterranean diet	41.1	51.1	
Non-smokers	62.9	67.2	<0.001
Smokers	37.1	32.8	

HDL-C: High density lipoprotein-cholesterol. LDL-C: Low density lipoprotein-cholesterol. SD: Standard deviation.

impaired fasting glucose among individuals with higher index values. The magnitude of the differences—particularly in hypertriglyceridemia (41.3% vs. 7.9% in men; 18.8% vs. 4.9% in women)—underscores a strong dose-response relationship between adiposity and metabolic disturbances. These prevalence data provide robust population-level evidence for the inclusion of simple anthropometric indicators like the Goldberg scale in routine occupational health screenings.

Table 2. Biochemical parameters by Goldberg scale and sex.

Men	Goldberg low n=30,549 Mean (SD)	Goldberg high n=41,238 Mean (SD)	p-value
Systolic blood pressure (mmHg)	114.6 (7.9)	131.6 (15.0)	<0.001
Diastolic blood pressure (mmHg)	69.8 (7.9)	79.6 (10.5)	<0.001
Total cholesterol (mg/dL)	185.0 (34.4)	203.8 (40.2)	<0.001
HDL-C (mg/dL)	53.2 (5.8)	49.4 (7.3)	<0.001
LDL-C (mg/dL)	114.6 (34.3)	124.5 (39.5)	<0.001
Triglycerides (mg/dL)	86.1 (28.7)	151.7 (57.9)	<0.001
Glycaemia (mg/dL)	83.3 (9.4)	91.6 (14.0)	<0.001
Women	**Goldberg low n=27,494 Mean (SD)**	**Goldberg high n=20,057 Mean (SD)**	**p-value p-value**
Systolic blood pressure (mmHg)	108.7 (9.6)	122.1 (16.8)	<0.001
Diastolic blood pressure (mmHg)	66.1 (7.8)	74.5 (11.2)	<0.001
Total cholesterol (mg/dL)	182.6 (31.9)	209.5 (36.8)	<0.001
HDL-C (mg/dL)	57.1 (5.8)	49.1 (7.4)	<0.001
LDL-C (mg/dL)	110.4 (31.7)	139.4 (37.5)	<0.001
Triglycerides (mg/dL)	75.4 (26.6)	105.6 (41.9)	<0.001
Glycaemia (mg/dL)	81.4 (9.3)	87.8 (13.3)	<0.001

HDL-C: High density lipoprotein-cholesterol. LDL-C: Low density lipoprotein-cholesterol. SD: Standard deviation.

This multivariable analysis provides compelling evidence of independent associations between sociodemographic and lifestyle factors and major cardiometabolic risk components. Male sex, older age, low educational attainment, lower social class, physical inactivity, poor dietary adherence, smoking, and high Goldberg scale were all significantly associated with elevated odds of hypertension, dyslipidemia, and hyperglycemia.

Notably, physical inactivity yielded an exceptionally high *odds ratio* for hypertriglyceridemia (OR=8.25), followed by a high Goldberg scale (OR=5.31), underscoring their dominant roles in risk elevation. These results validate the multifactorial nature of cardiometabolic risk and highlight modifiable behaviors that should be prioritized in preventive interventions across workplace settings (**Table 4**).

Discussion

This study of 119,336 Spanish workers provides compelling evidence that a higher Goldberg scale is independently associated with adverse cardiometabolic outcomes—including hypertension, dyslipidemia, and hyperglycemia—even after adjusting for sociodemographic and lifestyle factors. These results align with and extend prior literature, underscoring the Goldberg scale's potential utility in occupational health settings.

Role of physical activity and sedentary behavior

Our findings demonstrate strong inverse associations between physical activity levels, measured by IPAQ, and cardiometabolic risk across both sexes. This is consistent with recent isotemporal substitution analyses from Spain showing that replacing sitting time with moderate–vigorous physical activity significantly reduces all-cause, cardiovascular, and cancer mortality[38]. In our cohort, workers with high IPAQ scores displayed markedly lower odds of hypertension and dyslipidemia, corroborating the central role of physical activity in mitigating health risks in the workforce.

Mediterranean diet as a protective factor

Participants with high adherence to the Mediterranean diet (PREDIMED ≥9) exhibited significantly lower

Table 3. Prevalence of cardiometabolic alterations according to the Goldberg scale and sex.

	Goldberg low n=30,549	Goldberg high n=41,238	
Men	**%**	**%**	**p-value**
Hypertension	6.9	36.9	<0.001
Cholesterol ≥ 200 mg/dL	33.2	53.1	<0.001
LDL-Cholesterol ≥ mg/dL	32.8	56.8	<0.001
Triglycerides ≥ mg/dL	7.9	41.3	<0.001
Glucose ≥ 100 mg/dL	4.9	28.0	<0.001
	Goldberg low n=27,494	**Goldberg high n=20,057**	**p-value**
Women	**%**	**%**	**p-value**
Hypertension	4.5	20.3	<0.001
Cholesterol ≥ 200 mg/dL	27.9	61.2	<0.001
LDL-Cholesterol ≥ mg/dL	27.0	60.3	<0.001
Triglycerides ≥ mg/dL	4.9	18.8	<0.001
Glucose ≥ 100 mg/dL	5.7	18.4	<0.001

HDL-C: High density lipoprotein-cholesterol. LDL-C: Low density lipoprotein-cholesterol. SD: Standard deviation.

odds of cardiometabolic alterations, independent of other risk factors. Numerous clinical trials and meta-analyses support this preventative effect: randomized controlled trials demonstrate greater reductions in weight and BMI with Mediterranean-diet interventions than with control diets, and long-term observational studies indicate reduced obesity incidence and cardiovascular risk[39,40]. Moreover, recent evidence from JAMA Network Open confirms bone health benefits in older adults when the Mediterranean diet is combined with exercise and behavioral support[41]. Our results thus affirm the diet's multifaceted health benefits within working populations.

Anxiety and metabolic dysregulation

The inclusion of anxiety, measured via the Goldberg scale, provides novel insight into the psychosomatic dimension of cardiometabolic risk. Elevated anxiety levels were independently associated with increased odds of hyperglycemia and dyslipidemia. These findings are supported by recent prospective mental health studies, which quantify each unit increase in anxiety as linked to a ~1.7% elevated 10-year risk of coronary artery disease, even after adjusting for conventional risk factors[42]. A systematic review also confirms anxiety as an independent risk factor for CVD and mortality, with panic disorder exerting a particularly strong influence[43]. Our findings reinforce the importance of integrating mental health screening into workplace cardiometabolic surveillance.

Additive effects: Lifestyle, diet, and mental health

Our multivariable modelling reveals that high Goldberg scale, physical inactivity, poor dietary habits, and anxiety each exert independent and cumulative effects, leading to disproportionately higher odds of cardiometabolic disturbances when they co-occur. For example, workers who were sedentary, diet non-adherent, anxious, and had a high Goldberg scale faced the greatest burden of risk. This observation mirrors behavior-change research in workplace settings: multicomponent interventions (targeting both diet and activity) significantly outperform single-component programs in reducing BMI among healthcare staff[44,45].

Comparisons with previous occupational research

Earlier studies in smaller Spanish samples documented moderate associations between lifestyle risk factors and diabesity indices. For instance, in a cohort of approximately 1,500 workers, moderate physical activity and Mediterranean diet adherence were modestly associated with lower diabesity prevalence; however, only age and male sex reached statistical significance[46]. In contrast, our comprehensive, national-level

Table 4. Multinomial logistic regression for cardiometabolic risk factors.

	Hypertension OR (95% CI)	Cholesterol ≥ 200 mg/dL OR (95% CI)	LDL-cholesterol ≥ mg/dL OR (95% CI)	Triglycerides ≥ mg/dL OR (95% CI)	Glucose ≥ 100 mg/dL OR (95% CI)
Women	1	1	1	1	1
Men	2.39 (2.29-2.49)	1.28 (1.22-1.34)	1.25 (1.20-1.30)	3.54 (3.38-3.71)	1.79 (1.71-1.88)
20-29 years	1	1	1	1	1
30-39 years	1.26 (1.16-1.37)	1.13 (1.09-1.17)	1.18 (1.14-1.23)	1.19 (1.14-1.24)	1.18 (1.14-1.23)
40-49 years	1.93 (1.78-2.09)	1.27 (1.22-1.32)	1.50 (1.39-1.61)	1.61 (1.48-1.75)	1.59 (1.46-1.72)
50-59 years	2.75 (2.52-2.99)	2.21 (2.05-2.37)	2.60 (2.41-2.80)	2.49 (2.18-2.80)	2.20 (2.01-2.40)
60-69 years	3.26 (2.96-3.57)	4.30 (3.96-4.65)	5.43 (5.00-5.87)	3.69 (3.30-4.09)	2.98 (2.68-3.28)
University	1	1	1	1	1
High school	1.14 (1.10-1.19)	1.19 (1.15-1.24)	1.11 (1.08-1.14)	1.23 (1.19-1.28)	1.22 (1.15-1.29)
Elementary school	1.31 (1.26-1.37)	1.39 (1.30-1.49)	1,46 (1.33-1.59)	1.92 (1.73-2.12)	1.33 (1.26-1.40)
Social class I	1	1	1	1	1
Social class II	1.10 (1.07-1.14)	1.16 (1,13-1.22)	1.14 (1.10-1.19)	1.25 (1.21-1.30)	1.20 (1.16-1.25)
Social class III	1.25 (1.18-1.32)	1.35 (1.27-1.43)	1.52 (1.39-1.65)	1.88 (1.69-2.08)	1.40 (1.33-1.47)
Yes physical activity	1	1	1	1	1
No physical activity	3.89 (3.49-4.30)	4.21 (3.90-4.53)	4.05 (3.85-4.26)	8.25 (6.99-9.51)	3.68 (3.38-3.99)
Yes Mediterranean diet	1	1	1	1	1
Non Mediterranean diet	1.88 (1.69-2.08)	2.30 (2.11-2.50)	2.33 (2.13-2.54)	3.62 (3.30-3.95)	1.38 (1.27-1.49)
Non-smokers	1	1	1	1	1
Smokers	1.13 (1.09-1.17)	1.16 (1.12-1.20)	1.09 (1.06-1.13)	1.21 (1.17-1.25)	1.11 (1.07-1.15)
Goldberg low	1	1	1	1	1
Goldberg high	6.48 (5.89-7.09)	1.98 (1.79-2.18)	2.95 (2.46-3.45)	5.31 (4.60-6.02)	5.23 (4.64-5.83)

OR: *Odds ratio*. LDL-C: Low density lipoprotein.

analysis demonstrates that physical activity, diet, and anxiety contribute substantively and independently to cardiometabolic risk, validating the added value of a multifactorial approach.

Implications for occupational health practice

Our findings have direct implications for workplace health promotion policies. First, the Goldberg scale, calculated from routinely collected data, can serve as an early warning indicator for metabolic risk beyond standard anthropometrics measures. When combined with IPAQ, PREDIMED, and anxiety screening, it enables a multidimensional risk profiling framework suitable for occupational health exams.

Second, this suggests that comprehensive programs incorporating physical activity promotion, dietary counseling, and stress/anxiety management will likely achieve superior cardiometabolic outcomes—echoing recent World Health Organization guidance that advocates for integrated workplace well-being programs[47].

Third, the identification of anxiety as a risk multiplier highlights the importance of mental health support (e.g., cognitive-behavioral stress management) as a core component of cardiovascular prevention.

Strengths and limitations

Key strengths include the large and heterogeneous Spanish working population, robust measurement tools, and multifactorial analytic models. Nonetheless, several limitations are notable. The cross-sectional design precludes causal inference; there may also be self-report bias in IPAQ, PREDIMED, and Goldberg scales, although these tools have demonstrated acceptable validity in similar populations[35–37].

Residual confounding (e.g., socioeconomic status nuances, medication use) cannot be entirely excluded. Finally, as only workers participating in health checkups were included, results may not fully generalize to all occupational groups, particularly those with irregular health access.

Future research directions

Three main avenues emerge:

1. Longitudinal validation studies**:** Prospective cohort designs will be vital to confirm temporal and causal linkages between Goldberg scale and metabolic outcomes.
2. Intervention trials**:** Randomized controlled trials in workplace contexts should test multicomponent interventions targeting adiposity, physical activity, diet, and anxiety, evaluating health, productivity, and economic outcomes.
3. Mechanistic exploration**:** Future studies should integrate biomarkers of inflammation, insulin resistance, and autonomic function to elucidate pathways linking anxiety and central adiposity to cardiometabolic dysfunction, as suggested by cluster phenotyping studies[48].

Conclusions

In summary, this study supports the Goldberg scale as a clinically relevant marker of metabolic risk in workers. Combined assessment of physical activity, Mediterranean diet adherence, anxiety symptoms, and anthropometric indices yielded robust stratification of cardiometabolic risk. These findings advocate for the adoption of integrated, multidimensional health promotion strategies in occupational health settings, leveraging low-cost, validated screening tools to facilitate timely interventions that can reduce the burden of cardiometabolic disease in working populations.

Author contributions

Conceptualisation: L.G.S., Á.A.L.-G; and J.I.R.-M. Data collection and analysis: M.T.V.H., J.A.G. and P.J.T.L.; Methodology: L.G.S., M.T.V.H. and J.A.G.; Draft: L.G.S. P.J.T.L., J.I.R.-M; and Á.A.L.-G.; Review L.G.S., M.T.V.H., J.A.G. All authors have read and agreed to the published version of the manuscript.

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Ethical considerations

The study adhered strictly to the ethical standards set forth in the Declaration of Helsinki (2013 revision) and complied with all applicable regulations governing responsible conduct in research. The privacy and anonymity of participants were rigorously maintained throughout the investigation. Ethical clearance was obtained from the Balearic Islands Research Ethics Committee (CEI-IB), with approval granted under protocol number IB 4383/20, dated 23 November 2020.

To protect personal information, all participant data were anonymized and encoded, and only the principal investigator retained access to the corresponding identifying information. All members of the research team operated in accordance with Spain's Organic Law 3/2018, dated December 5, which upholds digital rights and data protection standards. This law ensures

participants' rights to access, amend, delete, or object to the processing of their personal data at any time.

Informed consent

Prior to enrolment, all participants provided written informed consent acknowledging their voluntary involvement in the study.

Data availability

The dataset supporting the findings of this study is stored in a secure, access-restricted database managed by ADEMA University School. The designated Data Protection Officer overseeing this process is Ángel Arturo López-González.

Conflict of interest

The authors declare that there are no conflicts of interest related to the design, execution, or publication of this study.

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