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Combined association of physical activity and depressive symptoms with cardiometabolic risk factors in Chilean adults

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Cardiometabolic risk factors such as obesity, raised blood pressure, high blood glucose and dyslipidemia are emerging health concerns worldwide. Therefore, the aim of this study was to estimate the combined association between physical activity and depressive symptoms with cardiometabolic risk factors in Chilean adults. Data was obtained from the National Health Survey of Chile 2016–2017, with a sample of 5995 adult participants. Assessment of Physical activity and depressive symptoms were done using the Global Physical Activity Questionnaire (GPAQ) and the CIDI ShortForm (CIDI-SF), respectively. Multivariable logistic regression was performed to estimate the combined association of physical activity and depressive symptoms with cardiometabolic risk factors. Participants in the category ≥ 150 min/Depressive symptoms had the highest prevalence of overweight (OR: 1.55, 95% CI: 1.17–2.05), obesity (OR: 1.97, 95% CI: 1.49–2.59) and high waist circumference (OR: 1.63, 95% CI: 1.39–1.92). Participants in the < 150 min/No depressive symptoms category had a lower prevalence of overweight/obesity (OR: 0.68, 95% CI: 0.60–0.78) and a 25% reduced high triglycerides prevalence, in comparison with the active category with no depressive symptoms. There is a positive association between depressive symptoms and overweight, obesity and waist circumference among subjects that complete physical activity recommendations but have depressive symptoms.

Keywords Physical activity, Depression, Cardiometabolic risk, Cardiometabolic disease, Obesity

In the past decades, the increase in the prevalence of cardiometabolic risk factors including general obesity, central obesity, diabetes, prediabetes, dyslipidemia and hypertension, among others, has led to a growing burden of cardiometabolic disease worldwide[1]. These cardiometabolic risk factors are emerging health concerns among adults in low and middle-income countries, as they are modifiable contributors to cardiometabolic disease and adverse outcomes, including a combination of metabolic abnormalities that increases the risk of type 2 diabetes and cardiovascular diseases (CVD)[2,3]. Cardiometabolic disorders are also linked to a rise in obesity and obesity-associated clustering of other cardiometabolic risk factors, where people with cardiometabolic multi-morbidities have an increased risk for CVD incident and all-cause mortality[4,5]. Therefore, CVD has become the leading cause of disability and death, mainly due to the aging population and unfavorable lifestyle behaviors that can lead to hypertension, dyslipidemia, diabetes as well as other non-communicable disorders[4].

Lifestyle and population behavior have been strongly related with morbidity and mortality, where physical inactivity is among the leading modifiable risk factor worldwide for CVD and all-cause mortality[6]. In this

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context, physical inactivity represents a major public health problem as nowadays almost one-third of the world's population is inactive, leading to diabetes, CVD, and a wide range of chronic diseases and premature deaths[7], with a 1.2-fold increased risk of diabetes and major CVD in physically inactive individuals[8].

Another disease that leads individuals to sedentary behaviors and physical inactivity, increasing cardiovascular risk, is depression[9,10]. Mental illnesses are prevalent in modern society with major public health implications that tend to co-occur among obesity and alterations in the cardiometabolic system, chronic status of inflammation, and tobacco abuse and their health consequences[11,12]. Thus, depressive symptoms have been considered a risk factor for metabolic syndrome and its components (waist circumference, hypertension, fasting blood glucose, triglycerides, and high-density lipoprotein cholesterol), with more likelihood to have lipid metabolism disturbances and increased body mass index (BMI) than those without depressive symptoms[13,14].

Lifestyle management approaches, such as sleep hygiene, a healthy diet, and exercise, have been considered important in the treatment of mental health disorders. Numerous studies have examined the effects of physical activity (PA) on depression, anxiety, and psychological distress, demonstrating benefits comparable to psychotherapy and pharmacotherapy[15,16]. Despite this evidence, adherence to PA recommendations remains low, and it has not been widely adopted as a therapeutic intervention for depression. Consequently, the combined impact of insufficient PA and depressive symptoms on the prevalence of cardiometabolic risk factors is still not well understood. Therefore, the aim of this study is to estimate the combined association between physical activity and depressive symptoms with cardiometabolic risk factors in Chilean adults.

Methods

Study and sample design

The data for this cross-sectional study was retrieved from the National Health Survey of Chile (*Encuesta Nacional de Salud de Chile – NHS)*, conducted between 2016 and 2017.

The NHS is a representative survey that used a complex, random, stratified and multistage probability sampling design to select participants, which included participants aged 15 and over from urban and rural areas of the fifteen regions of Chile. In the multistage sampling, counties were designed as the primary sampling units, followed by households within counties, and finally, one participant from selected households using a computational algorithm. Details of the NHS have been published elsewhere[17].

Informed consent was obtained from all subjects and/or their legal guardian(s) and all aspects of the study were in accordance with the Declaration of Helsinki and were performed in accordance with relevant guidelines and regulations. The NHS was approved by the Faculty of Medicine Ethics Committee of the Pontificia Universidad Catolica de Chile (No.16–019).

The NHS 2016–2017 included 6233 participants. In this study, we excluded adolescents aged 15 to 17 years (n= 238) and participants with missing or incomplete information on PA or depressive symptoms. Thus, our final analytical sample included 5995 adult participants with complete data (3727 women), aged between 18 and 98 years, which were grouped into two age categories (adults: 18–64 years and older adults: ≥65 years), according to the World Health Organization guidelines for PA[18].

Assessment of physical activity

Self-reported physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ), validated globally[19,20]and within the Latin American population[21]. Through its 16 questions, participants reported the duration, frequency, and intensity of physical activities performed in three domains (occupational, active commuting, and recreational). The frequency of self-reported PA was multiplied by the duration in each domain, and the results from each were summed to generate the total PA value. Participants were classified according to the WHO PA guidelines[18] as physically active (≥ 150 min/wk) or insufficiently active (< 150 min/wk).

Assessment of depressive symptoms

CIDI ShortForm (CIDI-SF) was used as a depressive symptoms screening instrument (abbreviated) as it is suitable for self-administration in cooperative non-psychotic subjects for evaluating anxiety and depression disorders[22]. It contains 30 questions about depressive symptoms, assessing these symptoms over a 12-month period. To indicate suspected depression, individuals must exhibit dysphoria and/or lack of interest, along with at least four of the following symptoms: tiredness, weight changes, sleep problems, difficulty concentrating, feeling of uselessness and thoughts of death[23]. Participants were then classified into two categories: Depressive symptoms/No depressive symptoms according to these results. The CIDI-SF has been used in general population surveys, as well as for clinical and research purposes, and has been validated in Chile, including in previous National Health Surveys[24].

Assessment of cardiometabolic risk factors

The cardiometabolic risk factors used in the present study were: BMI, waist circumference, triglycerides and cholesterol. Height was measured with a portable stadiometer with an accuracy of 0.1 cm, while weight was measured with a digital scale (Tanita HD713) with an accuracy of 0.1 kg. Weight measurements were taken barefoot, and participants were wearing light clothing[25]. BMI (kg/m^2) was then calculated and participants were classified into underweight/eutrophic (≤ 24.9 kg/m^2), overweight (≥ 25.0 kg/m^2) and obese (≥ 30.0 kg/m^2)[26]. Waist circumference was measured standing at the midpoint between the lowest rib and the iliac crest, with a non-deformable plastic band. Participants were classified as eutrophic/overweight-obesity at the cutoff point of > 88 cm for women and > 102 cm for men[17,27]. For triglycerides and cholesterol measurements, venous

blood samples were obtained after at least 8 h of fasting according to standardized methods described before[17]. Participants with triglycerides ≥ 150 mg/dL or elevated total cholesterol ≥ 200 mg/dL were considered to be at cardiometabolic risk.

Covariates

Covariates included sex (men and women); age (adults 18–64 years and older adults ≥ 65 years); geographic area (urban and rural); educational level (none, primary: <8 years to secondary: 8–12 years, and higher education: >12 years) and monthly household income (none, low: < US$ 310.00 to medium: US$ 310.00–705. 00 and high: > US$ 705.00).

Statistical analysis

Participants were classified by convenience according to WHO PA recommendations[18] and depressive symptoms according to CIDI-SF using the following combined categories: (1) ≥ 150 min/No depressive symptoms; (2) ≥ 150 min/Depressive symptoms; (3) < 150 min/No depressive symptoms and (4) < 150 min/Depressive symptoms.

Descriptive data is presented as frequency and percentages according to the combined categories of PA and depressive symptoms (≥ 150 min/No depressive symptoms, ≥ 150 min/Depressive symptoms, < 150 min/No depressive symptoms and < 150 min/Depressive symptoms). The chi-square test was used to compare the differences between combined categories of self-reported PA and depressive symptoms according to sociodemographic characteristics.

Initial data analysis was performed as a prerequisite for regression analyses. This included assessing linearity, homoscedasticity, independence and normality to confirm or refine the chosen model building strategy. These steps ensured the accurate interpretation and presentation of the modeling results[28]. Then, multivariate logistic regression models were performed (odds ratio: OR with their respective 95% confidence interval: 95% CI) to estimate the combined association of PA and depressive symptoms (independent variable) with indicators of cardiometabolic risk factors (dependent variable), including overweight, obesity, high waist circumference, high triglycerides and high cholesterol. Variables were divided by categories of PA and depressive symptoms and were adjusted by sex, age, geographic area, educational level, and monthly household income. All statistical analyses were performed with SPSS V28 software (SPSS Inc., IBM Corp., Armonk, New York, NY, USA). For all tests, a $p \leq 0.05$ was considered indicative of statistical significance.

Results

The total number of participants was 5995, after the exclusion of adolescents, with a mean age of 50.2 years (SD:18.5). Table 1 shows that, overall, 63.3% were women, 64.7% were middle age (18–64 years), 83.9% were from urban areas, 51.6% had a secondary educational level and a 70% had a low/medium income. In terms of cardiometabolic risk factors, a 68.4% had elevated BMI, 48.1% had high waist circumference, 61.6% had elevated triglycerides and 31% had elevated total cholesterol. There were statistically significant differences ($p \leq 0.05$) in sex, age, geographic area, educational level, income, bod, triglycerides and total cholesterol among the four categories of PA and depressive symptoms combined.

The least healthy category (< 150 min/Depressive symptoms) had the highest number of participants ($n = 2910$), of which the biggest proportion were women (83.4%), adults aged < 65 years (69%), with secondary educational level (49.2%) and low/medium income (69.4%). The prevalence of overweight and obesity according to BMI was high among the four categories, ranging from 70.6 to 66.9% from the healthier category to the least healthy one. High triglycerides prevalence was over 55% among the four categories, while normal total cholesterol predominated in all categories, with over 65%.

Table 2 presents the results of the combined association of PA and depressive symptoms with cardiometabolic risk factors. Participants in the category ≥ 150 min/Depressive symptoms had a higher prevalence of overweight (OR: 1.55, 95% CI: 1.17–2.05), obesity (OR: 1.97, 95% CI: 1.49–2.59) and high waist circumference (OR: 1.63, 95% CI: 1.39–1.92) compared to participants with ≥ 150 min/No depressive symptoms. There were some reductions in overweight indicators according to waist circumference, where the category < 150 min/No depressive symptoms had a lower prevalence of overweight/obesity compared to participants with ≥ 150 min/No depressive symptoms (OR: 0.68, 95% CI: 0.60–0.78). There was also a 25% reduction in high triglycerides prevalence in the < 150 min/Depressive symptoms, in comparison with the healthiest category. There were no significant combined associations with high total cholesterol.

Discussion

This study aimed to estimate the combined association of PA and depressive symptoms with cardiometabolic risk factors in Chilean adults. Our main findings showed a great number of participants who did not meet the PA guidelines (62.5%), which shows the high prevalence of insufficient PA. This correlates with a declared global prevalence of insufficient PA of 27.5%, reaching the highest levels in Latin America and the Caribbean in 2016, in women (43.7%)[29]. Thus, physical inactivity represents a major public health problem, which has been associated with obesity, diabetes, hypertension and metabolic syndrome, among several non-communicable diseases and premature mortality[30,31].

Lifestyle behaviors have been independently associated with an increased risk of major depression episodes, considering location, stressful life events, smoking, and history of chronic medical disease, contributing to a major burden of diseases within the Latin-American region[32]. Similarly, we found a high prevalence of depressive symptoms among the Chilean population, where depressive disorders are a public health concern

	Total ($n=5995$)	≥ 150 min/ No depressive symptoms ($n=453$)	≥ 150 min/ Depressive symptoms ($n=1793$)	< 150 min/ No depressive symptoms ($n=839$)	< 150 min/ Depressive symptoms ($n=2910$)	*p* value
Sex - n (%)						< 0.001
Women	3796 (63.3)	1865 (64.1)	723 (86.2)	830 (46.3)	378 (83.4)	
Men	2199 (36.7)	1045 (35.9)	116 (13.8)	963 (53.7)	75 (16.6)	
Age (years) - n (%)						< 0.001
Adults (18–64 years)	4478 (64.7)	377 (83.2)	1498 (83.5)	596 (71.0)	2007 (69.0)	
Older adults (≥ 65)	1517 (25.3)	76 (16.8)	295 (16.5)	243 (29.0)	903 (31.0)	
Geographic area						< 0.001
Urbana	5032 (83.9)	401 (88.5)	1501 (83.7)	723 (86.2)	2407 (82.7)	
Rural	963 (16.1)	52 (11.5)	292 (16.3)	116 (13.8)	503 (17.3)	
Educational level - n (%)						< 0.001
None/Primary	1527 (25.5)	80 (17.7)	365 (20.3)	241 (28.8)	841 (28.9)	
Secondary	3094 (51.6)	259 (57.2)	989 (55.2)	415 (49.5)	1431 (49.2)	
Professional	1374 (22.9)	114 (25.1)	439 (24.5)	183 (21.7)	638 (21.9)	
Income - n (%)						< 0.001
None	1086 (18.1)	64 (14.1)	329 (18.3)	135 (16.1)	558 (19.2)	
Low/Medium	4193 (70.0)	337 (74.4)	1230 (68.6)	604 (72.0)	2022 (69.4)	
High	716 (11.9)	52 (11.5)	234 (13.1)	100 (11.9)	330 (11.3)	
BMI (kg/m2) - n (%)						< 0.001
Underweight/Eutrophic	1898 (31.6)	133 (29.4)	591 (32.9)	211 (25.1)	963 (33.1)	
Overweight	2065 (34.5)	164 (36.2)	647 (36.1)	278 (33.1)	976 (33.5)	
Obese	2032 (33.9)	156 (34.4)	555 (31.0)	350 (41.8)	971 (33.4)	
Waist circumference						0.006
< 88 cm W/<102 cm M	2733 (51.9)	194 (47.1)	946 (60.0)	302 (39.6)	1291 (51.3)	
≥ 88 cm W/≥102 cm M	2534 (48.1)	218 (52.9)	631 (40.0)	461 (60.4)	1224 (48.7)	
Triglycerides						< 0.001
<150 mg/dL	2303 (38.4)	200 (44.2)	683 (38.1)	335 (39.9)	1085 (37.3)	
≥150 mg/dL	3692 (61.6)	253 (55.8)	1110 (61.9)	504 (60.1)	1825 (62.7)	
Total cholesterol						< 0.001
< 200 mg/dL	2465 (69.0)	197 (65.9)	743 (70.0)	346 (66.5)	1179 (69.7)	
≥ 200 mg/dL	1108 (31.0)	102 (34.1)	319 (30.0)	174 (33.5)	513 (30.3)	

Table 1. Sociodemographic characteristics according to combined physical activity and depressive symptoms categories in a Chilean population. BMI: body mass index; W: women; M: men. Data is presented as frequencies and percentages. *Significance value for the Chi-square test.

reaching 78.4% of the total number of participants, affecting particularly women, people with low education, and the poorer regions of the country[33].

There is ongoing debate regarding gender differences in the prevalence of depressive symptoms. It is important to recognize that sex differences in behaviors and coping styles are not absolute but tend to be more common in one sex than the other. Our findings align with previous studies, showing that females are at significantly greater risk than males for anxiety and depressive disorders, particularly during adolescence and early adulthood[34,35]. Sex differences in depression are multifactorial and likely influenced by variations in brain structure, function, and stress responsivity, as well as differences in exposure to reproductive hormones, social expectations, and life experiences. These factors may affect gene expression, contributing to sex differences in brain physiology across the lifespan[36].

According to the results, participants who completed the PA recommended guidelines[18], but had depressive symptoms (≥ 150 min/Depressive symptoms), had a 55% increased prevalence of being overweight, 97% of being obese and 63% of having high waist circumference compared to those who completed PA guidelines, but had no diagnosed depression. Thus, depressive symptoms were positively associated with obesity, independent of PA level. This suggests that in individuals with mental disorders, physical activity guidelines should be further explored to determine an appropriate dosage that can effectively reduce risk factors, such as obesity, in this population.

Evidence from epidemiological studies, clinical trials and meta-analyses support the association between obesity and adverse health outcomes among individuals with depressive disorders as both frequently co-occur in all races of populations, considering obesity as a risk factor for mood disorders and vice versa[37]. Other meta-analyses concluded that the association between depression leading to obesity was greater than that of obesity leading to depression, suggesting a bi-directional association between both conditions, where the presence of one increases the risk for developing the other[12,38].

Categories	OR	95% CI	*p* value
Overweight			
≥ 150 min/No depressive symptoms	Reference	Reference	
≥ 150 min/Depressive symptoms	1.55	1.17–2.05	0.002
< 150 min/No depressive symptoms	1.24	1.02–1.50	0.025
< 150 min/Depressive symptoms	1.53	1.08–2.18	0.017
Obesity			
≥ 150 min/No depressive symptoms	Reference	Reference	
≥ 150 min/Depressive symptoms	1.97	1.49–2.59	< 0.001
< 150 min/No depressive symptoms	1.06	0.88–1.29	0.506
< 150 min/Depressive symptoms	1.47	1.03–2.10	0.031
High waist circumference			
≥ 150 min/No depressive symptoms	Reference	Reference	
≥ 150 min/Depressive symptoms	1.63	1.39–1.92	< 0.001
< 150 min/No depressive symptoms	0.68	0.60–0.78	< 0.001
< 150 min/Depressive symptoms	1.19	0.97–1.47	0.086
High triglycerides			
≥ 150 min/No depressive symptoms	Reference	Reference	
≥ 150 min/Depressive symptoms	0.90	0.77–1.05	0.218
< 150 min/No depressive symptoms	0.94	0.83–1.06	0.341
< 150 min/Depressive symptoms	0.75	0.61–0.91	0.005
High total cholesterol			
≥ 150 min/No depressive symptoms	Reference	Reference	
≥ 150 min/Depressive symptoms	1.17	0.95–1.45	0.125
< 150 min/No depressive symptoms	0.96	0.82–1.14	0.699
< 150 min/Depressive symptoms	1.21	0.93–1.56	0.145

Table 2. Combined association of physical activity level and depressive symptoms with cardiometabolic risk factors in a Chilean population. OR: odds ratio; CI: confidence interval; 0 = eutrophic, 1 = obesity. Adjusted by sex, age, geographic area, educational level, income and BMI. $^{*}p \leq 0.05$.

Moreover, those participants who did not complete the minimum recommended PA level and had no depressive symptoms showed over 30% lower prevalence of high waist circumference compared to those who had no depressive symptoms but completed the PA guidelines, showing also the associated effect of PA levels in obesity prevalence. This relates with previous studies, showing that PA was inversely associated with the incidence of general and abdominal obesity, as well as preventing or attenuating gains in weight and waist circumference over time. There were no significant combined associations with high triglycerides and high total cholesterol[39,40].

Despite our results, depressive symptoms and depression have been related to PA level, considering PA days a week, as well as the weekly frequency of PA and strength training, suggesting a higher prevalence of depressive symptoms and depression in the inactive groups compared to the active ones, considering both sexes and all age groups[41]. In addition, significant mental health benefits from being physically active, even at levels below the public health recommendations, have been demonstrated, suggesting any increase in PA to improve mental health[42]. Thus, maintaining an appropriate level of PA for one year showed a positive effect in decreasing incident depressive symptoms[43], suggesting moderate intensity and aerobic exercise as efficacious in treating depression and depressive symptoms that should be offered as an evidence-based treatment option[15]. Similarly, depression and its consecutive negative health outcomes during aging could be countered maintaining PA levels, as a non-pharmaceutical method in treating and preventing depression in older adults[37].

One of the main limitations of this study was its cross-sectional design and the fact that variables were assessed only on one occasion. In terms of methodology, the information on lifestyle was self-reported and did not consider other objective measurements as well as obesity indicators, that were estimated by anthropometric measures and not direct ones, which can lead to misclassification bias. Also, the use of the depression symptom measure with unclear validity might have affected the high depression symptom prevalence. Lastly, our results cannot be generalized to adolescent population, since they were excluded. Among the strengths of this study, it highlights the extensive database used to represent Chilean population, which provides a better understanding of the behavior in this region.

Further research is suggested to clarify the interaction between the protective effect of PA and appropriate mental health in weight control management and cardiometabolic prevention. Finally, based on the findings, we also suggest comparative analyzes by sex, in order to deepen the understanding of the relationship between cardiometabolic risk factors, level of physical activity, and depressive symptoms.

Conclusion

There was a significant positive association between depressive symptoms and cardiometabolic risk factors independent of PA level, with a higher prevalence of overweight, obesity and high waist circumference in subjects who completed PA recommendations but have depression symptoms. More research regarding the role of PA in the relationship between depressive symptoms and cardiometabolic risk factors is needed for disease prevention.

Data availability

Data are available upon reasonable request from the corresponding author.

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Author contributions
Paloma Ferrero-Hernández, Gerson Ferrari: Conceptualization, Methodology, Software. Paloma Ferrero-Hernández, Gerson Ferrari, Claudio Farías-Valenzuela: Data curation, Writing- Original draft preparation. Leandro F. M. Rezende, Marcelo de Maio Nascimento, Adilson Marques: Visualization, Investigation, Validation: Eduardo Rossato de Victo: Writing- Reviewing and Editing.

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Declarations

Competing interests
The authors declare no competing interests.

Ethical approval
The protocol was approved by the Ethics and Research Committee of the Universidad de Santiago de Chile (USACH) (records no. 224/2022). The protocol of each wave of the National Healthy Survey from Chile was approved by the Ethics Committee of the Pontificia Universidad Católica de Chile (Pontifical Catholic University of Chile - (records no. 16–019), institution in charge of the studies. Participants signed an informed consent to take part in the study.

Additional information
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