ORIGINAL ARTICLE

Cardiorespiratory fitness as an integrative correlate of mental health in physically inactive university students: A cross-sectional study

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ABSTRACT

Physical fitness may capture functioning not reflected by self-reported physical activity. This study examined associations between fitness, anthropometric characteristics, and mental health in physically inactive university students, and whether fitness was associated with multiple mental health domains. This cross-sectional study included 135 inactive university students (77 women, 58 men; *M* = 22.5 years, *SD* = 3.2). Mental health was assessed using the Profile of Mood States, PERMA-Profiler, and Depression, Anxiety, and Stress Scale–21. Fitness measures comprised estimated VO_2max, handgrip strength, standing broad jump, and 4 × 10 m speed–agility; anthropometric indicators included body mass index, waist-to-height ratio, and neck circumference. Three principal outcomes were defined a priori; exploratory subscale analyses were corrected using the Benjamini–Hochberg false discovery rate (FDR). Sex- and age-adjusted models were complemented by multivariable and cross-validated elastic-net regression. Of 160 models, 23 reached $p < .05$ and 7 survived FDR correction. Estimated VO_2max was the only indicator associated with multiple domains: vigour (β = .429, $q = .007$), engagement (β = .364, $q = .017$), and perceived health (β = .617, $q < .001$). Perceived health was also associated with relative handgrip strength (β = .545), standing broad jump (β = .502), body mass index (β = −.363), and waist-to-height ratio (β = −.360; all qs < .001). Associations between VO_2max and the three principal outcomes were nominally significant but did not survive correction. In multivariable models, VO_2max was independently associated with well-being (β = .354, $p = .006$) and perceived health (β = .461, $p < .001$), and it was retained in every elastic-net model containing predictors. Cardiorespiratory fitness was the only fitness component associated with several mental health domains and independent of other indicators. Most subscale associations did not survive correction and remain hypothesis-generating. The cross-sectional design precludes causal or directional inference.

Keywords: cardiorespiratory fitness; mental health; university students; physical inactivity; well-being; false discovery rate.

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INTRODUCTION

Mental health encompasses emotional, psychological, and social well-being. The World Health Organization (WHO) defines it as a state in which individuals recognize their abilities, cope with normal stresses, work productively, and contribute to their community (World Health Organization, 2022). Its deterioration among university students has become a growing public health concern worldwide (He et al., 2024; Sivertsen et al., 2024).

University-related factors, including academic stress, social pressure, and uncertainty about the future, contribute to mental disorders, particularly anxiety and depression (Auerbach et al., 2018). Students report higher depression, anxiety, and psychological distress than non-university peers (Winzer et al., 2018). Approximately 31% experience a mental health problem during their academic trajectory (Auerbach et al., 2018), which may be related to limited access to effective emotional regulation strategies (Liu et al., 2025). Moreover, more than half experience some level of stress, anxiety, or depression (Bayram & Bilgel, 2008; Chen et al., 2013; Keyes et al., 2012; Regehr et al., 2013).

University students' mood is particularly affected by academic stress, sleep deprivation, and social pressure, increasing the likelihood of mood disorders (Antúnez & Vinet, 2012). These alterations affect academic performance and quality of life, with students living with obesity (Wang et al., 2022) and those who are physically inactive (Santana et al., 2023) being especially vulnerable.

Physical activity is widely recognized as a protective factor for mental health. Prospective evidence indicates that higher physical activity precedes lower incidence of depression (Schuch et al., 2018), and meta-reviews position exercise among the best-supported lifestyle interventions in psychiatry (Firth et al., 2020; Stubbs et al., 2018). Mechanistic reviews attribute these effects to a combination of physiological and psychological pathways (Mikkelsen et al., 2017), and Morgan (2013) suggested that physical activity may be comparable to conventional interventions for preventing and treating emotional disorders.

Physical activity and physical fitness are, however, distinct constructs, and this distinction is central to the present study. Physical activity is a behaviour—what a person does—and is typically captured by self-report over a short recall window, with well-documented measurement error and social-desirability bias. Physical fitness is a physiological phenotype—what a person is currently capable of—and integrates accumulated activity, genetic endowment, body composition, and adaptive capacity into an objectively measurable trait that is relatively stable over weeks to months (Åvitsland et al., 2020; Ortega et al., 2010). Two students reporting identical inactivity may therefore differ substantially in fitness. This matters here because the sample is restricted to inactive students: by design, behavioural variation is compressed, while fitness variation is preserved. Any association observed in this sample is thus attributable to fitness rather than to current activity behaviour, which is precisely the contrast that most of the existing literature cannot isolate.

Supporting this distinction, physical fitness was associated with mental health in 6,724 Chinese university students (Hong et al., 2024), while lower fitness was associated with higher anxiety, depression, and stress among 1,400 Norwegian adolescents (Åvitsland et al., 2020).

The American College of Sports Medicine (2021) defines physical fitness as the ability to perform daily activities with vigour and alertness, without undue fatigue, and with sufficient energy for leisure and unforeseen situations. Among its components, cardiorespiratory fitness and muscular strength have consistently shown associations with lower depression and anxiety (Ortega et al., 2010). Low

cardiorespiratory fitness has been associated with greater psychological distress (Oliveira et al., 2019), elevated stress (Kettunen et al., 2014), and common mental disorders (Dishman et al., 2012; Kandola et al., 2019; Loprinzi et al., 2017; Suija et al., 2013; Tolmunen et al., 2006). Higher muscular strength has been linked to lower depression risk (Marques et al., 2020). Notably, when cardiorespiratory fitness and grip strength are modelled jointly in large prospective cohorts, cardiorespiratory fitness carries most of the association with subsequent common mental disorders (Kandola et al., 2020), raising the possibility that fitness components are not interchangeable markers.

Anthropometric characteristics, understood as the balance between muscle and fat mass, have also been related to mental health. Less favourable anthropometric indicators have been associated with higher stress, anxiety, and depression in university students, a population exposed to social pressure regarding body image (Alfaro-González et al., 2025; Alghawrien et al., 2022).

Despite this evidence, most studies have been conducted in general populations and international contexts, have examined one fitness component at a time, and have rarely accounted for the strong intercorrelation among fitness and anthropometric indicators. Limited evidence exists on how these indicators are jointly related to different mental health domains in physically inactive university students, particularly in Latin America.

In Chile, depression and anxiety are the most prevalent disorders among university students, with rates exceeding those of the general population (Martínez-Líbano et al., 2023). Therefore, this study aimed (i) to estimate the associations between physical fitness, anthropometric characteristics, and mood profile, well-being, and affective states in physically inactive Chilean university students, and (ii) to determine which of these indicators, if any, remains associated with mental health once multiple testing and the shared variance among fitness indicators are accounted for. Because the design is cross-sectional, all objectives are framed as associational and no directional hypothesis is tested.

METHOD

Study design

A cross-sectional study was conducted within the Active-U Project, which examines exercise, physical fitness, and well-being in physically inactive Chilean university students. Data were collected between July and December 2022. The study was approved by the Ethics Committee of the Youth Studies Center at Andrés Bello University (Record 2022-15), and all participants provided written informed consent in accordance with the Declaration of Helsinki (World Medical Association, 2013).

Participants

The analytic sample comprised 135 Chilean university students (77 women and 58 men; *M* = 22.5 years, *SD* = 3.2). Inclusion criteria were (a) current university enrolment, (b) age 18–45 years, and (c) self-reported physical inactivity, defined as not meeting the World Health Organization physical activity guidelines (fewer than 150 min/week of moderate-intensity physical activity or fewer than 75 min/week of vigorous-intensity physical activity; Bull et al., 2020). Students enrolled in Physical Education Teacher Education, Sports Coaching, or programmes with practical sport-related courses were excluded, as were individuals with contraindications to physical fitness testing. The sample was concentrated in the early twenties (median = 22 years), with 17 participants older than 24 years.

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Recruitment and testing procedures

Participants were recruited through social media and institutional emails targeting university students in the Valparaíso Region. Interested individuals completed an online registration form to verify university enrolment, age, and self-reported physical activity level.

Eligible participants received standardized pre-assessment instructions by email, including recommendations on hydration, rest, and fasting for at least 90 minutes before the appointment. All assessments were conducted during a single in-person session in a standardized university gymnasium. Participants first completed the mental health questionnaires on university computers, followed by anthropometric assessment (body mass, height, waist circumference, and neck circumference). After a guided warm-up, they performed the physical fitness tests in a fixed order: handgrip strength, standing broad jump, 4 × 10 m speed–agility shuttle run, and 20 m shuttle-run test.

Physical fitness and anthropometric assessment

Physical fitness was assessed using field-based tests from the ALPHA-Fitness battery (Ruiz et al., 2011a, 2011b). Cardiorespiratory fitness was estimated with the 20 m shuttle-run test, and VO_2max was calculated from the final running speed using the following equation: $VO_2\text{max} = 5.857 \times \text{speed}\ (\text{km}\cdot\text{h}^{-1}) - 19.458$ (Léger & Lambert, 1982). This value was estimated rather than measured directly: It was derived from a performance-based prediction equation and therefore incorporated both the biological error of the shuttle-run protocol (pacing strategy, motivation, familiarity, footwear, and surface) and the error of the prediction equation itself, which was developed using samples that differed from the present sample. Estimated and directly measured VO_2max are correlated but not interchangeable, and the resulting nondifferential measurement error would be expected to attenuate rather than inflate associations. This limitation was considered explicitly when interpreting all cardiorespiratory findings. Muscular strength was assessed with a Jamar Plus+ digital dynamometer (range, 0–90 kg; resolution, 0.1 kg). Two trials were performed with each hand, and mean and relative handgrip strength ($\text{kg}\cdot\text{kg}^{-1}$) were calculated. Lower-limb power was assessed with the standing broad jump, and speed–agility was assessed with the 4 × 10 m shuttle-run test. Speed–agility times were sign-inverted before analysis so that higher values denoted better performance, consistent with the direction of the other fitness indicators. One participant had a recorded value of exactly 0 s, which is not physically attainable in this test; this value was treated as missing rather than as a valid observation.

Anthropometry followed ISAK/GREC protocols. Body mass was measured with a SECA 803 scale (0.1 kg), height with a portable SECA stadiometer, and waist and neck circumferences with a Lufkin® metallic tape. Body mass index (BMI) was calculated as $\text{kg}\cdot\text{m}^{-2}$, and waist-to-height ratio (WHtR) as waist circumference divided by height.

Mental health measures

Mood profile

Mood profile was assessed using the Profile of Mood States, long form (POMS-65; McNair et al., 1992), with a Likert scale ranging from 0 to 4. The instrument evaluates tension, depression, anger, vigour, fatigue, friendliness, and confusion. Total mood disturbance was calculated by summing the negative subscales (tension, depression, anger, fatigue, and confusion) and subtracting the positive subscales (vigour and friendliness), following the Spanish adaptation (Arce et al., 2000).

Well-being

Psychological well-being was assessed using the PERMA-Profiler, a 23-item instrument scored from 0 to 10 that evaluates Positive Emotion, Engagement, Positive Relationships, Meaning, Accomplishment, Health,

Loneliness, Happiness, and Negative Emotion (Butler & Kern, 2016). An overall well-being score was computed as the mean of the five PERMA domains plus happiness. Loneliness is scored so that higher values denote greater loneliness; this direction was verified against the expected pattern of correlations with negative emotion (r = .46) and positive relationships (r = −.44) before analysis.

Affective states

Affective states were assessed using the abbreviated Depression, Anxiety, and Stress Scales (DASS-21; Román, 2010), validated in Chilean university students (Antúnez & Vinet, 2012). This 21-item instrument includes Depression, Anxiety, and Stress subscales scored from 0 to 3.

Statistical analysis

Analyses were conducted in Python 3.11 (pandas, statsmodels, scikit-learn) with a fixed random seed (42) to ensure exact reproducibility; the analysis script and derived outputs are provided as supplementary material. Continuous variables are summarized as mean, standard deviation, and 95% confidence interval.

Principal and exploratory outcomes

The study was not pre-registered. To limit the influence of multiple testing on interpretation, three principal outcomes were designated—one global score per instrument: POMS total mood disturbance, PERMA overall well-being, and DASS-21 depression. All remaining subscale-level analyses (POMS subscales, individual PERMA dimensions, and DASS-21 anxiety and stress) are reported as exploratory and are interpreted as hypothesis-generating.

Single-predictor models

Each of eight independent variables (estimated VO_2max, absolute handgrip strength, relative handgrip strength, standing broad jump, speed–agility, BMI, WHtR, and neck circumference) was regressed on each of 20 mental health outcomes in separate linear models adjusted for sex and age, yielding 160 models. All continuous variables were standardized; therefore, the coefficients are standardized regression coefficients (βs) expressed in *SD* units and are directly comparable across predictors. Complete-case analysis was used for each model, so the sample size varied from 129 to 135.

Control of multiple testing

Because 160 tests were performed, the Benjamini–Hochberg false discovery rate procedure was applied within each instrument family (POMS, PERMA, and DASS-21), with a secondary correction applied across all 160 tests simultaneously (Benjamini & Hochberg, 1995). Both nominal p values and FDR-adjusted q values are reported for every model in Tables 2–4, and only associations with q < .05 are described as robust. This deliberately conservative choice was intended to distinguish findings that remained stable after adjustment for multiplicity from those that did not, rather than to maximize the number of statistically significant results.

Collinearity and multivariable models

Fitness and anthropometric indicators are strongly intercorrelated, so single-predictor models cannot establish independence. Variance inflation factors (VIFs) were therefore computed for a model containing all eight indicators plus sex and age. For the three principal outcomes and for perceived health (the outcome with the largest number of robust associations), a multivariable linear model entering all eight indicators, sex, and age simultaneously was fitted. Because collinearity inflates standard errors and destabilizes coefficient signs in such models, these were complemented by elastic-net regression with the penalty parameter and the L1/L2 mixing parameter selected by 10-fold cross-validation over a grid of l1-ratios (0.1–1.0) and 200

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candidate alphas (Zou & Hastie, 2005). Elastic net was chosen over LASSO alone because it handles groups of correlated predictors more gracefully, retaining or discarding them together rather than arbitrarily selecting one.

Significance was set at $p < .05$ for nominal tests and $q < .05$ after FDR adjustment. Given the cross-sectional design, all estimates are reported and interpreted as associations; no causal or directional language is used.

RESULTS

Sample characteristics

Table 1 presents sample characteristics for the 135 participants (77 women, 58 men; *M* = 22.54 years, *SD* = 3.17). BMI was *M* = 25.58 kg·m^{-2}, *SD* = 3.86, and estimated VO_2max was *M* = 31.91 mL·kg^{-1}·min^{-1}, *SD* = 6.62, values consistent with an inactive young-adult sample. Participants showed a handgrip strength of *M* = 37.59 kg, *SD* = 10.91, standing broad jump of *M* = 161.13 cm, *SD* = 37.56, and 4 × 10 m speed–agility time of *M* = 12.86 s, *SD* = 1.37. Mean scores were *M* = 43.15, *SD* = 25.50 for POMS total mood disturbance, *M* = 7.29, *SD* = 1.29 for PERMA overall well-being, and DASS-21 depression (*M* = 4.97, *SD* = 4.20), anxiety (*M* = 4.90, *SD* = 3.93), and stress (*M* = 5.40, *SD* = 3.63).

Table 1. Descriptive characteristics of the analytic sample (N = 135).

Variable	n	Mean	SD	95% CI lower	95% CI upper
Age (years)	135	22.54	3.17	22.01	23.07
Weight (kg)	135	69.61	12.07	67.57	71.64
Height (m)	135	1.65	0.09	1.63	1.66
Neck circumference (cm)	135	34.13	3.26	33.58	34.68
Waist circumference (cm)	135	79.55	9.37	77.97	81.13
BMI (kg·m^{-2})	135	25.58	3.86	24.93	26.23
WHtR	135	0.48	0.06	0.47	0.49
VO_{2max} (mL·kg^{-1}·min^{-1})	135	31.91	6.62	30.79	33.03
Speed-agility 4 × 10 m (s)	134	12.86	1.37	12.63	13.09
Handgrip mean (kg)	135	37.59	10.91	35.75	39.43
Relative handgrip (kg·kg^{-1})	135	0.54	0.13	0.52	0.56
Standing broad jump (cm)	134	161.13	37.56	154.77	167.49
POMS: Total mood disturbance	135	43.15	25.50	38.85	47.45
POMS: Tension	130	11.35	4.42	10.59	12.11
POMS: Depression	130	15.73	12.15	13.64	17.82
POMS: Anger	130	6.62	4.74	5.81	7.44
POMS: Vigor	130	18.65	5.94	17.62	19.67
POMS: Fatigue	130	6.42	4.06	5.72	7.11
POMS: Confusion	130	6.52	3.32	5.95	7.09
POMS: Friendliness	130	16.82	3.89	16.15	17.48
PERMA: Overall well-being	134	7.29	1.29	7.07	7.51
PERMA: Positive emotion	134	6.97	1.41	6.73	7.21
PERMA: Engagement	134	7.70	1.44	7.45	7.94
PERMA: Relationships	134	7.55	1.53	7.29	7.81
PERMA: Meaning	134	7.36	1.79	7.05	7.66
PERMA: Accomplishment	134	6.82	1.43	6.58	7.07
PERMA: Happiness	134	7.32	1.61	7.05	7.59
PERMA: Loneliness	134	4.04	2.71	3.59	4.50
PERMA: Health	134	4.97	2.42	4.56	5.37
DASS-21: Depression	134	4.97	4.20	4.26	5.68
DASS-21: Anxiety	134	4.90	3.93	4.23	5.56
DASS-21: Stress	135	5.40	3.63	4.79	6.01

Note. The table presents means, standard deviations, and 95% confidence intervals. Sample size varies because of item-level missing data. BMI = body mass index; WHtR = waist-to-height ratio; VO_2max = estimated maximal oxygen uptake; POMS = Profile of Mood States; PERMA = PERMA-Profiler; DASS-21 = Depression, Anxiety and Stress Scale–21. Speed–agility was sign-inverted so that higher values denote better performance; one record with a value of exactly 0 s was recoded as missing.

Overview of multiplicity

Across the 160 single-predictor models adjusted for sex and age, 23 associations (14.4%) reached the nominal threshold of $p < .05$. After Benjamini–Hochberg correction within instrument families, 7 associations (4.4%) retained $q < .05$; the same 7 survived correction across all 160 tests simultaneously. All 160 estimates, with nominal p values and q values, are reported in Tables 2–4 so that the full testing burden is visible. The results below are organised around this distinction: associations that survived correction are described as robust, and the remainder are described as exploratory.

Associations with mood profile (POMS)

One association survived FDR correction: higher estimated VO_2max was associated with higher vigour (β = .429, 95% CI [0.217, 0.642], $p < .001$, $q = .007$). Standing broad jump was also positively associated with vigour (β = .307, $p = .017$) but did not survive correction ($q = .500$).

At the nominal level, higher VO_2max was associated with lower total mood disturbance (β = −.226, $p = .047$) and lower depression (β = −.254, $p = .029$), and better speed–agility with lower total mood disturbance (β = −.212, $p = .032$); none survived correction (all $q = .500$). Relative handgrip strength was negatively associated with friendliness (β = −.241, $p = .042$, $q = .500$). No association between anthropometric indicators and POMS outcomes reached the nominal threshold.

Table 2. Sex- and age-adjusted linear regression models for physical fitness, anthropometric characteristics and mood profile (POMS).

Variable	Total mood disturbance	Tension	Depression	Anger	Vigor	Fatigue	Confusion	Friendliness
Neck circumference	0.125 (.339; .803)	−0.072 (.589; .983)	0.153 (.244; .718)	−0.020 (.881; .983)	−0.005 (.967; .983)	0.026 (.841; .983)	−0.050 (.704; .983)	0.137 (.287; .788)
BMI	0.101 (.243; .718)	−0.046 (.610; .983)	0.122 (.168; .685)	0.007 (.942; .983)	−0.014 (.867; .983)	0.041 (.646; .983)	0.006 (.943; .983)	0.113 (.193; .685)
WHtR	0.075 (.390; .892)	−0.091 (.308; .788)	0.091 (.304; .788)	−0.035 (.694; .983)	0.004 (.968; .983)	0.018 (.836; .983)	−0.015 (.861; .983)	0.123 (.157; .685)
VO_{2max}	−0.226* (.047; .500)	0.063 (.593; .983)	−0.254* (.029; .500)	0.117 (.320; .788)	0.429***† (<.001; .007)	−0.193 (.098; .607)	−0.064 (.583; .983)	0.181 (.113; .607)
Speed–agility	−0.212* (.032; .500)	−0.162 (.113; .607)	−0.157 (.122; .607)	−0.169 (.097; .607)	0.131 (.186; .685)	−0.082 (.420; .897)	−0.135 (.183; .685)	0.044 (.660; .983)
Handgrip (absolute)	−0.061 (.695; .983)	−0.012 (.940; .983)	0.017 (.912; .983)	−0.058 (.715; .983)	−0.069 (.653; .983)	−0.075 (.634; .983)	0.033 (.834; .983)	−0.236 (.123; .607)
Handgrip (relative)	−0.186 (.118; .607)	−0.037 (.765; .983)	−0.155 (.204; .687)	−0.042 (.735; .983)	0.008 (.948; .983)	−0.141 (.247; .718)	−0.008 (.945; .983)	−0.241* (.042; .500)
Standing broad jump	−0.109 (.405; .893)	0.032 (.813; .983)	0.003 (.985; .985)	−0.026 (.848; .983)	0.307* (.017; .500)	−0.069 (.607; .983)	0.017 (.900; .983)	0.080 (.545; .983)

*Note. Each cell reports the standardised regression coefficient (β), followed by the nominal p value and the Benjamini–Hochberg-adjusted q value in parentheses (p; q). All models were adjusted for sex and age; sample size ranged from 129 to 135. * p < .05. ** p < .01. *** p < .001. † q < .05 (survived correction for multiple testing). BMI = body mass index; WHtR = waist-to-height ratio. Speed–agility was sign-inverted so that higher values denoted better performance; a positive β therefore indicates an association between better performance and a higher outcome score.*

Associations with well-being (PERMA-Profiler)

Perceived health accounted for 5 of the 7 robust associations in the study. Higher estimated VO_2max (β = .617, $q < .001$), higher relative handgrip strength (β = .545, $q < .001$), longer standing broad jump (β = .502, $q < .001$), lower BMI (β = −.363, $q < .001$), and lower WHtR (β = −.360, $q < .001$) were all associated with higher perceived health. Smaller neck circumference (β = −.331, $p = .009$), higher absolute handgrip strength (β = .343, $p = .023$), and better speed–agility (β = .195, $p = .044$) were nominally associated but did not survive correction (q = .092, .127, and .199).

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The remaining robust association was between VO_2max and engagement (β = .364, *q* = .017). At the nominal level, VO_2max was also associated with overall well-being (β = .281, *p* = .014), meaning (β = .277, *p* = .016), and positive emotion (β = .255, *p* = .026); none survived correction (*q* = .106–.132). Accomplishment was nominally associated with neck circumference (β = .316, *p* = .015), better speed–agility (β = .247, *p* = .013), and WHtR (β = .204, *p* = .019), with *q* values of .106, .106, and .115, respectively.

Higher VO_2max was associated with *lower* loneliness (β = −.250, *p* = .030, *q* = .143), a direction consistent with the wider literature on social isolation and health; the association does not survive correction for multiple testing.

Table 3. Sex- and age-adjusted linear regression models for physical fitness, anthropometric characteristics and well-being (PERMA-Profiler).

Variable	Overall well-being	Positive emotion	Engagement	Relationships	Meaning
Neck circumference	0.115 (.381; .735)	0.064 (.625; .835)	0.092 (.483; .737)	−0.117 (.369; .735)	0.118 (.369; .735)
BMI	0.032 (.718; .924)	−0.000 (1.000; 1.000)	−0.006 (.945; .993)	−0.060 (.491; .737)	0.022 (.801; .943)
WHtR	0.076 (.386; .735)	0.046 (.598; .835)	0.016 (.853; .959)	−0.024 (.779; .943)	0.063 (.471; .737)
VO_{2max}	0.281* (.014; .106)	0.255* (.026; .132)	0.364**† (.001; .017)	0.174 (.131; .409)	0.277* (.016; .106)
Speed–agility	0.170 (.088; .327)	0.165 (.095; .327)	0.185 (.064; .269)	−0.001 (.989; 1.000)	0.155 (.121; .397)
Handgrip (absolute)	−0.076 (.623; .835)	−0.104 (.502; .737)	−0.135 (.388; .735)	−0.121 (.433; .737)	−0.106 (.497; .737)
Handgrip (relative)	−0.014 (.910; .993)	−0.007 (.956; .993)	−0.005 (.966; .993)	0.037 (.758; .943)	−0.046 (.702; .919)
Standing broad jump	0.139 (.289; .719)	0.130 (.319; .735)	0.155 (.238; .615)	0.102 (.435; .737)	0.072 (.583; .835)
Variable	**Accomplishment**	**Happiness**	**Loneliness**	**Health**	
Neck circumference	0.316* (.015; .106)	0.112 (.387; .735)	0.031 (.816; .943)	−0.331** (.009; .092)	
BMI	0.120 (.170; .510)	0.083 (.340; .735)	0.023 (.794; .943)	−0.363***† (<.001; <.001)	
WHtR	0.204* (.019; .115)	0.081 (.351; .735)	0.073 (.404; .737)	−0.360***† (<.001; <.001)	
VO_{2max}	0.149 (.199; .573)	0.196 (.085; .327)	−0.250* (.030; .143)	0.617***† (<.001; <.001)	
Speed–agility	0.247* (.013; .106)	0.117 (.239; .615)	−0.022 (.825; .943)	0.195* (.044; .199)	
Handgrip (absolute)	0.076 (.626; .835)	0.010 (.949; .993)	−0.116 (.457; .737)	0.343* (.023; .127)	
Handgrip (relative)	−0.029 (.809; .943)	−0.012 (.918; .993)	−0.091 (.449; .737)	0.545***† (<.001; <.001)	
Standing broad jump	0.094 (.478; .737)	0.154 (.235; .615)	−0.219 (.094; .327)	0.502***† (<.001; <.001)	

*Note. Each cell reports the standardised regression coefficient (β), followed by the nominal p value and the Benjamini–Hochberg-adjusted q value in parentheses (p; q). All models were adjusted for sex and age; sample size ranged from 133 to 134. * p < .05. ** p < .01. *** p < .001. † q < .05. Overall well-being was calculated as the mean of the five PERMA domains and happiness. Loneliness was scored so that higher values denoted greater loneliness; a negative β therefore indicates an association between higher fitness and lower loneliness. Speed–agility was sign-inverted so that higher values denoted better performance.*

Associations with affective states (DASS-21)

No association with DASS-21 outcomes survived FDR correction, and only one reached the nominal threshold: higher VO_2max was associated with lower depression (β = −.272, *p* = .017, *q* = .409). Neck circumference showed a borderline association with anxiety (β = .242, *p* = .059) and speed–agility with lower stress (β = −.152, *p* = .119), neither reaching significance.

Table 4. Sex- and age-adjusted linear regression models for physical fitness, anthropometric characteristics and affective states (DASS-21).

Variable	Depression	Anxiety	Stress
Neck circumference	0.191 (.143; .438)	0.242 (.059; .438)	0.119 (.352; .603)
BMI	0.114 (.191; .438)	0.124 (.148; .438)	0.023 (.784; .849)
WHtR	0.112 (.196; .438)	0.091 (.291; .537)	−0.010 (.911; .911)
VO_{2max}	−0.272* (.017; .409)	−0.097 (.395; .631)	−0.052 (.643; .849)
Speed–agility	−0.127 (.201; .438)	−0.024 (.810; .849)	−0.152 (.119; .438)
Handgrip (absolute)	−0.060 (.700; .849)	0.219 (.152; .438)	0.043 (.779; .849)
Handgrip (relative)	−0.158 (.186; .438)	−0.051 (.670; .849)	−0.054 (.647; .849)
Standing broad jump	−0.194 (.136; .438)	0.031 (.814; .849)	−0.139 (.279; .537)

*Note. Each cell reports the standardised regression coefficient (β), followed by the nominal p value and the Benjamini–Hochberg-adjusted q value in parentheses (p; q). All models were adjusted for sex and age; sample size ranged from 133 to 135. * p < .05. ** p < .01. No association survived false discovery rate correction. Speed–agility was sign-inverted so that higher values denoted better performance.*

Collinearity, multivariable and penalized models

Fitness and anthropometric indicators were strongly intercorrelated (r = .90 between BMI and WHtR, r = .82 between absolute handgrip strength and sex, and r = .82 between absolute and relative handgrip strength). Variance inflation factors (VIFs) in the full model confirmed substantial redundancy: neck circumference, 8.99; BMI, 13.53; WHtR, 8.53; VO_2max, 2.21; speed–agility, 1.52; mean handgrip strength, 24.34; relative handgrip strength, 17.96; standing broad jump, 3.12; sex, 6.41; and age, 1.16. Absolute and relative handgrip strength, BMI, neck circumference, and WHtR exceeded conventional thresholds, whereas estimated VO_2max and speed–agility were largely independent of the remaining predictors, as was age. Single-predictor estimates for the strength and anthropometric variables must therefore be interpreted as partially reflecting shared variance.

When all eight indicators, sex, and age were entered simultaneously (Table 5), the model for POMS total mood disturbance was not significant overall (R^2 = .097, p = .233) and no predictor retained an independent association; elastic-net regression shrank every coefficient to zero for this outcome, selecting the null model. The model for DASS-21 depression was likewise non-significant (R^2 = .078, p = .425), with VO_2max the strongest remaining term (β = −.212, p = .105); elastic net retained 5 of 10 terms, all with small coefficients and VO_2max the largest among the fitness indicators (−0.163).

For PERMA overall well-being, the multivariable model was significant (R^2 = .138, p = .046) and estimated VO_2max was the only indicator with an independent association (β = .354, 95% CI [0.105, 0.602], p = .006). Absolute handgrip strength carried a large negative coefficient (β = −.750, p = .073) that should be treated as a consequence of collinearity (VIF = 24.34) rather than as a finding: it is not reproduced in the single-predictor model (β = −.076, p = .623) and reverses sign relative to relative handgrip strength in the same model. For perceived health, the multivariable model explained substantially more variance (R^2 = .390, p < .001), with VO_2max (β = .461, p < .001) and sex (β = −1.101, p = .003) independently associated. Age was not independently associated with any outcome.

Elastic-net regression pointed in the same direction. Estimated VO_2max was retained in every model in which any variable was retained (0.309 for overall well-being, 0.386 for perceived health, and −0.163 for DASS-21

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depression), and it carried the largest fitness coefficient for perceived health and for DASS-21 depression. For overall well-being the largest fitness loading was instead the negative coefficient of absolute handgrip strength (−0.419), which is the same collinearity artefact identified above: it reverses sign relative to relative handgrip strength (0.207) in the same model and is not reproduced in the single-predictor analysis. Speed–agility and standing broad jump also retained non-zero coefficients in these three models.

Table 5. Multivariable and elastic-net models for the three principal outcomes and for perceived health.

Outcome	Predictor	β [95% CI]	*p*	Elastic-net β
POMS total mood disturbance	Neck circumference	0.040 [−0.468, 0.549]	.875	—
POMS total mood disturbance	BMI	0.048 [−0.576, 0.672]	.879	—
POMS total mood disturbance	WHtR	−0.171 [−0.667, 0.324]	.495	—
POMS total mood disturbance	VO_{2max}	−0.182 [−0.434, 0.070]	.155	—
POMS total mood disturbance	Speed–agility	−0.196 [−0.405, 0.014]	.067	—
POMS total mood disturbance	Handgrip (absolute)	0.249 [−0.588, 1.086]	.558	—
POMS total mood disturbance	Handgrip (relative)	−0.317 [−1.036, 0.402]	.384	—
POMS total mood disturbance	Standing broad jump	0.043 [−0.257, 0.343]	.776	—
POMS total mood disturbance	Sex (male)	0.466 [−0.402, 1.334]	.290	—
POMS total mood disturbance	Age	0.027 [−0.031, 0.084]	.363	—
PERMA overall well-being	Neck circumference	0.377 [−0.120, 0.873]	.136	0.161
PERMA overall well-being	BMI	0.080 [−0.531, 0.692]	.796	−0.017
PERMA overall well-being	WHtR	0.139 [−0.347, 0.624]	.573	0.190
PERMA overall well-being	VO_{2max}	0.354 [0.105, 0.602]	.006	0.309
PERMA overall well-being	Speed–agility	0.104 [−0.101, 0.309]	.318	0.109
PERMA overall well-being	Handgrip (absolute)	−0.750 [−1.572, 0.072]	.073	−0.419
PERMA overall well-being	Handgrip (relative)	0.494 [−0.215, 1.202]	.170	0.207
PERMA overall well-being	Standing broad jump	0.131 [−0.162, 0.425]	.378	0.084
PERMA overall well-being	Sex (male)	−0.717 [−1.568, 0.133]	.097	−0.383
PERMA overall well-being	Age	−0.014 [−0.070, 0.043]	.631	−0.019
DASS-21 depression	Neck circumference	0.200 [−0.314, 0.713]	.442	0.107
DASS-21 depression	BMI	0.083 [−0.549, 0.716]	.794	—
DASS-21 depression	WHtR	−0.146 [−0.648, 0.357]	.567	—
DASS-21 depression	VO_{2max}	−0.212 [−0.469, 0.045]	.105	−0.163
DASS-21 depression	Speed–agility	−0.082 [−0.294, 0.131]	.447	−0.058
DASS-21 depression	Handgrip (absolute)	−0.050 [−0.900, 0.800]	.908	—
DASS-21 depression	Handgrip (relative)	0.001 [−0.732, 0.733]	.999	—
DASS-21 depression	Standing broad jump	−0.084 [−0.387, 0.220]	.587	−0.018
DASS-21 depression	Sex (male)	0.164 [−0.715, 1.044]	.712	—
DASS-21 depression	Age	0.033 [−0.026, 0.091]	.271	0.033
PERMA perceived health	Neck circumference	0.218 [−0.200, 0.635]	.304	—
PERMA perceived health	BMI	−0.395 [−0.909, 0.120]	.131	−0.180
PERMA perceived health	WHtR	0.118 [−0.290, 0.526]	.568	—
PERMA perceived health	VO_{2max}	0.461 [0.251, 0.670]	<.001	0.386
PERMA perceived health	Speed–agility	0.049 [−0.124, 0.221]	.578	0.043
PERMA perceived health	Handgrip (absolute)	0.056 [−0.635, 0.747]	.872	—
PERMA perceived health	Handgrip (relative)	0.130 [−0.466, 0.726]	.667	0.128
PERMA perceived health	Standing broad jump	0.203 [−0.044, 0.450]	.107	0.122
PERMA perceived health	Sex (male)	−1.101 [−1.816, −0.386]	.003	−0.360
PERMA perceived health	Age	0.013 [−0.034, 0.061]	.579	0.008

Note. Multivariable models entered all eight fitness and anthropometric indicators plus sex and age simultaneously; β = standardized beta with 95% confidence interval. Model R^2: POMS total mood disturbance = .097 (p = .233); PERMA overall well-being = .138 (p = .046); DASS-21 depression = .078 (p = .425); PERMA perceived health = .390 (p < .001). Elastic-net coefficients are from models with the penalty and L1/L2 mixing parameters selected by 10-fold cross-validation; an em-dash denotes a coefficient shrunk to zero. Speed–agility was sign-inverted so that higher values denote better performance.

DISCUSSION

This study examined associations between physical fitness, anthropometric characteristics, and mental health indicators in physically inactive Chilean university students, with explicit control of multiple testing and

of the shared variance among fitness indicators. Three findings organize the interpretation. First, most subscale-level associations did not survive correction for multiple testing: 23 of 160 models reached nominal significance but only 7 retained $q < .05$. Second, of the eight indicators examined, only estimated cardiorespiratory fitness was associated with more than one distinct mental health domain after correction, and it was the only indicator that survived adjustment for the other fitness and anthropometric variables and was retained by penalized regression in every model in which any predictor was retained. Third, the largest and most consistent associations of any physical variable were with perceived health rather than with mood or affective symptoms.

Cardiorespiratory fitness as an integrative rather than a specific correlate

Taken together, these results are consistent with a specific reading: cardiorespiratory fitness behaves less like one physical attribute among several and more like an integrative marker of current functional capacity, which is in turn reflected across several psychological domains. The evidence for this reading is structural rather than rhetorical. Estimated VO_2max was the only indicator to appear across the mood (vigour), well-being (engagement) and perceived-health domains after correction; among the fitness variables only it and speed–agility had acceptable variance inflation factors, meaning that its association is not merely a projection of body size or sex; and it was retained by cross-validated elastic net in every model in which any variable was retained. Muscular strength and anthropometric indicators, by contrast, were associated exclusively with perceived health, and their apparent breadth in single-predictor models dissolved once collinearity was accounted for.

This pattern is consistent with prospective cohort evidence in which cardiorespiratory fitness and grip strength were modelled jointly and cardiorespiratory fitness carried most of the association with subsequent common mental disorders (Kandola et al., 2020), and with meta-analytic evidence that cardiorespiratory fitness is inversely related to depressive symptom severity across clinical and non-clinical samples (Kandola et al., 2019; Papasavvas et al., 2016). It should be emphasized, however, that the present design cannot distinguish between fitness contributing to psychological functioning and psychological functioning permitting the accumulation of activity that maintains fitness. Both readings are equally compatible with the data, and a third — that a shared third factor such as sleep, illness burden or socioeconomic position drives both — cannot be excluded.

A biopsychosocial account of why cardiorespiratory fitness might behave this way

If the association is not artefactual, several non-exclusive mechanisms operating at different levels of the biopsychosocial model could plausibly generate it, and the pattern of results here is informative about which are more likely.

At the biological level, aerobic capacity is a systemic phenotype reflecting cardiac output, peripheral oxygen extraction, autonomic regulation, and mitochondrial function. Higher cardiorespiratory fitness is associated with greater parasympathetic tone and with attenuated physiological and psychological reactivity to laboratory and real-life stressors (Gerber et al., 2026; Mücke et al., 2020), and aerobic training increases hippocampal volume and circulating neurotrophic factors (Erickson et al., 2011). A student with higher aerobic capacity may therefore mount a smaller and more rapidly resolved stress response to the same academic demand — a stress-buffering account rather than a mood-elevating one.

At the psychological level, aerobic capacity is the fitness component most directly experienced in daily life. Climbing stairs, walking between campus buildings, and sustaining attention through a long day all draw on it, and doing so without undue fatigue provides recurrent evidence of one's own competence. This is a

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plausible route to the specific domains that survived correction here: vigour is, by construction, the subjective correlate of available energy, and engagement requires the sustained effortful attention that fatigue erodes. It also explains why perceived health showed by far the strongest associations — perceived health is the psychological construct that most directly interrogates bodily capacity, and every fitness indicator was associated with it in single-predictor models.

At the social level, the account is weaker in this dataset and should be stated as such. If fitness operated primarily by enabling social participation, associations with positive relationships and loneliness would be expected to be among the strongest; instead, neither survived correction. The social pathway may still operate, but it is not supported by these data, and the absence of measures of social support, academic workload, and socioeconomic position prevents any adequate test of it.

The domain specificity of the surviving associations is itself informative and argues against a diffuse "fitness makes people feel better" interpretation. Associations were concentrated in domains describing perceived capacity and energy (perceived health, vigour, engagement) and were absent or non-robust in domains describing clinical symptom load (DASS-21 depression, anxiety, and stress; POMS tension, anger, and confusion). A parsimonious reading is that cardiorespiratory fitness tracks how capable students feel, and that this is related to, but not the same as, how symptomatic they are.

Associations that did not survive correction

Three nominally significant associations warrant explicit comment because they are theoretically ambiguous and, on the evidence available here, are best treated as unresolved rather than as findings.

Higher VO_2max was associated with lower loneliness (β = −.250, p = .030). The direction is consistent with the wider literature on social isolation and health (Cacioppo & Cacioppo, 2014; Hawkley & Cacioppo, 2010), but the association does not survive correction for multiple testing (q = .143) and we build no interpretation on it. Before analysis we verified the scoring direction of the PERMA loneliness item against its expected correlations with negative emotion and with positive relationships, so the sign is not an artefact of reverse coding.

Relative handgrip strength was negatively associated with friendliness (β = −.241, p = .042). We regard this as a chance finding: it did not survive FDR correction (q = .500), was not reproduced for absolute handgrip strength (p = .123), showed no coherent pattern across the other POMS subscales, and disappeared entirely in the multivariable model. With 160 tests, approximately eight nominally significant results are expected by chance alone, and this is a strong candidate for one of them.

Speed–agility showed nominal associations with lower total mood disturbance (β = −.212, p = .032), higher accomplishment (β = .247, p = .013), and higher perceived health (β = .195, p = .044), none of which survived correction. Its interpretation is further complicated by its correlation with the other fitness indicators (r = .54 with standing broad jump and .43 with VO_2max), so it cannot be regarded as an independent correlate of any outcome in these data.

Anthropometric indicators and perceived health

Anthropometric indicators were related exclusively to perceived health: higher BMI and WHtR were associated with lower perceived health, and both associations survived correction. Neither was associated with mood or with affective symptoms at any threshold. This dissociation is consistent with the interpretation above — that body composition informs how healthy students judge themselves to be without necessarily

tracking symptom burden — and with evidence that body-image pressures in university populations operate on self-evaluation more than on clinical symptomatology (Alghawrien et al., 2022). The nominal associations of neck circumference with accomplishment and with lower perceived health did not survive correction and are not interpreted.

Physical fitness is not physical activity: What this design adds

Because every participant met the criterion for physical inactivity, variation in current activity behaviour was compressed by design while variation in fitness was preserved: estimated VO_2max ranged across roughly four standard deviations within a nominally homogeneous behavioural group. The associations reported here therefore cannot be attributed to differences in how much students are currently exercising, which is the confound that limits inference in most of the physical-activity-and-mental-health literature. This is the principal design contribution of the study, and it also carries a practical implication: a student can be classified as inactive by questionnaire and still occupy the upper end of the fitness distribution, so activity screening alone is an incomplete way to identify students at physical risk.

Practical implications for university health services

These are cross-sectional associations, so they identify where to look rather than what to do. With that caveat, three implications follow for university health and wellness services.

First, on screening: a submaximal or field-based cardiorespiratory assessment is inexpensive, requires a gymnasium and a stopwatch, can be delivered to a cohort in a single session, and — unlike a self-report activity questionnaire — discriminates within the inactive group. Universities that already run entry health screening could add it at marginal cost, and the present data suggest it would identify a gradient that self-reported inactivity conceals.

Second, on programme content: if the associations reported here reflect any causal contribution, the components with the strongest associations were aerobic capacity and perceived functional capacity, not strength or body composition. That argues for programmes framed around what students can do — progressive aerobic capacity, tolerance of sustained effort, and energy for the academic day — rather than around weight or appearance, which in this sample were related only to perceived health and which risk reinforcing the body-image pressures already documented in this population. Existing university exercise programmes structured along these lines provide implementable models (Herbert, 2022).

Third, on integration and expectations: fitness-oriented programmes should be positioned as complementary to, not substitutes for, psychological services, and the effect sizes here are modest — the multivariable model for overall well-being explained 14% of variance and the models for total mood disturbance and for DASS-21 depression were not significant at all. Exercise is among the better-supported lifestyle interventions in mental health (Firth et al., 2020; Stubbs et al., 2018), but framing it as a solution to student mental health would overstate what these data, or the intervention literature, support. Randomized evaluation within university settings is the appropriate next step, and protocols for such trials in student populations already exist (Rostami et al., 2025).

Limitations

Several limitations qualify these findings. First, the cross-sectional design precludes any causal or directional inference. The observed associations are equally compatible with fitness contributing to psychological functioning, with better psychological functioning enabling the behaviour that maintains fitness, and with confounding by unmeasured common causes; nothing in this design adjudicates between them.

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Second, cardiorespiratory fitness was estimated from a field test rather than measured by gas analysis. The prediction equation and the shuttle-run protocol each introduce error related to motivation, pacing, and familiarity, and the resulting non-differential misclassification would be expected to attenuate the associations reported. This limitation bears directly on the central claim of the paper, since the case for cardiorespiratory fitness as an integrative correlate rests on a proxy measure; direct ergospirometry is required before that claim can be considered established.

Third, one speed–agility record held a value of exactly 0 s, which is not physically attainable in this test, and was treated as missing. Because we cannot verify from the dataset whether this participant was untested or whether a recoverable measurement exists, the speed–agility results should be read with that in mind.

Fourth, physical inactivity was self-reported and no device-based activity measurement was obtained, so misclassification of the eligibility criterion is possible; some participants may have been more active than reported, which would partially undermine the design contribution described above. All mental health indicators were also self-reported and were collected in a single session, so common-method variance may inflate associations among them.

Fifth, despite FDR correction, 160 tests were performed on 135 participants and the study was not pre-registered. The 7 surviving associations should be regarded as the most defensible subset rather than as confirmed effects, and 5 of the 7 concern a single outcome (perceived health), which is measured by a small number of items. Sixth, the sample was drawn from one Chilean region and consisted of volunteers, which limits generalizability. Finally, social and contextual variables — social support, academic workload, socioeconomic conditions, sleep — were not measured, and their absence is particularly consequential for interpreting the loneliness and relationship domains.

CONCLUSION

In physically inactive Chilean university students, most associations between physical fitness, anthropometric characteristics, and mental health did not survive correction for multiple testing. Estimated cardiorespiratory fitness was the exception: it was the only indicator associated with more than one mental health domain after correction, the only one that remained associated with well-being and perceived health when all fitness and anthropometric indicators were modelled simultaneously and was retained by cross-validated penalized regression in every model in which any predictor was retained.

These findings are compatible with cardiorespiratory fitness functioning as an integrative marker of perceived capacity in this population, and they suggest that fitness components are not interchangeable indicators of physical health for mental health purposes. Because the design is cross-sectional and cardiorespiratory fitness was estimated rather than measured, no directional interpretation is warranted. Longitudinal and randomized studies incorporating direct physiological measurement, device-based activity monitoring, and social-contextual covariates are required to determine whether the association reflects any causal contribution.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Contributions are specified according to the CRediT (Contributor Roles Taxonomy) as follows:

Conceptualisation: Juan Pablo Zavala-Crichton, Felipe Navarro-Henríquez, Astrid Titus-Cabrera, José Joaquín Álvarez-Opazo, and Patricio Solis-Urra. Methodology: Juan Pablo Zavala-Crichton, Felipe Navarro-Henríquez, Astrid Titus-Cabrera, José Joaquín Álvarez-Opazo, Patricio Solis-Urra, and Rodrigo Yáñez-Sepúlveda. Formal analysis: Juan Pablo Zavala-Crichton, Felipe Navarro-Henríquez, Astrid Titus-Cabrera, José Joaquín Álvarez-Opazo, and Patricio Solis-Urra. Investigation: Felipe Navarro-Henríquez, Astrid Titus-Cabrera, José Joaquín Álvarez-Opazo, and Patricio Solis-Urra. Data curation: Felipe Navarro-Henríquez, Astrid Titus-Cabrera, José Joaquín Álvarez-Opazo, Patricio Solis-Urra, and Rodrigo Yáñez-Sepúlveda. Writing – original draft: All authors. Writing – review & editing: Juan Pablo Zavala-Crichton, Paula Ortiz-Marholz, Claudio Hinojosa-Torres, Carlos Cristi-Montero, and Rodrigo Yáñez-Sepúlveda. Supervision: Juan Pablo Zavala-Crichton.

Additional contributions were as follows: Project administration: Juan Pablo Zavala-Crichton. Validation: Juan Pablo Zavala-Crichton and Rodrigo Yáñez-Sepúlveda. Visualization: Juan Pablo Zavala-Crichton.

All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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