Ideal Cardiovascular Health, Handgrip Strength, and Muscle Mass Among College Students: The FUPRECOL Adults Study

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Abstract

Garcia-Hermoso, A, Correa-Bautista, JE, Izquierdo, M, Tordecilla-Sanders, A, Prieto-Benavides, D, Sandoval-Cuellar, C, González-Ruíz, K, and Ramírez-Vélez, R. Ideal cardiovascular health, handgrip strength, and muscle mass among college students: the FUPRECOL Adults study. *J Strength Cond Res* 33(3): 747–754, 2019—The American Heart Association established the 2020 Strategic Impact Goals to define the concept of ideal cardiovascular health (CVH) and the metrics needed to monitor it across populations. The purpose of this study was to investigate the relationship between handgrip strength, muscle mass, and ideal CVH among Colombian college students. Data from 1,835 college students were analyzed (1,128 female). Muscular strength was estimated using a hand-held dynamometer and normalized to body mass (normalized grip strength [NGS]). The percentage of body fat was determined for bioelectrical impedance analysis using tetrapolar whole-body impedance. Ideal CVH was defined as meeting the ideal levels of 4 behaviors (smoking, body mass index, physical activity, and diet adherence) and 3 factors (total cholesterol, fasting glucose, and blood pressure). Higher levels of NGS and muscle mass (relative to body mass) were associated with a higher number of ideal CVH metrics in both sexes (p for trend <0.001). For the total ideal CVH metrics scored on a continuous scale from 0 (all 7 poor) to 7 (all 7 ideal), a 1-metric increase was associated with reduced odds of weak NGS (33 and 36%) and low-medium muscle mass (28 and 34%) mass in men and women, respectively (all $p < 0.001$). This study indicates that in Colombian college students, both handgrip strength and muscle mass are positively associated with the ideal CVH metrics. To reduce the possible future public health burden of muscular weakness, health professionals need to encourage the public to optimize lifestyle-related risk factors during the young adult stage.

Key Words risk factors, young adults, muscular strength

Introduction

With the rising rates of noncommunicable diseases over the past 30 years, a growing number of adults are exhibiting cardiometabolic risk factors, including hypertension, dyslipidemia, and dysglycemia (25). Decreased physical activity (PA) and sedentary behavior—combined with poor dietary habits—have been implicated as potential contributing factors in the noncommunicable disease crisis (27). In Colombia, the number of patients with cardiovascular risk factors has increased rapidly because of longer lifespan, the aging of the population, and lifestyle changes. During the period from 1998 to 2011, 21–25% of total deaths were due to cardiovascular disease (CVD) (5). The crude mortality rate varied from 93.5 to 108.8 per 100,000 habitants, whereas the age-adjusted mortality rate varied from 108.6 to 95.9 deaths per 100,000 (23).

Assessments of CVD risk in college students aged 18–24 years show an alarmingly high prevalence of abnormal risk factor profiles (6). Approximately 33% of young adults are

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overweight (4), and this excess weight leads to dyslipidemia and increases the risk of metabolic syndrome (22) and CVD (24). Early detection and intervention are critical because 80% of CVD events are preventable through diet and lifestyle (36). In response to the increasing burden of noncommunicable diseases, including CVD, the American Heart Association (AHA) established the 2020 Strategic Impact Goals to define the concept of ideal cardiovascular health (CVH) and the metrics needed to monitor it across populations (17). The 7 metrics for ideal CVH in adults (age ≥20 years) comprise 4 health behaviors (current smoking, body mass index [BMI], physical activity, and healthy diet score) and 3 physiological health factors (total cholesterol, blood pressure, and fasting plasma glucose levels). The few studies that have analyzed this ideal CVH in young adults suggest a direct association with markers related to future cardiovascular events (30), such as carotid intima-media thickness (26) or left ventricular structure and function later in life (7).

Although there is scientific evidence regarding the role of muscle strength preservation in preventing cardiometabolic risk and mortality in several populations (9), to the best of our knowledge, only one study has analyzed the relationship between ideal CVH and muscle strength in children and adolescents from Colombia, and it showed a positive association between the two (31). Poor diet, obesity, and physical inactivity have been shown to be the leading CVD risk factors in Colombian adults and another Latin American countries (34), raising concerns about whether an increased risk of these conditions also affects cardiometabolic status. These changes, in addition to the adoption of a Western lifestyle and diet, have led to an increase in the prevalence of overweight and obesity among Colombians, particularly among university students (8).

In addition, the prevalence of ideal CVH has not been examined in college students in any Latin American population. It is very important to identify the risk factors and to take steps to control noncommunicable diseases in Colombia. Therefore, the objective of this study was to investigate the relationship between handgrip strength, muscle mass, and ideal CVH among college students. It was hypothesized that higher scores on 7 metrics for ideal CVH, indicating better CVH, are associated with higher levels of handgrip strength and muscle mass in Colombian college students.

Methods

Experimental Approach to the Problem

This was a secondary analysis of cross-sectional of data from the Association of the Prehensile Force with Early Manifestations of Cardiovascular Risk in Jóvenes and Colombian Adults (FUPRECOL). Adults study, which investigated the association between muscular strength and metabolic risk factors in Colombian collegiate students.

Subjects

The students were enrolled in public or private universities from 3 distinct areas of Colombia: the capital district of Bogota (Cundinamarca), Tunja (Boyacá), and Santiago de Cali (Valle del Cauca). We recently published a complete description of the FUPRECOL Adults study's design and methods and the primary outcomes for our current cohort (29). The original sample consisted of adults (male: $n = 707$; female: $n = 1{,}131$). Of this group, 1,835 collegiate students (61.4% of women) had valid data for body composition and all the components of the cardiometabolic variables. There were no differences in the study's key characteristics (i.e., age, sex distribution, BMI, and ideal CVH components) between the current study sample and the original FUPRECOL Adults study sample ($n = 1{,}838$, all $p > 0.100$). Subject characteristics are listed in table 1.

Exclusion criteria included the following: medical or clinical diagnosis of a major systemic disease, including malignant conditions such as cancer, type 1 or 2 diabetes, high blood pressure, hypothyroidism, or hyperthyroidism; regular use of multivitamins; chronic inflammatory conditions, including rheumatoid arthritis, systemic lupus erythematosus, and multiple sclerosis; and infectious conditions. The volunteers received no compensation for their participation. All participants provided written consent, and each study was approved by the University of Rosario Review Board (Bogotá UMB Code No 01-1802-2013, UR Code No CEI-ABN026-000010; Cali UNIAJC Code No 111-02.01.48/16; Tunja Code No RECT 60) and complied with the Declaration of Helsinki (World Medical Association for Human Subjects).

Procedures

Clinical Examination. Clinical examinations were performed between January 25, 2015, and March 30, 2017, by trained personnel and followed standardized routines described in detail elsewhere (29). Briefly, body mass and muscle mass were measured using tetrapolar whole-body impedance (Tanita Model Tanita BC 420 MA® and SC-331S®; Tanita, Tokyo, Japan). A detailed description of the bioelectrical impedance analysis (BIA) technique can be found in a previous study (32). Muscle mass was normalized as muscle mass per body mass, i.e., muscle mass in kg/body mass in kg. In a study to validate 2 portable BIA devices for body composition assessment, multiple regression analyses showed clinically acceptable agreement between the Tanita BC 420 MA® and SC-331S® device and magnetic resonance imaging for visceral adipose tissue and fat mass measurements ($R^2 > 0.70, r > 0.84$) (38). The corresponding intraobserver technical error (% reliability) of the measurements was 95%. Before testing, participants were required to adhere to these BIA manufacturer's instructions, including not to (http://www.tanita.com/es/bc-418/): (a) eat or drink within 4 hours of the test; (b) consume caffeine or alcohol within 12 hours of the test; (c) take diuretics within 7 days of the test; (d) do physical exercise within 12 hours of the test; and (e) urinate within 30 minutes of the test.

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Waist circumference (WC) (cm) was measured at the uppermost border of the iliac crest around the abdomen. When this point was not evident, WC was measured at the midpoint between the last rib and the iliac crest using a metal tape measure (Lufkin W606PM®, Allers Parsippany, NJ, USA) in accordance with the International Society for the Advancement of Kinanthropometry guidelines (21). The evaluation process was performed by a team of professionals (4 physical therapy professors) with extensive experience in anthropometric measurement. Two percent of the sample was measured twice to ensure the quality of the measurements. The technical error of measurement values were less than 2% for all anthropometric variables.

We used a handgrip strength test (T.K.K. 5401-5001, Grip-A; Takei Scientific Instrument, Tokio, Japan), adjusted for each participant by sex and hand size as PA "proxy." The participants were instructed to stand with their arms completely extended, squeezing and to gradually and continuously squeeze the handgrip as hard as they could for at least 2 seconds. The test was performed twice, alternating hands between tests. A 90-second rest period was provided between trials. The best score for each hand was recorded in kilograms (32). The handgrip score (kg) was calculated as the average of the left and right hands and then expressed per kilogram of body mass. The reproducibility of our data was $R = 0.96$. Intrarater reliability was assessed by determining the intraclass correlation coefficient (0.98, confidence interval [CI] 95% 0.97–0.99, $n = 20$, median age = 22.8 ± 1.4 years, 66.2 ± 5.4 kg, 1.67 ± 0.1 m, 24.9 ± 3.1 kg·m^{-2}). As there is substantial covariance between strength capacity and body mass and the link between strength and both physical function and chronic health is directly mediated by the proportion of strength relative to body mass, handgrip strength was normalized as grip strength (NGS) per body mass, i.e., handgrip strength in kg/body mass in kg (1). In male, unfit and fit NGS values at these points were <0.47 and ≥0.48, respectively. In female, these cutoff points were <0.33 and ≥0.34, respectively (10). These cutoff points have been associated with the detection of metabolic syndrome in Colombian collegiate students.

Ideal Cardiovascular Health Behaviors. A standardized survey, the "FANTASTIC" lifestyle questionnaire (family, PA, nutrition, tobacco toxins, alcohol, sleep/stress, personality type, insight, and career), was used to collect comprehensive information about substance use through personal interviews with the participants (28). The physically active category was defined as ≥150 minutes of moderate activity per week (11). Data on smoking were collected through self-reported FANTASTIC quetionnaire (number of cigarettes smoked per day). Ideal smoking status was determined as nonsmoker or

Table 1. Characteristics of Colombian collegiate students (mean ± *SD* or frequencies), by sex.

	Female ($n = 1,128$)	Male ($n = 707$)	p†
Age (y)	20.59 (2.09)	20.51 (2.01)	0.624
Body mass (kg)	58.79 (10.36)	68.91 (12.23)	<0.001
Height (cm)	159.10 (5.86)	172.30 (6.66)	<0.001
Body mass index (kg·m^{-2})	23.21 (3.78)	23.17 (3.60)	0.810
Muscle mass (kg)	40.14 (3.38)	55.08 (6.57)	<0.001
Muscle mass/body mass	0.69 (0.07)	0.80 (0.08)	<0.001
Systolic blood pressure (mm Hg)	111.29 (11.16)	120.28 (12.97)	<0.001
Diastolic blood pressure (mm Hg)	71.74 (9.35)	74.20 (11.45)	<0.001
Glucose (mg/dl)	86.05 (11.58)	84.81 (11.99)	0.030
Total cholesterol (mg/dl)	146.39 (33.34)	132.75 (30.24)	<0.001
Alcohol (≥1 times per week), *n* (%)	404 (47.7)	317 (45.2)	0.318
Muscular strength			
Handgrip strength (kg)	24.16 (4.75)	39.42 (7.15)	<0.001
Normalized grip strength*	0.41 (0.09)	0.58 (0.11)	<0.001
Goal/metric			
Not currently smoking, *n* (%)	596 (73.4)	485 (70.5)	0.212
Body mass index <25 kg·m^{-2}, *n* (%)	827 (73.4)	526 (74.5)	0.616
Physically active, *n* (%)	231 (27.2)	251 (35.9)	<0.001
Healthy diet, *n* (%)	64 (7.5)	45 (6.4)	0.398
Total cholesterol <200 mg/dl, *n* (%)	1,056 (94.5)	676 (97.0)	0.012
Fasting glucose <100 mg/dl, *n* (%)	1,022 (91.6)	633 (90.9)	0.644
Optimal blood pressure, *n* (%)	937 (83.4)	416 (59.0)	<0.001

*Handgrip strength/body mass.
†*t*-test or χ^2 test was applied to compare unadjusted means by sex ($p < 0.001$).

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quit smoking >12 months ago. The accuracy of the information about lifestyle covariables obtained from the FANTASTIC questionnaire has been validated with different cross-sectional studies and is described in detail elsewhere (28).

Body mass index was calculated as (body mass·height^{-2}) and was classified using the World Health Organization (WHO) criteria (normal: 18.5–24.9 kg·m^{-2}; overweight: 25.0–29.9 kg·m^{-2}; and obese: ≥30 kg·m^{-2}) (40).

Dietary intake was measured using the test of Adherence to Mediterranean Diet (KIDMED) (35). This scale comprises 16 items with an affirmative or negative response; for example: "consumes fish regularly (at least 2-3 times per week)", which are related to patterns associated with the mediterranean diet. Twelve of these items have positive connotations (+1) while the other four have negative values (−1). The final score ranges from −4 to +12. The total score was divided into two categories of Mediterranean diet quality: ≤7 points = poor diet quality and ≥8 points = good diet quality (optimal Mediterranean diet style). Participants who had ≥8 points were categorized as having an ideal healthy diet, whereas those with 7 points or less were classified as having a non-ideal diet. This instrument has a reliability of *Cronbach's alpha* = 0.86.

Cardiovascular Health Risk Factors. For blood measurements, the participants were asked to arrive in a fasting state; abstain from exercise training, caffeine, nicotine, and alcohol 12 hours before the clinical examination; and continue their regular medication routines. Capillary blood samples (40 μL) were collected for determining serum biochemical parameters, including fasting glucose and total cholesterol, using portable Cardiocheck equipment (Mexglobal SA, Parsippany, NJ, USA).

Blood pressure was measured with an automatic monitor (Omrom HEM 705 CP; Health-care Co, Kyoto, Japan) following the recommendations of the European Heart Society (Each participant sat quietly with legs uncrossed for 5-10 minutes before blood pressure measurement with the arm supported at the level of the heart).

American Heart Association Criteria. The AHA guidelines (17) were used to determine the CVH profile based on the 7 metrics using the cutoff points for adults, with the participants receiving 1 point for the presence of each ideal metric. The ideal behaviors defined by the AHA are as follows: BMI <25 kg·m^{-2}, physically active status (≥150 minutes of moderate activity per week), nonsmoking status (either never

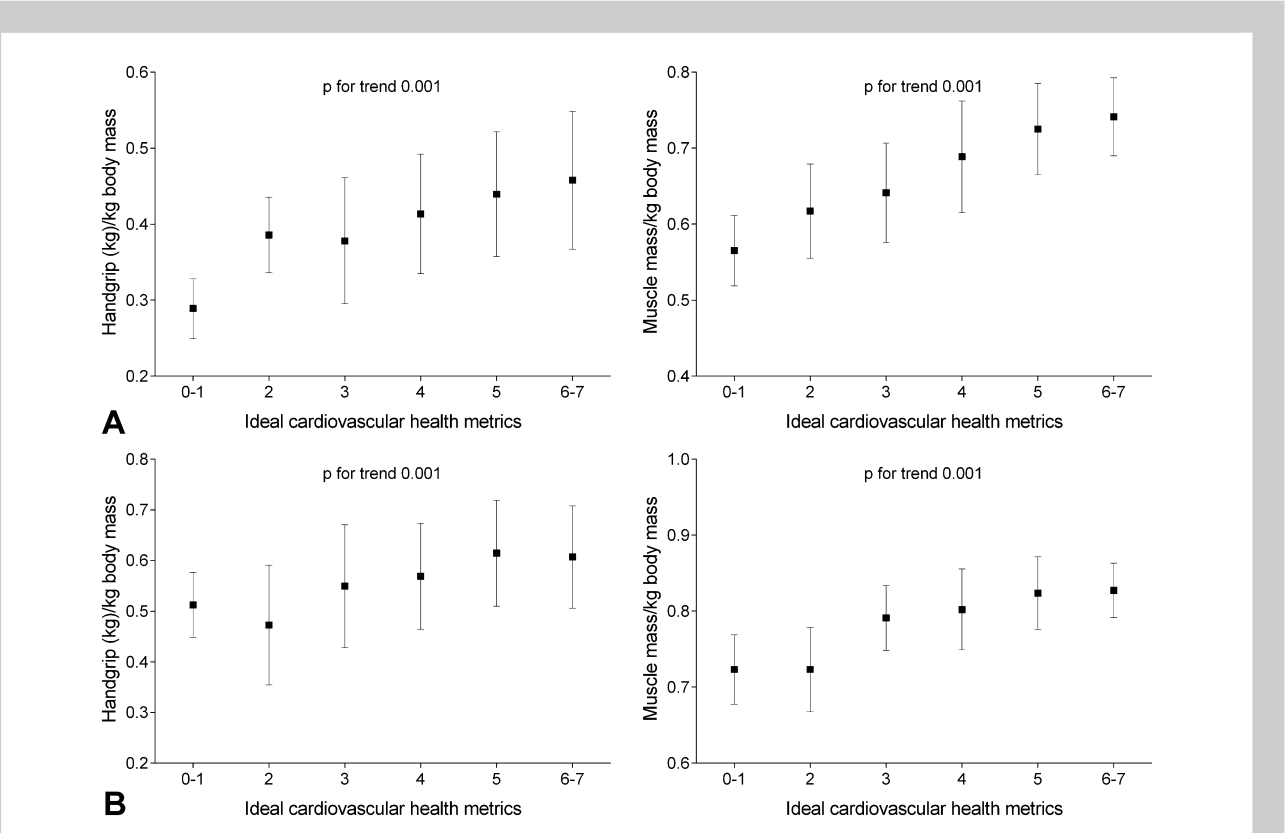

Figure 1. Association between normalized grip strength (measured as grip strength in kg/body mass in kg) and adjusted muscle mass (muscle mass in kg/body mass in kg) across ideal CVH metrics in college students. A) Female and (B) male. We collapsed 0 with 1 and 6 with 7 ideal metrics due to relatively few youths who had 0 (0.1% of total cohort), 1 (0.4% of total cohort), or 6 (12% of total cohort) and 7 (1% of total cohort) ideal CVH metrics. CVH = cardiovascular health.

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having smoked or having quit smoking >12 months ago), and a dietary pattern that promotes ideal CVH (≥8 points = good diet quality optimal Mediterranean diet style). The factors were classified as an untreated systolic blood pressure <120 mm Hg and diastolic blood pressure <80 mm Hg, untreated total cholesterol ≤200 mg/dl, and untreated fasting blood glucose <100 mg/dl.

Statistical Analyses

Descriptive statistics were computed and summarized; continuous variables are reported using mean values and *SD*s, and categorical variables are reported using proportions (%). The *t*-test was used to compare unadjusted means, and the chi-square test (χ^2) was used to explore sex-group differences. The associations among NGS, adjusted muscle mass, and ideal CVH metrics and between ideal CVH behaviors and each factor separately were assessed using analysis of covariance. Analyses were conducted for men and women separately and adjusted by age, university center, and alcohol use. Alcohol use was defined as the consumption of any alcoholic beverage 1 to 9 times per week for at least 6 months. Finally using a logistic regression, ideal CVH metrics were examined as a continuous variable, considering the odds ratio (OR) per 1-metric increase in the overall profile to compare the prevalence of low NGS and low-medium adjusted muscle mass. The data were analyzed using SPSS-IBM (software, v.22.0, SPSS, Inc., Chicago, IL, USA), and a value of $p \leq 0.05$ was considered statistically significant.

Results

The 1,835 participants included 1,128 female (61.4%), and the mean age was 20.56 (2.03) years. Male had lower body mass, height, muscle mass, muscle mass adjusted, blood pressure, handgrip, and NGS levels than female ($p < 0.001$), and female had higher glucose and total cholesterol than male ($p < 0.001$; Table 1).

Higher NGS and adjusted muscle mass levels were associated with a higher number of ideal CVH metrics in both sexes (p for trend <0.001; Figure 1).

In addition, higher NGS and adjusted muscle mass levels were associated with a higher number of ideal health behaviors (p for trend <0.001 in both male and female) and with a higher number of ideal health factors (p for trend <0.001 in both male and female; Figures 2 and 3).

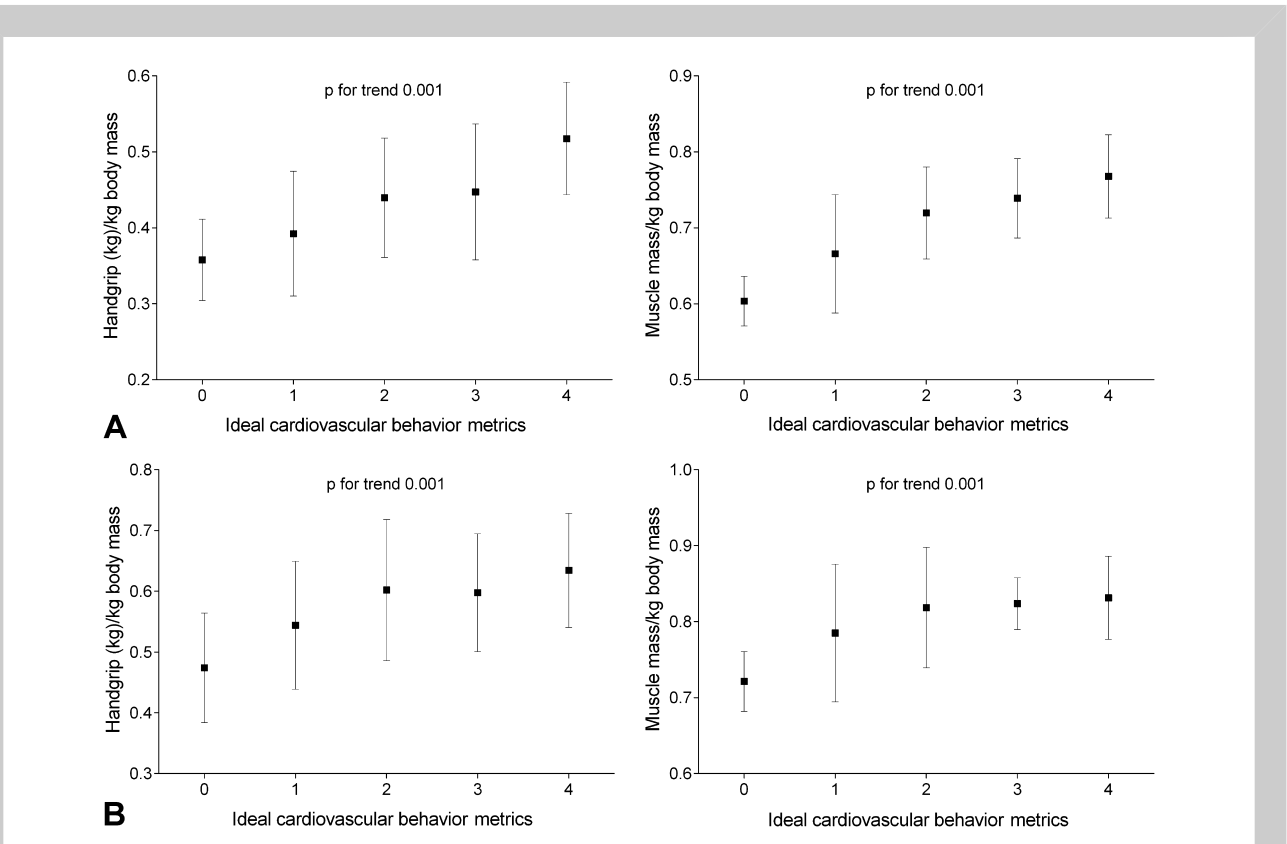

Figure 2. Association between normalized grip strength (measured as grip strength in kg/body mass in kg) and adjusted muscle mass (muscle mass in kg/body mass in kg) across ideal CVH behaviors (smoking, body mass index, physical activity, and Mediterranean diet adherence) in college students. A) Female and (B) male. CVH = cardiovascular health.

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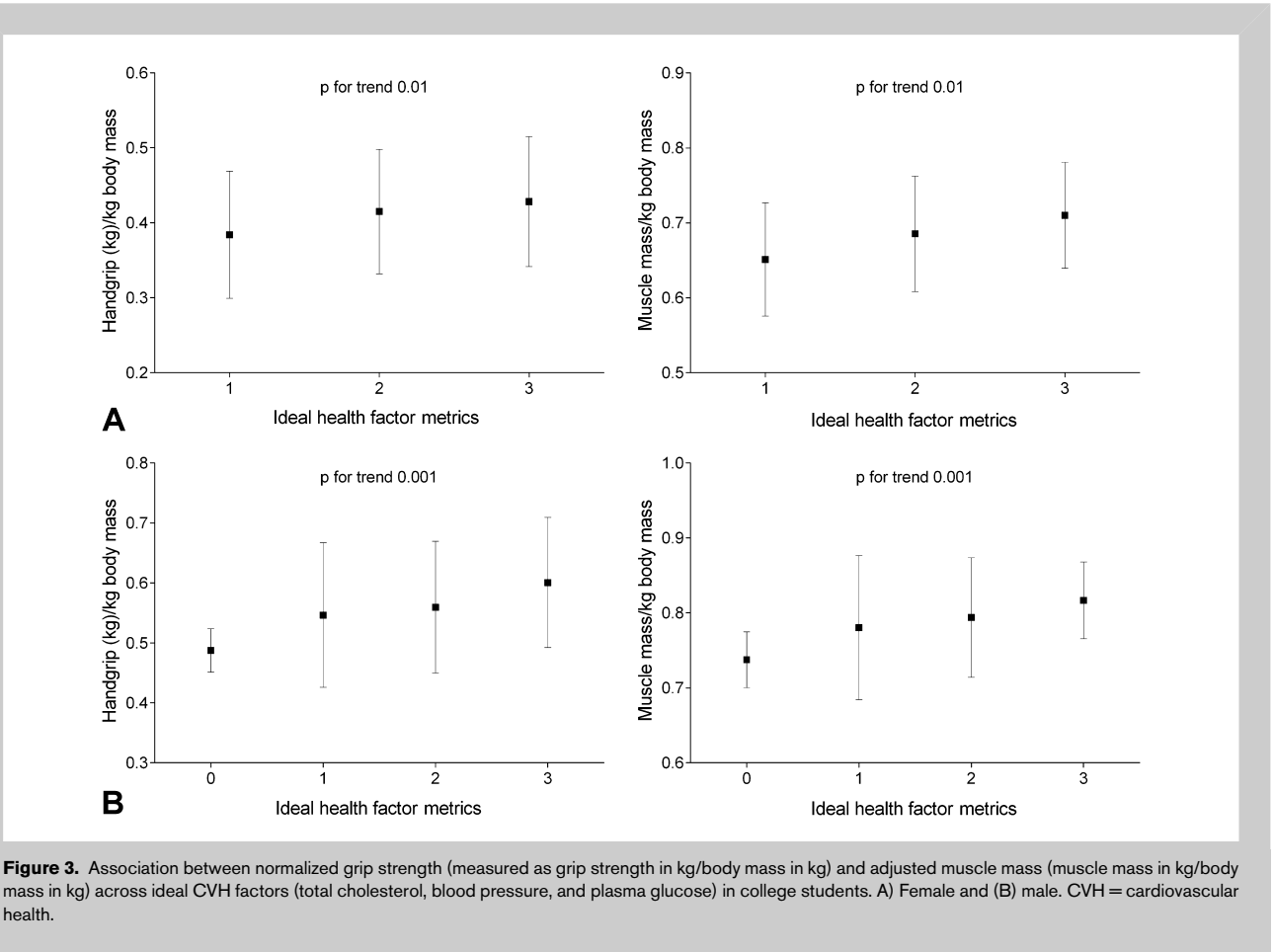

Figure 3. Association between normalized grip strength (measured as grip strength in kg/body mass in kg) and adjusted muscle mass (muscle mass in kg/body mass in kg) across ideal CVH factors (total cholesterol, blood pressure, and plasma glucose) in college students. A) Female and (B) male. CVH = cardiovascular health.

Finally, for the total ideal CVH metrics on a continuous scale from 0 (all 7 poor) to 7 (all 7 ideal), a 1-metric increase was associated with reduced odds of weak NGS (male, OR = 0.667 95% CI, 0.544–0.819, female, OR = 0.639 95% CI, 0.522–0.782) and low-medium muscle mass (male, OR = 0.719 95% CI, 0.588–0.879, female, OR = 0.656 95% CI, 0.540–0.796) (all $p < 0.001$).

Discussion

The findings of this study indicate that in Colombian college students, both handgrip strength and muscle mass are positively associated with the ideal CVH metrics determined by the AHA. These results are insightful considering the large reduction in overall fitness and PA levels observed in Latin American populations in recent decades (13,15). However, similar to larger studies, we found that handgrip strength may be an underappreciated, modifiable determinant of cardiometabolic risk factors in adults (3).

Although there are very few studies on this topic, Ramírez-Vélez et al. (31) showed that greater handgrip strength was associated with a higher number of ideal CVH metrics in a young population, which, together with our results, seems to suggest that muscular strength should be considered a hallmark for meeting ideal CVH metrics. Along this line, previous studies have shown the relationship between the individual components of ideal CVH and handgrip strength in young adults. Regarding the ideal CVH factors that were analyzed, previous studies provide evidence that muscular strength is protective against cardiometabolic risk factors (10). For example, Magnussen et al. (19) reported that the negative association between muscle strength and cardiometabolic risk factors is independent of cardiorespiratory fitness or adiposity level. In addition, López-Martínez et al. (18) demonstrated that in college students, muscle strength is negatively associated with metabolic risk and its individual components. Also, the PURE study suggests that muscle strength is a risk factor for incident CVD and can predict the risk of death in people who develop either CVD or non-CVD in people of diverse economic and sociocultural backgrounds, including Latin American population (15).

A recent prospective study of 7,418 adults (46 ± 9.5 years old) suggested that engaging in resistance exercise, even for less than 1 hour per week, is associated with a lower risk of developing metabolic syndrome, independent of whether the participant engages in aerobic exercise (2). These results seem to suggest the need to promote increased muscle

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strength in adults to better manage cardiometabolic risk factors. In this sense, muscle strength training should be considered in the management of cardiometabolic risk factors because studies show that exercise training that aims to increase muscle strength in adults is associated with significantly improved cardiometabolic health (16) and muscle mass (39).

Regarding health behaviors, there is a well-established link between PA, healthy diet, muscular strength (14), and muscle mass (37). Regular PA is a cornerstone strategy for managing cardiometabolic risk factors. As a consequence, agencies such as the American College of Sports Medicine recommend that adults aged between 18 and 64 years perform activities that increase bone and muscle strength, which includes resistance training, 2–3 days per week (11). Another recent study of university students shows that the Mediterranean diet and PA are related to healthy body composition parameters in young adults (37). In addition, a longitudinal study indicates that smoking is inversely related to muscle strength in healthy adults (12). This may be because circulating cigarette smoke constituents seem to play an important role in the underlying molecular mechanisms of muscle damage, such as reduced oxygen delivery and impaired mitochondrial function (33).

The findings of this study are limited by the cross-sectional design; therefore, the direction of causality cannot be determined. In addition, ideal health behaviors were measured using a self-administered questionnaire, and so, some of the questions may have been misinterpreted deliberately or unintentionally by some of the college students. Finally, the categorization of the ideal CVH metrics relies on the use of binary variables and on the assumption that all risk factors and behaviors contained in this concept contribute equally to the final score.

Practical Applications

This study shows for the first time the benefit of higher ideal CVH metrics for muscular strength and muscle mass in Colombian collegiate students. Therefore, to reduce the possible future public health burden of muscular weakness, physical educators, researchers, trainers, fitness professionals, physical therapists, and coaches need to encourage the public to optimize lifestyle-related risk factors during the young adult stage.

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