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Handgrip Strength and Ideal Cardiovascular Health among Colombian Children and Adolescents

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Objective To evaluate the association between handgrip strength and ideal cardiovascular health (CVH) in Colombian children and adolescents.

Study design During the 2014-2015 school years, we examined a cross-sectional component of the FUPRECOL (Association for Muscular Strength with Early Manifestation of Cardiovascular Disease Risk Factors among Colombian Children and Adolescents) study. Participants included 1199 (n = 627 boys) youths from Bogota (Colombia). Handgrip strength was measured with a standard adjustable hand held dynamometer and expressed relative to body mass (handgrip/body mass) and as absolute values in kilograms. Ideal CVH, as defined by the American Heart Association, was determined as meeting ideal levels of the following components: 4 behaviors (smoking status, body mass index, cardiorespiratory fitness, and diet) and 3 factors (total cholesterol, blood pressure, and glucose).

Results Higher levels of handgrip strength (both absolute and relative values) were associated with a higher frequency of ideal CVH metrics in both sexes (P for trend ≤ .001). Also, higher levels of handgrip strength were associated with a greater number of ideal health behaviors (P for trend < .001 in both boys and girls), and with a higher number of ideal health factors in boys (P for trend < .001). Finally, levels of handgrip strength were similar between ideal versus nonideal glucose or total cholesterol groups in girls.

Conclusions Handgrip strength was strongly associated with ideal CVH in Colombian children and adolescents, and thus supports the relevance of early targeted interventions to promote strength adaptation and preservation as part of primordial prevention. *(J Pediatr 2016;179:82-9).*

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Low muscular strength, as determined by handgrip dynamometry, is a recognized marker of poor health during adolescence,[1,2] and is associated with disease and mortality in adulthood.[3-5] Numerous studies support an inverse relationship between muscular strength and cardiovascular disease (CVD) risk factors in young populations, and generally express muscular strength relative to body mass.[1,6] Epidemiological studies indicate that muscle weakness has been associated with a higher frequency of adverse health consequences including obesity, systemic low-grade inflammation, and insulin resistance.[7-10] CVD events occur most frequently during or after the fifth decade of life, and yet the precursors of disease originate in childhood and adolescence.[1,11]

In response to the increasing burden of CVD risk factors, the American Heart Association established several strategic goals.[12] In 2010, the American Heart Association released a set of cardiovascular health metrics for adults and children that were intended to prioritize cardiovascular health, as opposed to CVD.[12] Population-representative studies have shown a low prevalence of ideal cardiovascular health (CVH) metrics in US children and adolescents, particularly for achieving physical activity recommendations and dietary intake.[13,14] Data from the Cardiovascular Risk in Young Finns Study and The Healthy Lifestyle in Europe by Nutrition also demonstrated that children and adolescence with a higher number of ideal CVH components had a reduced risk for hypercholesterolemia, hypertension, and elevated blood glucose.[15] Increases in ideal CVH are directly associated with aortic elasticity[16] and healthier levels of cardiorespiratory fitness (CRF) in adolescents.[17] Among adults, a recent systematic review[18] reported an inverse association between number of ideal CVH metrics and early all-cause and CVD-related mortality. Improved understanding of the health risks associated with muscle weakness will help to inform the development of targeted interventions for different phenotypes.

BMI	Body mass index
CRF	Cardiorespiratory fitness
CVD	Cardiovascular disease
CVH	Cardiovascular health

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Obesity and physical inactivity are leading CVD risk factors among Hispanic/Latino adults, raising concerns about whether an increased risk of these conditions also is manifested at younger ages.[19] Previous research has demonstrated an independent association between muscle weakness and increased cardiometabolic risk factors.[20,21]

In Colombia, a region that has undergone a well-documented epidemiologic transition and epidemic of CVD,[19-22] relatively little research on physical activity[22] and physical fitness exists.[23,24] Therefore, describing the magnitude of these risk factors in youth is important for prioritizing prevention and public health efforts.[19] Nevertheless, there have been no studies to date to determine the association between handgrip strength and ideal CVH in Latin American youth. Therefore, the objective of the present study was to investigate the relationship between handgrip strength and ideal CVH among Colombian children and adolescents.

Methods

This study aimed to examine the relationships between physical fitness levels, healthy and unhealthy behaviors, and cardiometabolic risk factors in Colombian children and adolescents. During the 2014-2015 school years, we examined a cross-sectional component of the FUPRECOL (Association for Muscular Strength with Early Manifestation of Cardiovascular Disease Risk Factors among Colombian Children and Adolescents) study[25-27] (in Spanish, Asociación de la FUerza PREnsil con Manifestaciones de Riesgo Cardiovascular Tempranas en Niños y Adolescentes COLombianos). The sample consisted of children and adolescents (boys n = 4000 and girls n = 4000) aged 9-17.9 years. Blood sampling was randomly performed in one-third of the recruited subjects (n = 2775). From this subgroup, 1199 schoolchildren (52.2% boys) had valid data muscular strength and all components included in the ideal CVH concept. There were no differences in the study key characteristics (ie, age, sex distribution, body mass index [BMI], and muscular strength) between the current study sample and the original FUPRECOL (Association for Muscular Strength with Early Manifestation of Cardiovascular Disease Risk Factors among Colombian Children and Adolescents) study sample (n = 8000; all $P > .100$). The children and adolescents were of low to middle socioeconomic status (1-3 defined by the Colombian government), enrolled in public elementary and high schools (grades 5-11), and from the capital district of Bogota in a municipality in the Cundinamarca Department in the Andean region. A convenience sample of volunteers was included and grouped by sex and age with 1-year increments (a total of 9 groups).

Measurements

Handgrip Strength Assessment. Consistent with recommendations,[28,29] we restricted our analysis to the following health-related[30] field-based tests that have demonstrated adequate levels of criterion-related validity, and reliability[27-29] in the assessment of 2 dimensions of muscular strength: handgrip strength and normalized handgrip strength in kg/body mass in kg.[31-33] Handgrip was measured using a standard adjustable hand held dynamometer (Takei Digital Grip Strength Dynamometer Model T.K.K. 540, Takei Scientific Instruments Co, Ltd, Niigata, Japan). Participants were given a brief demonstration and verbal instructions for the test and, if necessary, the dynamometer was adjusted to the participant's hand size according to predetermined protocols.[27] Handgrip strength was measured with the subject in a standing position, with the shoulder adducted and neutrally rotated, and arms parallel but not in contact with the body. The participants were asked to squeeze the handle as hard as possible for a maximum of 3-5 seconds, and no verbal encouragement was given during the test. Handgrip strength performance was recorded as the best score from either hand, without consideration for hand dominance. Because there is substantial covariance between strength capacity and body mass—and, moreover, the links between muscle strength and both physical function and chronic health are mediated by the proportion of strength relative to body mass—grip strength was normalized as strength per body mass [ie, (grip strength in kg)/(body mass in kg)]. Handgrip measurements in a subsample (n = 229; median age: 12.8 ± 2.4 years; 46.2 ± 12.4 kg; 1.50 ± 0.1 m; 19.9 ± 3.1 kg/m^2) were recorded to ensure reproducibility on the day of the study. The reproducibility of our data was R = 0.96. Intrarater reliability was assessed by determining the intraclass correlation coefficient (0.98; 95% CI, 0.97-0.99). Monthly, each dynamometer was tested using a standardized calibration procedure that showed that the device was within 1 kg of accuracy over the whole measuring range (from 0 to 100 kg), and with a 100-g sensitivity.

Anthropometric Measurements. Body weight was measured in the subjects' underwear and with no shoes, using electronic scales (Tanita BC544, Tokyo, Japan) with a low technical error of measurement (technical error of measurement = 0.510%). Height was measured using a mechanical stadiometer platform (Seca 274, Hamburg, Germany; technical error of measurement = 0.01%). BMI was calculated as the body weight in kilograms divided by the square of height in meters (kg/m^2). Obesity status was defined as having a BMI above the age- and sex-specific thresholds of the International Obesity Task Force.[34] Participants who had a BMI < 85th percentile were categorized as meeting the ideal CVH criteria for BMI.

Biochemical Determinations. Blood samples were collected between 6:00 a.m. and 8:00 a.m. by 2 experienced pediatric phlebotomists after ≥12 hours fasting. Before the extraction, fasting condition was confirmed by the child and parents. Blood samples were obtained from an antecubital vein, and analyses were subsequently completed within 1 day from collection. In children and adolescence, levels of total cholesterol have been defined as "ideal" < 4.40 mmol/L (<170 mg/dL), or "nonideal" ≥ 4.40 mmol/L (≥170 mg/dL). Fasting serum glucose concentrations were analyzed enzymatically and also classified as ideal < 5.6 mmol/L (<100 mg/ dL), or nonideal ≥ 5.6 mmol/L (≥100 mg/dL). Interassay reproducibility (coefficient of variation) was determined from 80 replicate analyses of 8 plasma pools over 15 days, and shown to be 2.6% for total