MAYO CLINIC

ORIGINAL ARTICLE

Cardiorespiratory Fitness Cutoff Points for Early Detection of Present and Future Cardiovascular Risk in Children: A 2-Year Follow-up Study

José Castro-Piñero, PhD; Alejandro Perez-Bey, MS; Víctor Segura-Jiménez, PhD; Virginia A. Aparicio, PhD; Sonia Gómez-Martínez, PhD; Rocio Izquierdo-Gomez, PhD; Ascensión Marcos, PhD; and Jonatan R. Ruiz, PhD; on behalf of the UP&DOWN Study Group

Abstract

Objective: To examine the association between cardiorespiratory fitness (CRF) at baseline and cardiovascular disease (CVD) risk in 6- to 10-year-olds (cross-sectional) and 2 years later (8- to 12-year-olds [longitudinal]) and whether changes with age in CRF are associated with CVD risk in children aged 8 to 12 years.

Patients and Methods: Spanish primary schoolchildren (n=236) aged 6 to 10 years participated at baseline. Of the 23 participating primary schools, 22% (n=5) were private schools and 78% (n=18) were public schools. The dropout rate at 2-year follow-up was 9.7% (n=23). The 20-m shuttle run test was used to estimate CRF. The CVD risk score was computed as the mean of 5 CVD risk factor standardized scores: sum of 2 skinfolds, systolic blood pressure, insulin/glucose, triglycerides, and total cholesterol/high-density lipoprotein cholesterol.

Results: At baseline, CRF was inversely associated with single CVD risk factors (all $P<.05$) and CVD risk score at baseline and follow-up ($P<.001$). Cardiorespiratory fitness cutoff points of 39.0 mL/kg per minute or greater in boys and 37.5 mL/kg per minute or greater in girls are discriminative to identify CVD risk in childhood (area under the curve, >0.85; $P<.001$) and to predict CVD risk 2 years later ($P=.004$). Persistent low CRF or the decline of CRF from 6-10 to 8-12 years of age is associated with increased CVD risk at age 8 to 12 years ($P<.001$).

Conclusion: During childhood, CRF is a strong predictor of CVD risk and should be monitored to identify children with potential CVD risk.

 ■ Mayo Clin Proc. 2017;92(12):1753-1762

Cardiovascular disease (CVD) is one of the main causes of global mortality and disease-related morbidity in developed countries.[1,2] Although CVD events occur most frequently during or after the fifth decade of life, there is evidence indicating that CVD precursors have their origin in childhood and adolescence.[3,4] Moreover, adverse CVD risk factors during childhood have been found to track into adulthood.[5] Consequently, early detection and diagnosis of CVD risk factors in children and adolescents will contribute to the development of effective prevention programs, counseling, and public health policies. Clustering of CVD risk factors seems to be a much stronger measure of cardiovascular health in children and adolescents than single CVD risk factors. Moreover, a composite CVD risk score could, to some extent, compensate for day-to-day fluctuations in the single CVD risk factors.[6,7]

Cardiorespiratory fitness (CRF) is a powerful marker of cardiovascular health. High CRF during childhood and adolescence has been associated with a healthier cardiovascular profile during these years[8] and also later in life.[9,10] Previous studies have established health-related CRF cutoff points for children and adolescents to identify the target population for primary CVD prevention.[11,12] Of note is that most of these studies have been conducted in adolescents, and no consensus exists regarding the health-related

For editorial comment, see page 1743; for a related article, see page 1763

From the Department of Physical Education, Faculty of Education Sciences, University of Cádiz, Puerto Real, Spain (J.C.-P., A.P.-B., V.S.-J.); Department of Physiology, Faculty of Pharmacy, Faculty of Sport Sciences, and Institute of

Affiliations continued at the end of this article.

CRF cutoff points associated with a healthier cardiovascular profile in early childhood.

The available existing data are from a cross-sectional design,[12] and it would also be desirable to know whether the identified health-related CRF cutoff point is associated with future cardiovascular health. The UP&DOWN study is a 3-year longitudinal study conducted in a Spanish sample of children and adolescents.[13] This study was designed to assess the impact of physical activity and sedentary behaviors over time on health indicators and to identify the psychoenvironmental and genetic determinants of physical activity in a Spanish sample of children and adolescents. Data from the UP&DOWN study provide an excellent opportunity to study the association between the CRF and cardiovascular health of children in a cross-sectional as well as a longitudinal dimension.

We studied (1) the association between CRF at baseline (6-10 years old) and CVD risk in 6- to 10-year-old (cross-sectional) and 8- to 12-year-old (longitudinal) children; (2) whether there is a CRF cutoff point associated with CVD risk at 6 to 10 years old (cross-sectional); (3) whether the health-related CRF cutoff point identified at 6 to 10 years old is associated with CVD risk 2 years later (longitudinal, 8 to 12 years old); and (4) whether changes with age (from 6-10 years to 8-12 years) in CRF are associated with CVD risk in 8- to 12-year-old children.

PATIENTS AND METHODS

Study Design and Population

The UP&DOWN study includes a convenience sample of 2225 youth aged 6 to 18 years (1188 children aged 6-10 years) from Spanish schools. Blood sampling was randomly performed in one-fourth of the recruited children and adolescents (n=514; 240 children aged 6-10 years). In the present study, primary schoolchildren aged 6 to 10 years at baseline were included as long as they had complete data at baseline and follow-up on skinfold thickness, blood pressure, serum triglyceride (TG) levels, total cholesterol (TC) level, high-density lipoprotein cholesterol (HDL-C) level, glucose level, insulin level, and CRF. Hence, the present study analyzed 236 primary schoolchildren (109 girls) at baseline from 23 primary schools in Cadiz (southern Spain); 22% (n=5) were private schools (in which 35% of students had a mother with a university education) and 78% (n=18) were public schools (in which 28% of students had a mother with a university education). Finally, 213 children (98 girls) aged 8 to 12 years completed the data in the follow-up study (23 children [9.7%] dropped out). Baseline data were collected from September 1, 2011, through June 30, 2012, and follow-up data were collected from September 1, 2013, through June 30, 2014.

The study complies with the Declaration of Helsinki and was approved by the ethics committee of the Hospital Puerta de Hierro (Madrid, Spain), the bioethics committee of the Spanish National Research Council (Madrid, Spain), and the committee for research involving human subjects at the University of Cádiz (Cádiz, Spain). Parents and school supervisors were informed by letter about the nature and purpose of the study, and written informed consent was provided.

Procedures

Pubertal Development. After a brief visual observation, participants self-classified in 1 of the 5 stages of pubertal development according to Tanner.[14] Breast development in girls and genital development in boys was used.

Skinfold Thickness. We measured triceps and subscapular skinfold thickness on the nondominant side of the body using a Holtain caliper (range, 0-40 mm; precision, 0.2 mm) according to Lohman et al's anthropometric standardization reference manual.[15] We performed the measurements twice, but not consecutively, and the mean value of the 2 measurements was used in the analyses.

Blood Pressure. We measured systolic blood pressure (SBP) using a validated digital automatic blood pressure monitor (Omron M6; Omron Healthcare Co Ltd) according to the International Protocol of the European Society of Hypertension.[16] The participants sat quietly on a chair for 5 minutes before the measurements were conducted on the left arm in an extended position. We took 2 measures 1 to 2 minutes apart. We performed an additional measurement if the first 2 readings differed by

Mayo Clin Proc. ■ December 2017;92(12):1753-1762 ■ https://doi.org/10.1016/j.mayocp.2017.09.003
www.mayoclinicproceedings.org