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RESEARCH LETTER

# Prevalence and correlates of cardiovascular health among early adolescents enrolled in the SI! Program in Spain: a cross-sectional analysis

**Rodrigo Fernandez-Jimenez [1,2,3]*, Gloria Santos-Beneit[1,4], Amaya de Cos-Gandoy[1,4], Juan Miguel Fernández-Alvira[1], Anna Tresserra-Rimbau[5,6], Carolina Storniolo[5,6], Mónica Domènech[5,7], Emily P. Laveriano-Santos[6], Patricia Bodega[1,4], Mercedes de Miguel[1,4], Carla Rodríguez[4], Isabel Carvajal[4], Borja Ibañez[1,3,8], Ramón Estruch[5,7], Rosa Maria Lamuela-Raventós[5,6], and Valentin Fuster [1,9]†**

[1]Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid, Spain; [2]Hospital Universitario Clinico San Carlos, Madrid, Spain; [3]Centro de Investigación Biomédica En Red en enfermedades CardioVasculares (CIBERCV), Madrid, Spain; [4]Foundation for Science, Health and Education (SHE), Barcelona, Spain; [5]Centro de Investigación Biomédica en Red Fisiopatología de la Obesidad y la Nutrición (CIBEROBN), Institute of Health Carlos III, Madrid, Spain; [6]Department of Nutrition, Food Science and Gastronomy, School of Pharmacy and Food Sciences, XaRTA, INSA, University of Barcelona, Barcelona, Spain; [7]Department of Internal Medicine, Hospital Clínic, Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), University of Barcelona, Barcelona, Spain; [8]Department of Cardiology, IIS-Fundación Jiménez Díaz Hospital, Madrid, Spain; and [9]Division of Cardiology, The Zena and Michael A. Wiener Cardiovascular Institute, Icahn School of Medicine at Mount Sinai, New York, NY, USA

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The American Heart Association (AHA) recommends the assessment of cardiovascular health (CVH) through the assessment of health behaviours [smoking status, body mass index (BMI), physical activity, and diet] in addition to traditional cardiovascular risk factors (blood pressure, total cholesterol, and glucose measurements).[1] Numerous studies have demonstrated an inverse association between the number of ideal CVH factors and the incidence of adverse outcomes in adults.[2] Recent studies have emphasized the importance of having a good CVH profile early in life.[3] Adolescence is a critical period for the initiation of unhealthy habits. With the aim of instilling sustained healthy behaviours in adolescents, we recently launched the SI! Program for Secondary School trial (NCT03504059), which enrolled 24 secondary public schools in Madrid and Barcelona, Spain.[4] We conducted a cross-sectional analysis at enrolment of adolescents' CVH and their correlates with different socioeconomic characteristics. Details about the recruitment of schools and adolescents can be found elsewhere.[4]

Adolescents' CVH metrics were assessed using medical devices and questionnaires guided by a team of nutritionists and nurses as previously described.[4] Parents/caregivers completed an online survey with questions related to sociodemographic parameters. We used the AHA measures of ideal CVH in children and adolescents.[1] For each of the seven CVH metrics, a value of 1 was assigned when the criterion was met (ideal metric) and a value of 0 when it was not met. Scores thus ranged from 0 to 7, with a higher score indicating a better CVH profile. A poor CVH score was defined as ≤3 ideal metrics, an intermediate score as 4 or 5 ideal health metrics, and an ideal score as 6 or 7 ideal health metrics. All adolescents with valid data for at least 5 of the 7 individual metrics were included in the analysis. For participants with one ($n = 9$, 0.7%) or two ($n = 45$, 3.4%) missing metrics, the missing metrics were assigned a score calculated as the average of the remaining metrics for the individual concerned. Two participants had more than two individual metrics missing, and were excluded from the analysis. For subgroup analyses of socioeconomic correlates, missing values on variables used to create subgroups were not imputed; instead, the pairwise deletion was performed.

Crude prevalence of categorized overall CVH (poor, intermediate, ideal), together with their 95% confidence intervals (CI), were calculated using the Wilson approximation. Prevalence ratio (PR) point estimates (and their 95% CIs) of categorized overall CVH were calculated with generalized models using a Poisson distribution with a log link and robust error variance. Mixed-effects linear regression models were used to assess adjusted between-group differences for the overall CVH as a continuous variable (range 0–7). Stratified models were built according to sociodemographic variables of interest. In all adjusted models, fixed effects were age and sex, whereas region (Madrid or Barcelona) and schools within each region were handled as random effects. Crude models included only random effects.

This analysis included 1324 adolescents (641 girls, 683 boys) out of 1326 enrolled in the trial, with a mean age of 12.0 (SD 0.5) years.

* Corresponding authors. Tel: (+34) 91 453 12 00, Fax: (+34) 91 453 12 65; Email: rfernandez@cnic.es (R.F.-J.);
† Tel: (+34) 91 453 12 00, Fax: (+34) 91 453 12 65; Email: vfuster@cnic.es (V.F.)

The mean overall CVH score (range 0–7) was 4.3 points (95% CI 4.3–4.4). The lowest scoring individual component was dietary habits, with just 0.6% (95% CI 0.3–1.2) of adolescents meeting ideal recommendations (*Figure 1A*). Smoking habits scored the highest, with 92.3% (95% CI 90.7–93.6) of adolescents reporting never having smoked. The overall prevalence of overweight and obesity was 17.6% (95% CI 15.7–19.8) and 10.0% (95% CI 8.5–11.7), respectively. According to the number of ideal CVH components, most adolescents were classified as having an intermediate ($n = 889$, 67.2%) or poor ($n = 289$, 21.8%) overall CVH. Only 1 adolescent (0.1%) had seven ideal CVH components.

Overall CVH scores were better among female adolescents than males [4.5 points (95% CI 4.4–4.5 vs. 4.2 points (95% CI 4.1–4.3)]. Similarly, adolescents from high-income families scored better than those from low-income families [4.5 points (95% CI 4.4–4.6) vs. 4.2 points (95% CI 4.1–4.3)], as did those whose parents had a higher educational level vs. those with the lowest educational level [4.5 points (95% CI 4.4–4.5) vs. 4.2 points (95% CI 4.1–4.4)] and those from a non-migrant background vs. those from a migrant background [4.4 points (95% CI 4.3–4.4) vs. 4.2 points (95% CI 4.1–4.3)]. Similar adjusted trends were observed for the analysis of overall CVH score as a continuous variable (range 0–7 points, *Figure 1B*) or as a categorical variable (poor, intermediate, and ideal, *Table 1*).

Comprehensive data on contemporary CVH in early adolescents in Europe are scarce.[5] Our study represents one of the largest samples of contemporaneous early adolescents examined for CVH and sociodemographic correlates to date in Spain. Because prior studies included children of a variety of ages,[6] our results are difficult to contextualize. Nevertheless, in agreement with prior data, dietary habits scored the lowest among all health metrics examined. On the other hand, non-smoking scored the highest; however, the proportion of young adolescents (~8%) who reported already having tried smoking is not negligible. Although we found better CVH profiles in girls than in boys, the evidence for gender differences in CVH scores is conflicting. In line with previous data,[7] we found that parental education and household income showed a direct association with overall CVH. Furthermore, adolescents from a migrant background had a lower overall CVH and might represent a particularly vulnerable population. Early promotion of CVH is considered a global priority.[8] The SI! Program for Secondary School is part of a multidimensional educational intervention with the overarching goal of promoting lifelong CVH by instilling healthy behaviours from early childhood in a variety of socioeconomic settings.[9,10]

Some limitations warrant consideration. Because of the cross-sectional nature of the analysis, our study demonstrates associations but not causation. The schools and participant adolescents were recruited with a non-probabilistic sampling method; therefore, the population analysed might not be representative of the overall adolescent population in Spain. Nevertheless, the mean overall participation rate of individuals from enrolled schools was ~53% and

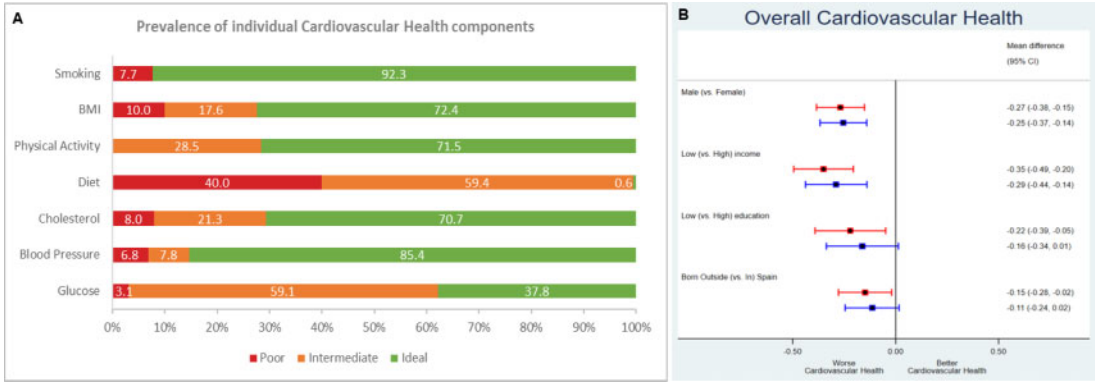


**Figure 1** (*A*) Prevalence of poor, intermediate, and ideal individual cardiovascular health components. Stacked bars represent the percentage of adolescents enrolled in the SI! Program with poor (red), intermediate (orange), or ideal (green) individual cardiovascular health components defined according to American Heart Association criteria. Adolescents who reported never having smoked a whole cigarette were categorized as having an ideal smoking status; all other individuals were classified as having a poor smoking status. Age- and sex-adjusted BMI percentiles were calculated according to Centers for Disease Control standards, with ideal, intermediate, and poor BMI defined as <85th percentile, 85–95th percentile, and >95th percentile, respectively. Ideal physical activity was defined as ≥60 min/day moderate-to-vigorous activity, intermediate activity as any activity <60 min/day, and poor physical activity as no physical activity. Adolescents who met all four healthy diet criteria (consumption of fruits and vegetables ≥4.5 servings/day, fish ≥2 servings/week, fibre-rich whole grains ≥ 1 servings/day, and sugar-sweetened beverages ≤1 L/week) were classified as having an ideal diet, whereas those meeting 2–3 or only 0–1 of the criteria were classified as having an intermediate or poor diet, respectively. Blood pressure (BP) percentiles and stages were calculated according to blood pressure reference data from the American Academy of Pediatrics with ideal, intermediate, and poor BP defined as <90th percentile, 90–95th percentile, and >95th percentile, respectively. Ideal total cholesterol (TC) was TC <170 mg/dL, intermediate TC 170–199 mg/dL, and poor TC ≥200 mg/dL. Ideal fasting blood glucose was <100 mg/dL, intermediate glucose 100–125 mg/dL, and poor glucose ≥126 mg/dL. (*B*) Differences in overall cardiovascular health across sociodemographic variables of interest. Forest plots represent crude (red) and adjusted (blue) mean differences and 95% confidence intervals in overall cardiovascular health as a continuous variable (range 0–7 points). The X-axis is in linear scale.

**Table 1 Prevalence of overall cardiovascular health and prevalence ratios according to different sociodemographic characteristics**

| | *n* (%) | Prevalence of overall cardiovascular health (95% CI) | | | Prevalence ratio (95% CI) | |
|---|---|---|---|---|---|---|
| | | Poor ≤3 ideal components | Intermediate 4–5 ideal components | Ideal 6–7 ideal components | Crude | Adjusted |
| All | 1,324 (100) | 21.8 (16.7–24.1) | 67.2 (64.6–69.6) | 11.0 (9.5–12.8) | — | — |
| Sex | | | | | | |
| Male | 683 (51.6) | 25.5 (22.4–28.9) | 65.6 (62.0–69.1) | 8.9 (7.0–11.3) | Ref. | Ref. |
| Female | 641 (48.4) | 17.9 (15.2–21.1) | 68.8 (65.1–72.3) | 13.3 (10.9–16.1) | 1.14 (1.07–1.22) | 1.13 (1.11–1.15) |
| Household income | | | | | | |
| Low | 406 (33.1) | 25.9 (21.8–30.3) | 65.0 (60.3–69.5) | 9.1 (6.7–12.3) | Ref. | Ref. |
| Average | 380 (31.0) | 24.0 (19.9–28.5) | 65.5 (60.6–70.1) | 10.5 (7.8–14.0) | 1.04 (0.95–1.14) | 1.03 (1.03–1.04) |
| High | 440 (35.9) | 14.3 (11.4–17.9) | 71.4 (67.0–75.4) | 14.3 (11.4–17.9) | 1.20 (1.10–1.30) | 1.17 (1.14–1.20) |
| Parental education | | | | | | |
| Less than secondary school | 215 (17.1) | 26.1 (20.6–32.3) | 65.1 (58.5–71.2) | 8.8 (5.7–13.4) | Ref. | Ref. |
| Secondary or professional school | 528 (41.9) | 22.9 (19.5–26.7) | 68.4 (64.3–72.2) | 8.7 (6.6–11.4) | 1.04 (0.93–1.15) | 1.03 (0.98–1.09) |
| University degrees | 518 (41.1) | 17.8 (14.7–21.3) | 67.8 (63.6–71.6) | 14.5 (11.7–17.8) | 1.17 (1.05–1.30) | 1.14 (1.10–1.17) |
| Parents born in Spain | | | | | | |
| Yes | 849 (68.0) | 19.6 (17.0–22.4) | 68.3 (65.1–71.4) | 12.1 (10.1–14.5) | Ref. | Ref. |
| No | 399 (32.0) | 24.3 (20.4–28.8) | 66.7 (61.9–71.1) | 9.0 (6.6–12.2) | 0.92 (0.85–0.99) | 0.92 (0.80–1.07) |

Prevalence ratios of having overall healthier categorized cardiovascular health were calculated from generalized models using a Poisson distribution with a log link and robust error variance. Stratified models were built according to the different sociodemographic variables of interest. Adjusted models included age and sex as fixed effects and region (Madrid or Barcelona) and schools within each region as random effects. Crude models included only random effects. Parental educational level was categorized according to the International Standard Classification of Education (ISCED): Low (families with no studies or only primary studies; 0–1 ISCED score), medium (secondary studies and professional training; 2–4 ISCED score), and high (university studies; 5–6 ISCED score). This analysis considered the parent/caregiver with the highest education level. Socioeconomic status (SES) was defined according to the most recently published Spanish average annual household income at the time of baseline data collection (2016, €26 730). Household income was classified into three categories: low (below the average), average (around the average), and high (above the average). A migrant background was assumed if at least one of parent/caregiver was born outside Spain.

did not significantly differed by region. Finally, the prevalence of ideal glucose levels may have been underestimated because some adolescents were likely assessed in non-fasting conditions, thus reducing the overall CVH score.

In conclusion, most early adolescents enrolled in the SI! Program for Secondary School trial in Spain had a poor or intermediate CVH, with just ∼11% of them demonstrating ideal CVH (6 or 7 ideal CVH components). The lowest scoring individual component was dietary habits, with only 0.6% of adolescents meeting ideal recommendations. Self-reported family low-income status, low parental education, and migrant condition were associated with worse adolescent CVH. Health promotion interventions should be implemented at young ages, with a particular focus on dietary habits and low socioeconomic settings.

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