Ideal cardiovascular health and inflammation in European adolescents: the HELENA study


PII: S0939-4753(16)30333-7
DOI: 10.1016/j.numecd.2016.12.003
Reference: NUMECD 1681

To appear in: Nutrition, Metabolism and Cardiovascular Diseases

Received Date: 16 July 2016
Revised Date: 13 December 2016
Accepted Date: 14 December 2016


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Ideal cardiovascular health and inflammation in European adolescents: the HELENA study.

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Word count for abstract: 245
Word count for text: 2990
Number of references: 30
Number of tables: 4 (plus two presented as supplementary material)
Number of figures: 1 (plus one presented as supplementary material)
ABSTRACT

Background and aims: Inflammation plays a key role in atherosclerosis and this process seems to appear in childhood. The ideal cardiovascular health index (ICHI) has been inversely related to atherosclerotic plaque in adults. However, evidence regarding inflammation and ICHI in adolescents is scarce. The aim is to assess the association between the ICHI and inflammation in European adolescents.

Methods and results: 543 adolescents (251 boys and 292 girls) from the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study, a cross-sectional multi-center study including 9 European countries, were measured. C-reactive protein (CRP), complement factors C3 and C4, leptin and white blood cell counts were used to compute an inflammatory score. Multilevel linear models and multilevel logistic regression were used to assess the association between ICHI and inflammation controlling by covariates. Higher ICHI was associated with a lower inflammatory score, as well as with several individual components, both in boys and girls (p<0.01). In addition, adolescents with at least 4 ideal components of the ICHI had significantly lower inflammatory score and lower levels of the study biomarkers, except CRP. Finally, the multilevel logistic regression showed that for every unit increase in the ICHI, the probability of having an inflammatory profile decreased by 28.1% in girls.

Conclusion: Results from this study suggest that a better ICHI is associated with a lower inflammatory profile already in adolescence. Improving these health behaviors, and health factors included in the ICHI, could play an important role in CVD prevention.

Keywords: Cardiovascular health; inflammation; European adolescents.
INTRODUCTION

Cardiovascular diseases (CVD), such as coronary artery disease, are the result of atherosclerosis progression (1). Evidence suggest that inflammation has a key role in the origin and development of atherosclerosis (2) as it triggers the formation of the fatty streak and its development into complex plaque (3). Atherosclerosis has its origins in childhood and is associated with early risk factors (4), yet symptoms may appear later in life (5). The relationship between inflammation and cardiovascular diseases is present already in childhood (6).

High concentrations of C-reactive protein (CRP) seem to track from childhood to adulthood (7). However, there are other biomarkers contributing to the characterization of the inflammatory process such as cytokines (8), e.g. tumor necrosis factor alpha (TNF-alpha), or interleukins, e.g. interleukin 6 (IL-6). Nevertheless, other biomarkers have also been considered (9).

In addition, CRP is not always associated with atherosclerosis diagnosed by image techniques (10) therefore, the use of a score that combines several inflammatory biomarkers could provide an overall estimation of the inflammatory status. A previous study (11) developed an inflammatory score, which included CRP, complement factors C3 and C4, leptin and white blood cells (WBC) being selected due to their high correlation with fatness and traditional cardio-metabolic risk factors.

In 2010, the American Heart Association (AHA) released the ideal cardiovascular health index (ICHI), (12) including four health behaviors and three health factors. The behavior-related criteria were: non-smoking, being physically active, having normal body mass index (BMI), and eating a healthy diet, while the health factors included were: normal blood pressure, plasma total cholesterol and glucose. The ICHI has been inversely related to the presence of atherosclerotic plaque in adults (13); therefore, it could represent a useful epidemiological tool to assess the cardiovascular profile.

Although there are some studies assessing the relationship between cardiovascular profile and metabolic risk factors in adolescents or young adults, (14, 15) there is not sufficient evidence on the association between inflammation and cardiovascular health in young populations.
The aims of the present study were to assess the association between ICHI and inflammatory markers in European adolescents and to examine the use of an inflammatory score to assess the inflammatory status in adolescents (14).
METHODS

Study design
The HELENA study is a cross-sectional multi-center study (n=3528) conducted in 10 European cities: Athens and Heraklion in Greece, Dortmund in Germany, Ghent in Belgium, Lille in France, Pecs in Hungary, Rome in Italy, Stockholm in Sweden, Vienna in Austria and Zaragoza in Spain. HELENA study has been previously described(16). The study was performed according to the ethical guidelines of the Edinburgh revision of the 1964 Declaration of Helsinki (2000). The local Ethics Committees of each center approved the protocol and written informed consent was obtained.

Study population
Out of the total HELENA sample, one third from the 10 cities was chosen to provide blood samples (n=1089, 31%). Therefore, around 100 adolescents in each city were selected by means of the immunological parameters which were those with the highest variability within the blood measurements that were included in the study (16). Overall, 543 participants (251 boys and 292 girls) met the inclusion criteria for the present analysis: having data on the variables included in the ICH index and having measured the CRP, C3 and C4 complement factors, leptin and WBC. (Supplementary Figure 1)

Physical examinations
Weight and height were measured in underwear and barefoot with a SECA 861 (Seca Ltd) and with a stadiometer SECA 225 (Seca Ltd). In addition, body mass index (BMI) was calculated as body weight in kilograms divided by the square of height in meters. Pubertal maduration was examined by a clinician and was assessed according Tanner (5-point-scale). Systolic and diastolic blood pressure was measured with an automatic oscillometric device (Omron M6). Participants were seated in a quiet room for ten minutes with their backs supported and feet on the ground. The lowest value of the two measurements, taken with a difference of 5 minutes, was recorded and the mean was used in data analysis. All anthropometric measures were taken following a standardized protocol.

Socioeconomic status
A modified version of the family affluence scale (FAS) was used as a proxy of socioeconomic status (SES). The adolescents completed a questionnaire asking about the numbers of cars and computers at home, having internet and whether the adolescent had his or her own room. In the HELENA study, the FAS was modified by replacing ‘frequency of family holidays’ by ‘Internet availability at home’. Adolescents were scored from 0 (very low SES) to 8 (very high SES).

Blood analysis
Blood withdrawal was performed in fasting status. WBC counts and percentages were determined with automated blood cell counters. C-reactive protein (CRP) levels were quantified by immunoturbidimetry (AU 2700, Olympus, Rungis, France). Serum C3 and C4 complement factors were analyzed by nephelometry (Behring Diagnostics, CA, USA). The coefficient of variation (inter-assay precision) was 1.9% for CRP, 1.4% for C3, and 1.2% for C4. Detection limits (sensitivity) were 0.007 mg/L for CRP, 0.01 g/L for C3, and 0.002 g/L for C4. Serum leptin (ng/mL) was measured using the RayBio Human Leptin ELISA (Enzyme-Linked Immunosorbent Assay; RayBiotech, Norcross, GA, USA) kit. The sensitivity of the leptin assay was <6 pg/mL, with intra-assay and interassay coefficients of variation of <10% and <12%.

Ideal cardiovascular health index
The AHA released the ICHI in 2010 (12) with the cut off values for adolescents.

Health behaviors
Four health behaviors were considered for the ICH index: smoking behavior, physical activity, BMI and diet.
Smoking status was categorized considering those who had never smoked as having an ideal smoking behavior. Adolescents who performed more than 60 min of moderate to vigorous self-reported exercise every day were classified as having an ideal physical activity level. BMI z-score and BMI categories were derived using the British 1990 Growth Reference Data from the Child Growth.(17, 18)
To assess dietary intake the HELENA-Dietary Assessment Tool (HELENA-DIAT)(19), a self-report dietary recall based on six meal occasions, was used. The dietary indicators used to assess ideality of the diet were: consumption of fruit and vegetables (more than 400 g per day), fish and fish products (at least 28 g per day), fiber (at least 1.1 grams per
10 g of carbohydrates per day), sodium (less than 1500 mg per day), and soft drinks (less than 145 mL per day). Having at least 4 of these indicators classified as ‘ideal’ was considered as ideal healthy diet.

Health factors

The cut-off for the biomarkers assessed to consider them ideal was <170mg/dL for plasma total cholesterol and <100mg/dL for glucose.

The lower value of the diastolic blood pressure and systolic blood pressure was used in the analysis to classify blood pressure status as ideal when lower than the 90th centile for the blood pressure (12).

Inflammatory score

A continuous score was computed from some inflammatory biomarkers: CRP, C3, C4, WBC and leptin. The selection of these biomarkers was based on a preliminary analysis with fatness and traditional cardio-metabolic risk factors as previously assessed within the HELENA study (11) (Supplementary material table 1).

Standardized values of the biomarkers were calculated for boys and girls and by 1-year age groups with the following formula: standardize value= (value – mean) / standard deviation (SD), as has been done elsewhere.(11) Z-scores from biomarkers were summed up to create a score of inflammation.

Statistical analysis

Analyses were stratified by sex. Normality assumption was checked and transformation was performed if required. Partial correlations, adjusted for age, sex, pubertal stage and center, between traditional and nontraditional cardio-metabolic biomarkers were performed for the selection of the inflammatory biomarkers for the inflammatory score.

Student t test and chi-squared test were performed for the differences between the study participants by sex. Additionally, ANCOVA was performed to assess mean value of the inflammatory score by the ideal category and non-ideal category of each component of the ICHI, adjusting by tanner as covariate and center as random factor.
Multilevel linear models (level: center) were used to assess the associations between the inflammatory score (dependent variable) and the ICHI. Two different models were carried out. In the first model, the covariates used were Tanner and SES while in the second model the cardiorespiratory fitness was included. Frequencies between number of components of the ICHI and inflammatory score were assessed and the p for trend was calculated.

Finally, a multilevel logistic regression (level: center) was performed. The inflammatory index was transformed into a categorical variable using the median value in order to split the sample into two groups (I: > -0.737; II: ≤ -0.737 for boys and I: > -0.268; II: ≤ -0.268 for girls) and the ideal cardiovascular health index was considered as independent variable. Two different models were performed. In the first model, the covariates used were Tanner and SES while in the second model the cardiorespiratory fitness was included. Interactions between covariates and dependent variable were assessed before calculating the multivariate regression model using Wald test in both multilevel models: linear and logistic, and no statistical significance was observed in any. Also, multicollinearity was assessed by means of variance inflation factor values calculation for covariates in each multilevel linear model, and all were < 10.

Data were managed and analyzed with SPSS Statistics v.19 and R software with lme4 package for multilevel regression models and AED package to test for multicollinearity.
RESULTS

Baseline characteristics are shown in Table 1. There were significant differences by sex in some of the ICHI components and some biomarkers. None of the boys and only 9% of the girls followed a healthy diet, almost 47% of the girls had high total cholesterol levels and 40% of the girls did not comply with PA guidelines. Results for the selection of the inflammatory biomarkers are found in Supplementary table 1. Differences in mean concentration of the inflammatory score by the categories of each ICHI component are presented in Supplementary table 2. Significant sex differences were found in BMI, physical activity and blood pressure. Plasma glucose showed significant differences by category of ICHI component in boys.

Results for the multilevel linear models of the ICHI are presented in Table 2, for boys, and Table 3, for girls. In model 1, the ICHI was significantly and inversely related to the inflammatory score and its components: inflammatory score (p<0.001 for boys and girls), C3 (p=0.001 for boys and p<0.001 for girls), C4 (p=0.002 for boys and p=0.001 for girls), WBC (p=0.017 for girls) and log-leptin (p<0.001 for boys and girls). In model 2, the biomarkers significantly and inversely associated with the ICH index were: inflammatory score (p=0.005 for boys and p=0.005 for girls), C3 (p=0.001 in girls), C4 (p=0.004 in boys and p=0.039 in girls) and log-leptin (p<0.001 in boys and p=0.006 in girls). Also, lower levels of inflammation were associated with a higher number of components of the ICH index in boys (p<0.001) and girls (p<0.001) (Figure 1).

Finally, the multilevel logistic regression (Table 4) showed the probability of having a higher or lower inflammatory state when increasing one unit of the ICHI. For boys, when increasing the ICHI with one unit, the probability of having a higher inflammatory status decreased 30.7% (OR=0.693, 95%CI: 0.544-0.883, p=0.003) in the model 1, while this probability decreased 26.5% (OR=0.735, 95%CI: 0.533-1.014 p=0.061) in model 2. In girls, when increasing the ICHI with one unit the probability of having a higher inflammatory status decreased 22.3% (OR=0.677, 95%CI: 0.539-0.850, p<0.001) in the first model and 28.1% (OR=0.719, 95%CI: 0.534-0.969, p=0.031) for model 2.
DISCUSSION

Findings from this study suggest that the ICHI proposed by the AHA is negatively associated with inflammation, measured by biomarkers and an inflammatory score, in a sample of European adolescents. Less than optimal cardiovascular health during adolescence seems to be critical in the development of future CVD.(20) A very low prevalence of the ICHI has been shown in a U.S sample of adolescents, especially regarding both behavioral components, physical activity and diet.(21) Furthermore, in another study in adolescents, the ICHI was inversely associated with aortic intima-media and directly associated with aortic elasticity, already in adolescence, supporting the relevance of this tool as part of a primary prevention of future cardiovascular events.(22)

However, none of the European adolescents included in our study sample met the 7 components of the ICHI. This result is in line with previous studies reporting the same outcome in adolescents (14, 20, 22). Maybe these results are due to the low scores of the ideal diet score component; this component includes at least four ideal diet criteria out of five, and was also the component least often met in our sample, 1.7%. In studies performed in adults, the ideal diet score was also the less frequent component; prevalence being <1% (23) and 0.4% (24). In our sample, among the diet components, the optimum level of sodium intake was achieved only by 8.7% of the adolescents, being the most difficult criteria to meet, but also one of the most challenging criteria to measure accurately. In contrast, having <100mg/dL for glucose was the most commonly achieved component of the ICHI since 91.2% of our sample met this criteria.

In our sample, we observed a negative association between ICHI and the inflammatory score, suggesting that the higher the ICHI the lower the inflammatory score. To our knowledge, there are no previous studies assessing the relation between ICHI and inflammation in adolescence. However, a previous study observed that ICHI in adolescence was a good predictor of cardio-metabolic health in adulthood (20). As, individually, the components of the ICHI, such as cardiovascular risk factors, have been already related to biomarkers of inflammation (25). It seems that cardiovascular risk could be mediated through inflammation.
In the current study, the observed associations were found using the ICHI as a 7-component variable and the inflammatory score, independently of sex. However, the ICHI was associated with all the individual biomarkers of the inflammatory score except CRP. This protein is the most widely clinical biomarker of inflammation because it is easily and reliably measured and it has been related to adiposity and cardiovascular risk factors in healthy children. (26) Moreover, CRP has been related to the prediction of coronary heart disease (27) and atherosclerosis in adults (28). However, based on our findings, it would be recommended to investigate other biomarkers related to traditional metabolic risk factors, in addition to CRP, to evaluate the inflammatory status.

Cardiorespiratory fitness can be considered as a marker of cardiovascular health in children and adolescents (29) and has been related to an increased prevalence of CVD risk factors in adolescents and adults (30). A previous study with HELENA data showed that higher levels of cardiorespiratory fitness were positively associated with the ICHI in adolescents. (14) Our results show that the ICHI was associated with inflammation independently of cardiorespiratory fitness in girls.

There were several limitations to our findings. First, the cross-sectional nature of the study is a limitation. The inflammatory score is sample specific and each biomarker weighted equally for the prediction of cardio-metabolic risk. Blood samples only reflect inflammation at this specific time point. However, this study has many strengths including the use of an inflammatory score that sums up several inflammatory biomarkers, related to cardio-metabolic risk to assess an overall cardio metabolic status as well as the use of standardized and harmonized information from 9 European countries.

In conclusion, results from the current study show that there is an association between the ideal cardiovascular health in adolescence and inflammatory status. Despite not being significant for CRP, results were strongly associated with a composite index of inflammation including CRP, WBC, C3, C4 and leptin, in both gender, and, in girls, independently of the cardiorespiratory. Since the most difficult ICHI criteria to achieve was ideal diet, we should concentrate efforts to improve consumption of those food items included in the index, especially emphasizing the reduction of salt intake. These results provide further insight to better understand the association between lifestyle and
cardiovascular risk. Longitudinal studies in adolescent populations measuring the
association between inflammation and cardiovascular risk are needed to confirm these
results and to prevent future related diseases.
ACKNOWLEDGEMENTS

Thanks to Anke Carstensen, Rosa Maria Torres and Ulrike Albers for the laboratory work. The HELENA Study was supported by the European Community Sixth RTD Framework Programme (Contract FOOD-CT-2005-007034). This analysis was also supported by the Spanish Ministry of Science and Innovation (JCI-2010-07055) and the European Regional Development Fund (FEDER). A grant from the Spanish Ministry of Economy and Competitiveness was received by JRR (grants RYC-2010-05957).

CONFLICT OF INTEREST: None declared


REFERENCES


APPENDIX

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Table 1. Characteristics of the study participants.

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Boys (n=251)</th>
<th>Girls (n=292)</th>
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<tr>
<td>Age (years)</td>
<td>14.80±1.28</td>
<td>14.81±1.17</td>
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<tr>
<td>Tanner I % (n)</td>
<td>0.8 (2)</td>
<td>0 (0)</td>
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<td>0.126</td>
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<tr>
<td>Tanner II % (n)</td>
<td>12.4 (31)</td>
<td>6.9 (20)</td>
<td></td>
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<tr>
<td>Tanner III % (n)</td>
<td>17.6 (44)</td>
<td>24.5 (71)</td>
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<tr>
<td>Tanner IV % (n)</td>
<td>46.0 (115)</td>
<td>45 (132)</td>
<td></td>
<td>0.887</td>
</tr>
<tr>
<td>Tanner V % (n)</td>
<td>23.2 (58)</td>
<td>23.1 (67)</td>
<td></td>
<td>0.964</td>
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<tr>
<td>Moderate-vigorous PA (min/day)</td>
<td>121.73±91.47</td>
<td>90.89±72.21</td>
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<td>&lt;0.001</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>21.04±3.96</td>
<td>21.14±3.38</td>
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<td>0.763</td>
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<tr>
<td>Systolic blood pressure (mm Hg)</td>
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<td>112.85±11.19</td>
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<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>64.02±8.61</td>
<td>65.04±8.72</td>
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<td>0.174</td>
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<td>Glucose (mg/dL)</td>
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<td>88.43±5.99</td>
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<td>Inflammatory score</td>
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<td>CRP (mg/L)</td>
<td>0.82±1.18</td>
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<td>C3 (g/L)</td>
<td>1.11±0.16</td>
<td>1.13±0.16</td>
<td></td>
<td>0.089</td>
</tr>
<tr>
<td>C4 (g/L)</td>
<td>0.20±0.06</td>
<td>0.21±0.06</td>
<td></td>
<td>0.271</td>
</tr>
<tr>
<td>Leptin (ng/mL)</td>
<td>9.17±14.93</td>
<td>29.1±25.06</td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WBC (10x3/µL)</td>
<td>6.06±1.34</td>
<td>6.45±1.55</td>
<td></td>
<td>0.002</td>
</tr>
</tbody>
</table>

**Ideal health behaviours**

| Smoking % (n)        | 61.8 (155)    | 59.2 (173)   |               | 0.552 |
| Body mass index % (n)| 78.5 (197)    | 82.9 (242)   |               | 0.195 |
| Physical activity % (n)| 70.5 (177) | 59.9 (175) |       | 0.010 |
| Diet % (n)           | 0 (0)         | 9 (3.1)      |               |       |

**Ideal health factors**

| Total cholesterol % (n) | 78.5 (197) | 53.4 (156) | <0.001 |
| Blood pressure % (n)   | 88.8 (223) | 90.1 (263) | 0.643 |
| Plasma glucose % (n)   | 84.5 (212) | 96.9 (283) | <0.001 |

Table 2. Multilevel linear models of the ideal cardiovascular health index and inflammation in boys.

<table>
<thead>
<tr>
<th>BOYS</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inflammatory score</td>
<td>Inflammatory score</td>
</tr>
<tr>
<td>Ideal cardiovascular</td>
<td>Beta</td>
<td>95% CI</td>
</tr>
<tr>
<td>health index</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.794</td>
<td>-1.146, -0.442</td>
</tr>
<tr>
<td>CRP*</td>
<td>Beta</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td>-0.040</td>
<td>-0.183, -0.096</td>
</tr>
<tr>
<td>C3</td>
<td>Beta</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td>-0.297</td>
<td>-0.047, -0.011</td>
</tr>
<tr>
<td>C4</td>
<td>Beta</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td>-0.011</td>
<td>-0.018, -0.004</td>
</tr>
<tr>
<td>WBC</td>
<td>Beta</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td>-0.077</td>
<td>-0.229, 0.074</td>
</tr>
<tr>
<td>Leptin*</td>
<td>Beta</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td>-0.393</td>
<td>-0.509, -0.227</td>
</tr>
</tbody>
</table>

95% CI: Confidence Interval. CRP: C-reactive protein. C: Complement factor. WBC: Whole blood cells count.

*CRP and Leptin are log-transformed.

Model 1: Adjusted by tanner and socioeconomic status (SES)

Model 2: Adjusted by tanner, SES, and cardiorespiratory fitness.
Table 3. Multilevel linear models of the ideal cardiovascular health index and inflammation in girls.

<table>
<thead>
<tr>
<th>GIRLS</th>
<th>Ideal cardiovascular health index</th>
<th></th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inflammatory score</td>
<td></td>
<td>Inflammatory score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
</tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>GIRLS</td>
<td>CRP*</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GIRLS</td>
<td>C3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>GIRLS</td>
<td>C4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GIRLS</td>
<td>WBC</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>GIRLS</td>
<td>Leptin*</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
<td>Beta</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

95% CI: Confidence Interval. CRP: C-reactive protein. C: Complement factor. WBC: Whole blood cells count.

*CRP and Leptin are log-transformed.

Model 1: Adjusted by tanner and socioeconomic status (SES)

Model 2: Adjusted by tanner, SES, and cardiorespiratory fitness.
Table 4. Multilevel logistic regression.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
<td>p-value</td>
<td>OR</td>
</tr>
<tr>
<td>BOYS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICHI</td>
<td>0.693</td>
<td>0.544-0.883</td>
<td>0.003</td>
<td>0.735</td>
</tr>
<tr>
<td>GIRLS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICHI</td>
<td>0.677</td>
<td>0.539-0.850</td>
<td>&lt;0.001</td>
<td>0.719</td>
</tr>
</tbody>
</table>

OR: Odds ratio
Model 1: Adjusted by tanner and socioeconomic status (SES)
Model 2: Adjusted by tanner, SES, and cardiorespiratory fitness.
CI: Confidence Interval.
FIGURE LEGENDS

Figure 1. Association between inflammatory score and Ideal Cardiovascular Health index.

Supplementary Figure 1. Flow diagram of the study population.
Boys

Ideal cardiovascular health index

Inflammatory score

p for trend < 0.001

Girls

Ideal cardiovascular health index

Inflammatory score

p for trend < 0.001
HIGHLIGHTS

Less than ideal cardiovascular health is associated with inflammation in adolescence
C-reactive protein was not associated with cardiovascular health
Diet is the component of the cardiovascular index most difficult to achieve
Prevention should start early in life to avoid future cardiovascular diseases