Prevalence of ideal cardiovascular health in European adolescents: The HELENA Study

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Key words: Cardiovascular Disease, Cardiovascular health, Epidemiology, Public health Risk Factor.

Abbreviations: AHA, American Heart Association; BMI, body mass index; CI, confidence interval; iCVH, ideal cardiovascular health; HELENA study, Healthy Lifestyle in Europe by Nutrition in Adolescence study; NHANES, National Health and Nutrition Examination Survey.

ABSTRACT

Background: The ideal cardiovascular health (iCVH) construct consists of 4 health behaviours and 3 health factors and is strongly related to later cardiovascular disease. However, the prevalence of iCVH in European adolescents is currently unknown.

Methods:

The Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study is a cross-sectional, multicentre study conducted in 9 European countries during 2006-2007 and included 3528 adolescents (1683 boys and 1845 girls) between 12.5 and 17.5 years of age. Status (ideal vs. non-ideal) for the health behaviours (smoking status, body mass index, physical activity and diet) and health factors (total cholesterol, blood pressure and fasting glucose) were determined.

Results:

Overall, the prevalence of ideal health behaviours was low; non-smoking (60.9% ideal), body mass index (76.8%), physical activity (62.1%), and diet (1.7%). The prevalence of ideal health factors was; total cholesterol (65.8%), blood pressure (62.0%) and plasma glucose (88.8%).

Conclusions

The low prevalence of iCVH behaviours, especially diet and physical activity, identified in European adolescents is likely to influence later cardiovascular health which strongly motivates efforts to increase ideal health behaviours in this population.

Key words: cardiovascular health, epidemiology, prevention, public health, risk factor

1. INTRODUCTION

Cardiovascular disease is a leading cause of death worldwide (1, 2). In 2010, the American Heart Association (AHA) presented a new construct, ideal cardiovascular health (iCVH), which incorporated health behaviours and traditional cardiovascular risk factors to assess cardiovascular health (3). iCVH was defined as the simultaneous presence of 7 ideal components, consisting of 4 health behaviours (non-smoking status and ideal body mass index (BMI), physical activity and diet) and 3 health factors (ideal total cholesterol, blood pressure and fasting glucose). Cut-offs to define ideal status were provided for children and adults (3).

Numerous studies have used the iCVH construct and reported that a higher number of iCVH components are related to better health (4). For instance, iCVH components in adulthood have been related to lower morbidity and mortality from cardiovascular diseases (5, 6) as well as all-cause mortality (5, 6). The importance of having an iCVH early in life has been pointed out previously (4, 7-9). In adolescents, a higher number of iCVH components was associated with higher levels of cardiorespiratory fitness (9), an important marker of health (10, 11), and with aortic elasticity (8). Laitinen *et al.* (7) found a strong association between adolescent and adult iCVH and also reported that each number of additional iCVH component in adolescence was associated with a 34 % lower risk of hypertension and metabolic syndrome 21 years later. Taken together, these findings indicate that iCVH, already in adolescence, is of great importance not only for present but also for future health.

Although previous studies have provided important knowledge regarding cardiovascular risk factors in various adolescent populations (12-14), there is a great lack of data of the prevalence of iCVH in contemporary European adolescents. This data could contribute to the development of effective prevention programs, counselling, and public health policies.

Therefore, data obtained within the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study provide an excellent opportunity to study the iCVH of European adolescents. The HELENA study was designed to provide reliable data on nutrition and health-related variables in a relatively large sample of European adolescents from 9 different countries and includes the components of the iCVH construct (9). Thus, in this study we examined the prevalence of iCVH and its components in European adolescents.

2. METHODS

2.1 Study participants

Detailed information regarding sampling procedures and study methods in the HELENA study has been published previously (15-17). Since randomized sampling of the entire European adolescent population was not feasible, the HELENA study investigated 10 European cities in countries all across Europe. As described previously (16), countries were chosen according to their socioeconomic status, cultural reference and geographical locations of Europe (north, south, central, east, west). Hence, cities in Northern (Sweden), Southern (Greece, Italy and Spain), Central (Germany and Austria), Eastern (Hungary) and Western Europe (Belgium and France) were considered. Cities were subsequently chosen since they could be considered representative of its country in terms of average cultural, socioeconomic and demographical markers. Based on these criteria the following 10 cities were included in the HELENA study: Stockholm (Sweden), Athens and Heraklion (Greece), Rome (Italy) and Zaragoza (Spain), Dortmund (Germany), Vienna (Austria), Pécs (Hungary), Ghent (Belgium), Lille (France). Within each city a multi-stage random cluster sampling stratified for type of school (private/public), location (zone/district), socioeconomic status and age was performed in efforts to assure representativeness on a city-level (15). As argued previously (16), this sampling procedure is thought to provide a fair estimation of the average nutritional and health status of European adolescents. The data collection for the HELENA cross-sectional study was conducted between 2006 and 2007 and detailed information of study methods have been published previously (15-17). The final sample in the HELENA sample consisted of 3528 adolescents (1683 boys and 1845 girls) between 12.5 and 17.5 years of age. Blood sampling was randomly performed in approximately one third of the sample (n=1076). All adolescents and their parents or guardians signed an informed written consent before being enrolled in the study. The study was conducted according to the Declaration of

Helsinki and the corresponding local Human Research Review Committees of the centres involved approved the study protocol (18).

2.2 Ideal Cardiovascular Health

A detailed description of the classification of iCVH behaviours and factors as ideal and non-ideal in the HELENA study have been presented previously (9). Briefly;

Health Behaviours: Smoking status was obtained through a self-reported questionnaire and adolescents who reported that they had never smoked were categorized as having an ideal status, i.e. non-smoking. Participants' weight and height were measured using standard procedures as previously described (17). BMI was calculated as weight (in kg) divided by height (in m²). Subsequently, the international cut-offs from the World Obesity Federation (formerly International Obesity Task Force), applicable for children aged 2-17 years, was applied to categorize adolescents as overweight or obese (19). These cut-offs have been widely used and are connected to the adult cut-offs for overweight (25.0 kg/m²) and obesity (30.0 kg/m²). Adolescents that were not overweight or obese were classified as having an ideal BMI. Physical activity was self-reported using a questionnaire (20) and ≥ 60 minutes of moderate-to-vigorous intensity physical activity every day was classified as ideal.

Participants completed two non-consecutive 24-h dietary recalls using the HELENA-Dietary Assessment Tool (21). Dietary data was corrected for between- and within-person variability to in order to compensate for day-to-day variation (22). In accordance to the original publication of iCVH (3), the healthy diet score was used to define ideal diet in adolescence. Ideal intake levels per day (scaled to a total daily energy intake of 2000 kcal) for the five components in healthy diet score were: i) ≥ 400 grams of fruits and vegetables ii) ≥ 28 grams of fish iii) ≥ 3 28 gram equivalent servings of fibre rich grains (1.1 g of fibre per 10 g of carbohydrate) iv) < 1500 mg sodium v) ≤ 145 ml of soft drinks. Participants with ≥ 4 of these 5

components at ideal levels were classified as having an ideal healthy diet (3). Health Factors: 30mL of venous blood was drawn after an overnight fast. Total cholesterol ideal status was defined as <4.40 mmol/L (<170 mg/dL) (3). Furthermore, fasting serum glucose concentrations <5.6 mmol/L (<100 mg/dL) was considered ideal (3). Blood pressure was measured twice in a resting state and the lowest values were used in the analyses. **Due to the lack of European reference data in adolescence and since the 90th percentiles was higher than the adult definition for ideal blood pressure, we applied the adult cut-off for ideal blood pressure (i.e. < 120 systolic and < 80 mm HG diastolic blood pressure) in the current analysis. In a supplementary analysis we also calculated the prevalence of ideal blood pressure if blood pressure < 90th percentile using sex-specific centiles from the entire HELENA study population was used to define ideal (i.e. boys: <140 systolic and <80 mm HG diastolic blood pressure; girls: <131 and <78 mg HG respectively) since this also has been a common way to define ideal blood pressure in adolescence (8, 23).**

2.3 Statistical analysis

To assess the statistical power of the study we calculated the required sample size to estimate 95 % confidence intervals (CI). Assuming a margin of error of 2 % and 3 % the maximal sample sizes required were 2401 and 1067, respectively. Hence, we could estimate the overall prevalence for the components of iCVH with a margin of error ≤ 3 %. The proportion of the iCVH components and their 95 % confidence intervals (CI) were calculated and chi square tests were applied to test differences in the proportion of ideal behaviours and factors. All hypothesis tests were two-sided and $P < 0.05$ was considered statistically significant. Analyses were conducted using SPSS Statistics 22 (IBM, Armonk, NY, USA).

3. RESULTS

Figure 1 shows the prevalence of the individual iCVH components for all adolescents, and detailed estimates and results stratified sex and age are presented in **Table 1**. Most adolescents had ideal plasma glucose (88.8 %) whereas only 1.7 % had ideal status for the diet component. As shown in **Table 2**, few adolescents also had ideal status for the individual ideal dietary indicators. More than half of the adolescents had ideal status for non-smoking (60.9 %), BMI (76.8 %), physical activity (62.1 %), total cholesterol (65.8 %) and blood pressure (62.0 %). The prevalence of ideal blood pressure was 89.0 % if definition was based on percentiles. Results were virtually similar when the analysis of iCVH components was restricted to the 1076 participants with blood sampling, i.e. non-smoking (59.7 %), BMI (77.8 %), physical activity (62.9 %), diet (2.0 %) and blood pressure (61.6 %).

4. DISCUSSION

This study reports the iCVH of contemporary European adolescents from the HELENA study. Overall, the prevalence of iCVH behaviours was low. For instance, 62.1 % of participants had ideal physical activity levels and only 1.7 % had an ideal diet.

4.1 Prevalence of ideal cardiovascular health

Shay *et al.* (23) showed that approximately 47 % of U.S. adolescents from the National Health and Nutrition Examination Survey (NHANES, 2005-2010) had at least 5 iCVH components, and concluded that the low prevalence of iCVH health behaviours will likely lead to increased obesity prevalence and decreased cardiovascular health later in life. They also showed that the prevalence of ideal physical activity was low ($\approx 56\%$) and ideal diet was followed by almost no one ($<1\%$), which is in agreement with our results (62.1 % and 1.7 %, respectively). The low prevalence of ideal diet in U.S. and European adolescents is in agreement with a review, which showed that 10 of 16 studies in U.S. adults reported $\leq 5\%$ prevalence of ideal diet (24). Due to the low prevalence of ideal diet, some studies (6, 8) defined ideal diet as ≥ 2 ideal dietary indicators instead of ≥ 4 . In the present study, only 27.7 % of the adolescents had ≥ 2 ideal dietary indicators (**Table 2**).

There is no contemporary and comprehensive European iCVH data available in adolescence, yet information has been published from Turku (Finland) (8). In this study, Pahkala *et al.* (8) reported follow-up data at 15, 17 and 19 y, collected between approximately 2005 and 2011, from a childhood lifestyle intervention. Comparable to our data, the Finnish adolescents' most prevalent iCVH components at ideal levels were BMI and glucose whereas ideal diet was obtained by virtually no one. Adolescent data on iCVH, collected in 1986, have also been reported from the Cardiovascular Risk in Young Finns Study (7) and when compared to the

current study, the Finnish adolescents had overall a worse iCVH status with low prevalence of non-smoking status (22.4 %), ideal physical activity (6.9 %) and ideal total cholesterol (33.2 %) compared to our data. However, comparison with our data is problematic given the geographical difference and that data was collected about 30 years ago. Hence, further studies on iCVH in adolescents are needed to be able to monitor changes in iCVH over time.

4.2 Strengths and limitations

An important strength of this study is that it included a relatively large sample of adolescents and thus was powered to estimate the prevalence of iCVH. Although adolescents from a diverse European population, including nine countries, were investigated future studies should consider a random sampling of the entire European adolescent population. Though our data represent the most contemporary data of iCVH in European adolescents it was collected in 2006-2007 which motivate future studies. Another limitation was that physical activity was self-reported using a questionnaire that had been pilot-tested and validated (20). The HELENA study also assessed physical activity objectively using accelerometry in a sub-sample of the adolescents (n=2200) and the prevalence of ideal physical activity was lower (41.0 %) by means of accelerometer data compared to the questionnaire. Finally, sample sizes varied across the iCVH components, which represent another limitation.

4.3 Interpretation and implications

This study provides novel data of the prevalence of iCVH in a diverse European adolescent setting. The results show that the prevalence of iCVH behaviours were low, especially for the prevalence of ideal diet, however there was also a relatively large proportion of the adolescents who had non-ideal status regarding smoking, BMI and physical activity. This may have importance for their future cardiovascular health since a higher iCVH in

adolescence has been related to better cardiovascular health in adulthood (7). The low prevalence of ideal diet and physical activity is of special importance since they represent two key health behaviors and both diet and physical activity/fitness in youth (9, 10, 25, 26) and adulthood (27-29) have been consistently related to later cardiovascular risk. Furthermore, since childhood and adolescence represent an important period in time when healthful behaviors may be established (30) it is important to promote a healthy diet and physical activity habits early in life both in the school and home environment. Some promising results have been published regarding the promotion of iCVH during early childhood and adolescence (8). However, further work is needed to identify youth with an increased risk of low iCVH as well as developing strategies to increase iCVH in this age group.

4.4 Conclusion

The low prevalence of iCVH behaviours, especially diet and physical activity, identified in European adolescents is likely to influence later cardiovascular health which strongly motivates efforts to increase ideal health behaviours in this population.

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Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

REFERENCES

1. Go AS, Mozaffarian D, Roger VL et al. Executive summary: heart disease and stroke statistics--2013 update: a report from the American Heart Association. *Circulation*. 2013;**127**:143-52.
2. Nichols M, Townsend N, Scarborough P, Rayner M. Cardiovascular disease in Europe 2014: epidemiological update. *Eur Heart J*. 2014;**35**:2929.
3. Lloyd-Jones DM, Hong Y, Labarthe D et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. *Circulation*. 2010;**121**:586-613.
4. Shay CM, Gooding HS, Murillo R, Foraker R. Understanding and Improving Cardiovascular Health: An Update on the American Heart Association's Concept of Cardiovascular Health. *Prog Cardiovasc Dis*. 2015;**58**:41-9.
5. Fang N, Jiang M, Fan Y. Ideal cardiovascular health metrics and risk of cardiovascular disease or mortality: A meta-analysis. *Int J Cardiol*. 2016;**214**:279-83.
6. Yang Q, Cogswell ME, Flanders WD et al. Trends in cardiovascular health metrics and associations with all-cause and CVD mortality among US adults. *JAMA*. 2012;**307**:1273-83.
7. Laitinen TT, Pahkala K, Magnussen CG et al. Ideal cardiovascular health in childhood and cardiometabolic outcomes in adulthood: the Cardiovascular Risk in Young Finns Study. *Circulation*. 2012;**125**:1971-8.
8. Pahkala K, Hietalampi H, Laitinen TT et al. Ideal cardiovascular health in adolescence: effect of lifestyle intervention and association with vascular intima-media thickness and elasticity (the Special Turku Coronary Risk Factor Intervention Project for Children [STRIP] study). *Circulation*. 2013;**127**:2088-96.
9. Ruiz JR, Huybrechts I, Cuenca-Garcia M et al. Cardiorespiratory fitness and ideal cardiovascular health in European adolescents. *Heart*. 2015;**101**:766-73.

10. Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M. Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes (Lond)*. 2008;**32**:1-11.
11. Ruiz JR, Castro-Pinero J, Artero EG et al. Predictive validity of health-related fitness in youth: a systematic review. *Br J Sports Med*. 2009;**43**:909-23.
12. Caleyachetty R, Echouffo-Tcheugui JB, Tait CA, Schilsky S, Forrester T, Kengne AP. Prevalence of behavioural risk factors for cardiovascular disease in adolescents in low-income and middle-income countries: an individual participant data meta-analysis. *Lancet Diabetes Endocrinol*. 2015;**3**:535-44.
13. May AL, Kuklina EV, Yoon PW. Prevalence of cardiovascular disease risk factors among US adolescents, 1999-2008. *Pediatrics*. 2012;**129**:1035-41.
14. Rendo-Urteaga T, de Moraes AC, Collese TS et al. The combined effect of physical activity and sedentary behaviors on a clustered cardio-metabolic risk score: The Helena study. *Int J Cardiol*. 2015;**186**:186-95.
15. Beghin L, Huybrechts I, Vicente-Rodriguez G et al. Main characteristics and participation rate of European adolescents included in the HELENA study. *Arch Public Health*. 2012;**70**:14.
16. Moreno LA, De Henauw S, Gonzalez-Gross M et al. Design and implementation of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. *Int J Obes (Lond)*. 2008;**32 Suppl 5**:S4-11.
17. Nagy E, Vicente-Rodriguez G, Manios Y et al. Harmonization process and reliability assessment of anthropometric measurements in a multicenter study in adolescents. *Int J Obes (Lond)*. 2008;**32 Suppl 5**:S58-65.
18. Beghin L, Castera M, Manios Y et al. Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the HELENA Cross-Sectional Study. *Int J Obes (Lond)*. 2008;**32 Suppl 5**:S12-8.

19. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes*. 2012;**7**:284-94.
20. Hagstromer M, Bergman P, De Bourdeaudhuij I et al. Concurrent validity of a modified version of the International Physical Activity Questionnaire (IPAQ-A) in European adolescents: The HELENA Study. *Int J Obes (Lond)*. 2008;**32 Suppl 5**:S42-8.
21. Vereecken CA, Covents M, Sichert-Hellert W et al. Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. *Int J Obes (Lond)*. 2008;**32 Suppl 5**:S26-34.
22. Harttig U, Haubrock J, Knuppel S, Boeing H. The MSM program: web-based statistics package for estimating usual dietary intake using the Multiple Source Method. *Eur J Clin Nutr*. 2011;**65 Suppl 1**:S87-91.
23. Shay CM, Ning H, Daniels SR, Rooks CR, Gidding SS, Lloyd-Jones DM. Status of cardiovascular health in US adolescents: prevalence estimates from the National Health and Nutrition Examination Surveys (NHANES) 2005-2010. *Circulation*. 2013;**127**:1369-76.
24. Younus A, Aneni EC, Spatz ES et al. Prevalence of Ideal Cardiovascular Health Among Adults in the United States. *J Am Coll Cardiol*. 2015;**66**:1633-4.
25. Kaikkonen JE, Mikkila V, Raitakari OT. Role of childhood food patterns on adult cardiovascular disease risk. *Curr Atheroscler Rep*. 2014;**16**:443.
26. Andersen LB, Riddoch C, Kriemler S, Hills AP. Physical activity and cardiovascular risk factors in children. *Br J Sports Med*. 2011;**45**:871-6.
27. Kodama S, Saito K, Tanaka S et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *JAMA*. 2009;**301**:2024-35.
28. Schwingshackl L, Hoffmann G. Diet quality as assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension score, and

health outcomes: a systematic review and meta-analysis of cohort studies. *J Acad Nutr Diet*. 2015;**115**:780-800 e5.

29. Lavie CJ, Arena R, Swift DL et al. Exercise and the cardiovascular system: clinical science and cardiovascular outcomes. *Circ Res*. 2015;**117**:207-19.

30. Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. *Maturitas*. 2011;**70**:266-84.

Table 1. Prevalence of ideal cardiovascular health in European adolescents

	Non-smoking		Ideal health behaviours				Diet		Cholesterol		Ideal health factors		Plasma glucose	
	n	% ideal (95% CI)	n	% ideal (95% CI)	n	% ideal (95% CI)	n	% ideal (95% CI)	n	% ideal (95% CI)	n	% ideal (95% CI)	n	% ideal (95% CI)
All	3427	60.9 (59.3-62.5)	3528	76.8 (75.4-78.2)	3041	62.1 (60.4-63.8)	2330	1.7 (1.2-2.2)	1076	65.8 (63.0-68.6)	3443	62.0 (60.4-63.6)	1076	88.8 (86.9-90.7)
Sex														
Boys	1628	61.5 (59.1-63.9)	1683	73.2 (71.1-75.3)	1445	68.6 (66.2-71.0)	1077	0.3 (0.0-0.6)	508	77.8 (74.2-81.4)	1631	48.4 (46.0-50.8)	508	83.3 (80.0-86.6)
Girls	1799	60.3 (58.0-62.6)	1845	80.2 (78.4-82.0)	1596	56.2 (53.8-58.6)	1253	3.0 (2.1-3.9)	568	55.1 (51.0-59.2)	1812	74.3 (72.3-76.3)	568	93.7 (91.7-95.7)
<i>P</i> value*		0.46		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001
Age														
12.5-14.99 y	1948	71.8 (69.8-73.8)	2015	75.1 (73.2-77.0)	1688	68.8 (66.4-70.8)	1322	1.4 (0.8-2.0)	617	64.8 (61.0-68.6)	1965	68.9 (66.7-70.9)	617	89.1 (86.6-91.6)
15.0-17.49 y	1479	46.5 (44.0-49.0)	1513	79.1 (77.0-81.2)	1353	53.7 (51.0-56.4)	1008	2.1 (1.2-3.0)	459	67.1 (62.8-71.4)	1478	52.8 (50.2-55.4)	459	88.2 (85.2-91.2)
<i>P</i> value*		< 0.001		0.006		< 0.001		0.23		0.44		< 0.001		0.64

* Refers to the *P* value of a chi square test

Table 2. Prevalence of ideal dietary indicators in 2330 European adolescents.

Dietary indicator	% ideal (n)
Fruit and vegetables*	8.2 (191)
Fish*	22.3 (519)
Fibre*	13.6 (318)
Sodium*	9.5 (221)
Soft drinks*	51.7 (1205)
Number of ideal dietary indicators	
0	31.7 (739)
1	40.6 (947)
2	20.0 (465)
3	6.0 (139)
4	1.7 (40)
5	0 (0)

* Ideal intake levels, per day, for the five dietary indicators were as follows:

i) ≥ 400 grams of fruits and vegetables ii) ≥ 28 grams of fish iii) ≥ 3 28 gram servings of fibre rich grains (1.1 g of fibre per 10 g of carbohydrate) iv) < 1500 mg sodium v) ≤ 145 ml of soft drinks

FIGURE LEGEND

Figure 1. Prevalence of ideal cardiovascular health (iCVH) components in European adolescents. BMI, body mass index; BP, blood pressure; PA, physical activity.

Supplemental material

Prevalence of ideal cardiovascular health in European adolescents:

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