Cumulative Effect of Psychosocial Factors in Youth on Ideal Cardiovascular Health in Adulthood

The Cardiovascular Risk in Young Finns Study

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Background—The American Heart Association has defined a new metric of ideal cardiovascular health as part of its 2020 Impact Goals. We examined whether psychosocial factors in youth predict ideal cardiovascular health in adulthood.

Methods and Results—Participants were 477 men and 612 women from the nationwide Cardiovascular Risk in Young Finns Study. Psychosocial factors were measured from cohorts 3 to 18 years of age at the baseline of the study, and ideal cardiovascular health was examined 27 years later in adulthood. The summary measure of psychosocial factors in youth comprised socioeconomic factors, emotional factors, parental health behaviors, stressful events, self-regulation of the child, and social adjustment of the child. There was a positive association between a higher number of favorable psychosocial factors in youth and greater ideal cardiovascular health index in adulthood (β=0.16; $P<0.001$) that persisted after adjustment for age, sex, medication use, and cardiovascular risk factors in childhood (β=0.15; $P<0.001$). The association was monotonic, suggesting that each increment in favorable psychosocial factors was associated with improvement in cardiovascular health. Of the specific psychosocial factors, a favorable socioeconomic environment (β=0.12; $P<0.001$) and participants' self-regulatory behavior (β=0.07; $P=0.004$) were the strongest predictors of ideal cardiovascular health in adulthood.

Conclusions—The findings suggest a dose-response association between favorable psychosocial factors in youth and cardiovascular health in adulthood, as defined by the American Heart Association metrics. The effect seems to persist throughout the range of cardiovascular health, potentially shifting the population distribution of cardiovascular health rather than simply having effects in a high-risk population. **(*Circulation*. 2015;131:245-253. DOI: 10.1161/CIRCULATIONAHA.113.007104.)**

Key Words: cardiovascular system ■ follow-up studies ■ prevention and control ■ psychology ■ stress, psychological

The American Heart Association (AHA) has defined a new metric of ideal cardiovascular health to accommodate both an expanded emphasis on prevention and greater understanding of the origins of cardiovascular disease as part of its 2020 Impact Goals. The explicit goal of the AHA statement is to improve cardiovascular health of all Americans by 20% by the year 2020 while reducing deaths resulting from cardiovascular diseases and stroke by 20%.[1] To monitor progress toward these goals, the AHA has launched a concept of ideal cardiovascular health. This concept is defined by the presence of 7 ideal health factors that describe whether a person has ideal cardiovascular health and indicate where improvement is needed to attain better health.[1] Substantial evidence demonstrates that the ideal cardiovascular health index is associated with better vascular health[2] and with reductions in cardiovascular morbidity and mortality.[3,4]

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Childhood and youth are important stages of life because cardiovascular diseases are rooted in early life[5,6] and social

Received November 4, 2013; accepted October 17, 2014.

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The online-only Data Supplement is available with this article at http://circ.ahajournals.org/lookup/suppl/doi:10.1161/CIRCULATIONAHA.113.007104/-/DC1.

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Circulation **is available at http://circ.ahajournals.org** **DOI: 10.1161/CIRCULATIONAHA.113.007104**

determinants of health start to accumulate in childhood.[7,8] Of childhood factors, higher socioeconomic status and nonsmoking in the family of origin have been identified as predictors of ideal cardiovascular health in adulthood.[7] Although the importance of psychosocial factors has been acknowledged,[1,8–10] there remains a lack of knowledge on whether psychosocial factors, emerging already in youth, would have a protective role in good cardiovascular health in adulthood. Release of the AHA 2020 Impact Goals makes it critical to examine all aspects, including psychosocial factors, that may help in the attainment of these goals.

Prior work examining the association of psychosocial factors with cardiac outcomes has concentrated on negative psychosocial factors predicting high-risk cardiovascular outcomes.[9,11–14] Common findings are that socioeconomic adversity,[15–19] exposure to poor parenting practices,[17,20–22] and difficulty in behavior regulation[23–26] during youth predict greater levels of cardiovascular risk factors in adulthood. With few exceptions,[20,27] most of these studies have been retrospective by design, relying on adulthood reports about earlier experiences. Retrospective designs introduce the methodological problem of reporting or recollection bias, and one way to overcome that limitation is the use of prospective studies with measurements taking place in real time before adult outcomes.

Another topic warranting research is the cumulative exposure to multiple psychosocial factors. Theoretical models on life-course health suggest that the origins of adult health lie in early-life psychosocial exposures[11,14,28] and that the combination thereof is a better indicator of total psychosocial burden than a single factor.[29,30] Accordingly, exposure to several psychosocial factors has been associated with greater health impacts than exposure to single factors.[31–34] Such an accumulating effect has been shown by the Dunedin prospective study in which children who had experienced several psychosocial disadvantages had higher metabolic risk 32 years later in adulthood.[20] There is, however, less knowledge on whether the accumulation of psychosocial factors might positively influence the development of healthy cardiovascular outcomes. One of the few such studies is the prospective Collaborative Perinatal Project, which examined psychosocial predictors of a constellation those investigators called a favorable cardiovascular profile. That study showed that high childhood attention regulation, high cognitive ability, and a positive childhood environment were associated with a more favorable cardiovascular profile in adulthood and that the effects of psychosocial factors were additive.[27] If evidence suggests that psychosocial effects are not attributable to any one factor, current prevention or intervention strategies focusing on a single risk or resilience factor may be too limited.

Building on this prior work, we examined whether the accumulation of psychosocial factors measured in youth would be associated with the ideal cardiovascular health concept in adulthood. To the best of our knowledge, no previous studies have examined youth psychosocial origins of the AHA ideal cardiovascular health metrics. The present study included family characteristics related to socioeconomic, emotional, health-behavioral, and stress-related exposures, as well as the child's own behavioral regulation and adaptation, together indicating total accumulation of psychosocial factors in youth. The psychosocial factors, as well as baseline cardiovascular risk factors, were examined prospectively, and ideal cardiovascular health was measured 27 years after the baseline. The data are from the Cardiovascular Risk in Young Finns Study and are representative of the Finnish population.

Methods

Participants

The Cardiovascular Risk in Young Finns study is a multicenter follow-up study assessing risk factors underlying cardiovascular diseases. The participants were a random selection from the national register of Finland covering the entire country. The baseline survey was conducted in 1980 among participants who were 3 to 18 years of age.[35] After exclusion of 19 participants with type I diabetes mellitus, there were 3577 initially healthy participants in 1980. The adulthood assessment took place 27 years later in 2007 when the participants were 30 to 45 years old. Participants with missing data were excluded, resulting in an analytic sample of 1089 participants. Reasons for data loss are listed in Table 1. Attrition analyses showed that participants in the analytic sample were older and had a more favorable level of psychosocial factors in youth, especially higher socioeconomic status, higher self-regulatory behavior, and higher social adjustment. The included participants also had lower blood pressure and lower body mass index in youth than participants who were not included in the present sample (Table I in the online-only Data Supplement). The study plan and data collection procedures were accepted by the institutional review committees at the participating universities (updated by the Hospital District of Southwest Finland, September 21, 2010; document No. 88/180/2010), and the study protocol conformed to the proposals by the World Health Organization and the Helsinki Declaration. Informed consent was obtained from all study participants; in addition, parents' consent was requested for participants <12 years of age.

Measures

Ideal Cardiovascular Health Index in Adulthood

The ideal cardiovascular health index comprised 7 ideal metrics measured in 2007, each contributing 1 point to the ideal cardiovascular health index score. Ideal health behaviors included the following: body mass index (<25 kg/m^2), moderate physical activity (≥150 min/wk, vigorous physical activity for ≥75 min/wk, or a combination thereof), not smoking (either never having smoked or quitting smoking >12 months ago), and ideal diet (having ≥4 ideal diet components of the following 5 components: ≥450 g/d fruits or vegetables, ≥2 servings of fish per week, 3 or more 1-oz servings a day of whole grains, sodium <1500 mg/d, and ≤450 kcal of sugar-sweetened beverages per week). Ideal health factors were systolic blood pressure <120 mm Hg, diastolic blood pressure <80

Table 1. Reasons for Missing Data in the Cardiovascular Risk in Young Finns Study

Reason	n
Total sample in 1980	3596
Diagnosis of childhood diabetes mellitus (type I)	19
Nonresponse*	1382
Missing items†	759
Withdrawal from the study‡	122
Moved abroad	72
Could not be contacted	49
Death	104
Remaining analytic sample	1089

*Did not return the questionnaire at the 27-year examination.
†Returned the questionnaire but incompletely filled it out.
‡Written notification of permanent discontinuation.

mm Hg, total cholesterol ≤5.17 mmol/l (≤200 mg/dL), and fasting glucose <5.6 mmol/l (<100 mg/dL). The measurement procedures have been described in detail previously.[35] For each metric, we assigned a score of 1 (yes) or 0 (no), and then we summed across metrics to obtain an ideal cardiovascular health index. Because there were only a few participants having an ideal level in 0 factors (n=18) or all 7 factors (n=11), we combined the extreme groups so that the final ideal cardiovascular health index had values of ≤1, 2, 3, 4, 5, or ≥6.

Adulthood Covariates

Participants using cholesterol-lowering medication (n=26), antihypertensive medication (n=66), or medication to maintain glucose balance (n=4) were classified as users (1) and others as nonusers (0).

Psychosocial Factors in Youth

We assessed 6 psychosocial factors that have been proposed as central components of childhood psychosocial environment in previous literature.[11–14] The psychosocial factors were socioeconomic environment, emotional environment, parental health behaviors, stressful events, self-regulation of the child, and social adjustment of the child. These factors were assessed by parents who filled in hand-written questionnaires at the baseline examination in 1980 (see Table II in the online-only Data Supplement for a list of all items).

Cumulative scores have recently become common in research on childhood psychosocial factors.[31] Typically, such models define binary risk factors (risk versus no risk), which are then summed together to form a cumulative score. Such an approach has the advantage of being parsimonious, making no assumptions about the relative strengths of multiple risk factors or their collinearity, and enabling testing of additive effects over a range of exposures.[31] We built the 6 psychosocial factors from binary variables in which 1 stands for favorable and 0 for less-than-favorable level. The cutoff points were based on previous evidence and theoretical knowledge, as described in Table 2 and in the following:

1. Favorable socioeconomic factors score consisted of 4 components[36]: upper white-collar occupation (1 point), academic/college degree (1 point), family income in highest 25% (1 point), and occupational stability as indicated by the absence of unemployment spells/retirement/long-term sick leave (1 point). Thus, the score ranged from 0 points (less than favorable level in all components) to 4 points (favorable level in all components).
2. Favorable emotional family environment score consisted of 4 components. The first was absence of previously diagnosed parental mental disorder (1 point), measured by asking both parents whether they had ever been diagnosed as having mental disorder. The second was high parental care-giving nurturance, measured with a 7-item scale (α=0.70) previously used in this data set.[37] A reply of "very often" to all items (shown in Table II in the online-only Data Supplement) gave 1 point. The third component was high parental life satisfaction, measured with a 3-item scale (Table II in the online-only Data Supplement; α=0.70). A positive reply to all 3 items gave 1 point. Fourth, reasonable alcohol use was included because of evidence indicating that unhealthy drinking is harmful to emotional development.[38] Parents reporting intoxication "never or at maximum 3 times per year" were classified as reasonable users (1 point). Altogether, the scale range was 0 to 4.
3. Optimal health behaviors of the parents were asked separately from both parents. Because we had no data on parental diet, we used body mass index <30.0 kg/m^2 as a proxy of excess energy intake (0=overweight, 1=not overweight). Other health behaviors were nonsmoking (1 point) and participating in regular physical activity (1 point for exercise at least once a week). Summing together maternal and paternal health behaviors resulted in a scale range of 0 to 6.
4. Lack of stressful events included events that may threaten the child's sense of stability and continuity.[39,40] Stressful events were moving residence, change of school, parental divorce or separation, death of a family member, and serious disease in the family. The absence of each event gave 1 point; thus, the scale range was 0 to 5, with a higher score indicating a more favorable situation.
5. Self-regulatory behavior of the participant consisted of 2 scales measuring high self-control and high aggression control. The predictive validity of both scales has been established previously.[25,26] The self-control scale consisted of 1 question (Table II in the online-only Data Supplement) in which children described as being very controlled "always or most of the time" received 1 point. Aggression control (α=0.60) was measured with 6 items (shown in Table II in the online-only Data Supplement), each giving 1 point. The total score was formed by combining scores from self-control and aggression control (range, 0–7).
6. Social adjustment consisted of a question about parental worry about the child's adjustment (1 point) and parental evaluation of the child's general level of adjustment (1 point). Our previous work has shown that these questions predict outcomes that are theoretically related to social adjustment.[26,37]

Favorable Psychosocial Factors Score (Cumulative Score)

The 6 psychosocial factors were summed together to form a favorable psychosocial factors score (cumulative score) following a procedure recommended previously[31] and described in Table 2. However, summing together psychosocial factors with different variances would lead to a score that gives greater weight to factors with greater variance. We had no hypothesis to weigh any factor more than the other; thus, each psychosocial factor score was converted into a standard score before summation. (Because some of the variables were skewed, the standardization was rerun with quantile-quantile normalization to a standard normal distribution, but that had no effect on the score; therefore, the same form of standardization was used for every psychosocial factor.) Such a procedure would treat each psychosocial factor as an equal contributor to the cumulative score. The formula for the score was as follows: socioeconomic environment (z score)+emotional environment (z score)+parental health behaviors (z score)+stressful events (z score)+self-regulation (z score)+social adjustment (z score)=favorable psychosocial factors score. Figure I in the online-only Data Supplement shows that the distribution was slightly skewed to the left (mean=0.00; SD=2.84; range, −11.58 to 6.09).

Clinical Measurement of Cardiovascular Risk Factors in Youth

Body mass index, blood pressure, and cholesterol were chosen as indicators of childhood cardiovascular risk because they have been shown to predict the ideal cardiovascular health index previously in the same data set.[7] Clinical measurements were conducted by trained staff at the study baseline in 1980. Diastolic blood pressure was measured only in a subsample and therefore was excluded from the present analyses. The included measurements were body mass index (kg/m^2), systolic blood pressure (the average of 3 measurements using mercury sphygmomanometer), and a blood draw from which total cholesterol was obtained (duplicate measurement in the same laboratory by use of standardized enzymatic methods). The measurement procedures have been described in detail previously.[35]

Statistical Analyses

Main Analyses

The favorable psychosocial factors score predicting the ideal cardiovascular health index was examined by use of linear regression analysis. The model was adjusted for age, sex, adult medication, and for childhood cardiovascular risk factors. As a post hoc analysis, we examined whether the association between favorable childhood psychosocial factors and ideal cardiovascular health was monotonically linear. To test linearity, we used multinomial regression analysis in which the ideal cardiovascular health index was examined as a multiple-category outcome. Thereafter, logistic regression analyses assessed the associations of favorable psychosocial factors

Table 2. Process Chart of the Construction of the Favorable Pychosocial Factors Score

Component	Definition of Favorable Level	Absent	Present
Favorable socioeconomic environment			
Occupational status	Upper white collar*	0	1
Educational level	Academic or college degree*	0	1
Family income	Annual income in highest quartile	0	1
Occupational stability	Steady employment†	0	1
Favorable emotional environment			
Parental mental health	Free of diagnosis for mental disorder†	0	1
Parental nurturance	Positive reply to the nurturance scale‡	0	1
Parental life satisfaction	Positive reply to the satisfaction scale‡	0	1
Reasonable alcohol use	Intoxication ≤3 times a year†	0	1
Optimal health behaviors of parents			
Energy intake (mother)	Body mass index <30.0	0	1
Energy intake (father)	Body mass index <30.0	0	1
Smoking (mother)	No daily smoking	0	1
Smoking (father)	No daily smoking	0	1
Physical activity (mother)	Exercise ≥1 times per week	0	1
Physical activity (father)	Exercise ≥1 times per week	0	1
Lack of stressful events			
Stability of living environment	No change of residence during youth	0	1
Stability of school environment	No change of school during youth	0	1
Stability of family environment	No parental divorce or separation	0	1
Loss of significant persons	No death of family member	0	1
Health-related events	No long-term hospitalization/disease*	0	1
Self-regulatory behavior of the child			
Self-control scale	High ability to tolerate frustration	0	1
Aggression control scale	(1) Does not fight	0	1
	(2) Does not hit	0	1
	(3) Does not need much discipline	0	1
	(4) Does not swear	0	1
	(5) Other children have not complained	0	1
	(6) Other parents have not complained	0	1
Social adjustment of the child			
Social adjustment scale	(1) Not worried about my child	0	1
	(2) I consider my child as well adjusted	0	1

*Either parent had to fulfill this criterion.
†Both parents had to fulfill this criterion.
‡Main caregiver replied in 2-parent households, and the available parent replied in single-parent households.
§Each psychosocial factor was converted into a standard score and then summed together. Thus, the favorable psychosocial factors score represents the cumulative score of the 6 psychosocial factors, each contributing with equal weight.

score with the individual health metrics as dichotomous outcome variables (eg, overweight versus overweight). Finally, regression models examined the specific associations of the 6 psychosocial factors on ideal cardiovascular health. Each psychosocial factor was entered as a predictor separately (univariate model) and at the same time (multivariate model), with adjustment for all covariates. All analyses were conducted with STATA 13.1. software. To adjust for multiple analyses, we divided P=0.05 by 6 (the number of psychosocial factors), resulting in a value of P< 0.008, which was considered the critical level of significance in all analyses.

Supplementary Analyses

We conducted 2 types of supplementary analyses to examine the robustness of the findings to the cutoff points of childhood factors and to the patterning of missing data.

Analyses in Raw Data

To overcome the potential limitations of using binary variables as the basis for psychosocial factors (eg, the possibility to optimize prediction by choosing cutoff points), we formed

the youth psychosocial factors from raw data. We standardized each original item and summed those items into the 6 psychosocial factors (The raw items are shown in Table II in the online-only Data Supplement). Then, the 6 psychosocial factors were summed up into a raw psychosocial factors score (mean=0.03; SD=7.93; range −39.59 to 19.55; Figure I in the online-only Data Supplement). We reconducted, as supplementary information, the analyses of this study using the raw score of psychosocial factors, and we ran the models separately in younger and older cohorts and separately by age and sex group to examine potential age or sex specificity of the findings.

Analyses With Multiple Imputations

We used imputation procedures to correct for possible bias that is inherent in complete-case data if the individuals in the analytic sample differ systematically from the individuals who had dropped out from the study.[41,42] We imputed values for participants who had missing values in any of the variables using the multiple imputation method by chained equations in STATA 13.1. We ran the statistical analyses described in the Main Analyses section in imputed data (n=3577) and report the pooled estimates of 50 imputed data sets. The standard imputation procedure assumes that data are missing at random; therefore, we also ran sensitivity analyses under the not-missing-at-random assumption, following the procedure described by Carpenter et al.[43]

Results

Descriptive Statistics

Characteristics of the sample are shown in Table 3. The participants were on average 10 years old at baseline and on average 37 years old at the adulthood measurement. The favorable psychosocial factors score was slightly skewed to the favorable direction (Figure I in the online-only Data Supplement). The participants had on average 2.6 points on the ideal cardiovascular health index in adulthood. Intercorrelations between the specific psychosocial factors showed that the socioeconomic factor was associated with healthier behaviors of the parents (r=0.17, P<0.001) and greater social adjustment of the child (r=0.10, P<0.001). The emotional factor correlated with health behaviors of the parents (r=0.16, P<0.001), higher self-regulatory behavior of the child (r=0.12, P<0.001), and greater social adjustment of the child (r=0.10, P=0.001). The other factors had correlations of <0.10.

Favorable Psychosocial Factors and Ideal Cardiovascular Health

Table 4 shows a positive association between the favorable psychosocial factors score in youth and ideal cardiovascular health index in adulthood after adjustment for age, sex, adulthood covariates, and childhood cardiovascular risk factors (β=0.15; P≤0.001). The multinomial regression analyses showed that when favorable psychosocial factors rose by 1 point, the probability of having 2, 3, 4, 5, or ≥6 ideal cardiovascular health metrics rose by 6%, 14%, 17%, 17%, and 35% compared with having ≤1 ideal cardiovascular health metric (Table III in the online-only Data Supplement). To illustrate the association, the favorable psychosocial factors score was divided into quintiles and plotted against ideal cardiovascular health. The Figure shows a dose-response pattern in which ideal cardiovascular health increased according to rising levels of favorable psychosocial factors (F=6.12; P for linear trend <0.001).

Table 3. Descriptive Statistics of the Main Variables: The Cardiovascular Risk in Young Finns Study (n=1089)

Characteristic	n (%)	Mean (SD)
Males	477 (43.8)	
Age at baseline (in 1980)		10.2 (4.9)
Age at 27-y follow-up (in 2007)		37.2 (4.9)
Psychosocial factors in youth		
Favorable socioeconomic environment		1.67 (1.16)
Favorable emotional environment		2.51 (0.97)
Favorable health behaviors of parents		4.90 (1.15)
Lack of stressful events		4.81 (0.45)
High self-regulatory behavior		6.67 (0.72)
High social adjustment		1.52 (0.68)
Favorable psychosocial factors score*		0.00 (2.84)
Ideal cardiovascular health index in adulthood		2.63 (1.44)
Health metrics in adulthood		
Body mass index <25 kg/m^2	532 (48.9)	
Physical activity at goal level	557 (51.2)	
Healthy diet	64 (5.9)	
Nonsmoker	812 (74.6)	
Total cholesterol <5.17 mmol/L (<200 mg/dL)	644 (59.1)	
Blood pressure <120/<80 mm Hg	535 (49.1)	
Plasma glucose <5.6 mmol/L (<100 mg/dL)	797 (73.2)	
Ideal cardiovascular health index in adulthood		
≤1 point	101 (9.3)	
2 points	164 (15.1)	
3 points	209 (19.2)	
4 points	282 (25.9)	
5 points	234 (22.5)	
≥6 points	99 (9.1)	

*Each psychosocial factor was converted into a standard score and then summed together. Thus, the variable represents the cumulative score of the 6 psychosocial factors, each contributing with equal weight.

The favorable psychosocial factors score was more strongly associated with some health metrics than others, namely with leaner body mass index (odds ratio=1.14; 95% confidence interval=1.08–1.20; P<0.001), not being a smoker (odds ratio=1.12; 95% confidence interval=1.07–1.19; P<0.001), and more favorable glucose level (odds ratio=1.11; 95% confidence interval=1.05–1.17; P<0.001).

Of the specific psychosocial factors, a favorable socioeconomic environment (β=0.12; P<0.001) and higher self-regulatory behavior of the participant (β=0.07; P=0.004) were associated with more ideal cardiovascular health in adulthood in the fully adjusted model (Table 5).

Results of the Supplementary Analyses

The psychosocial factor score based on raw data was positively associated with the ideal cardiovascular health index after adjustment for all covariates (β=0.15; P≤0.001; Table IV

Table 4. Linear Regression Models of Favorable Psychosocial Factors in Youth Predicting the Ideal Cardiovascular Health Index in Adulthood: The Cardiovascular Risk in Young Finns Study (n=1089)

	Adjusted for Age, Sex, Medication Use*		Plus Childhood Cardiovascular Risk Factors	
Predictors in the Model	β	*P*	β	*P*
Age	−0.12	<0.001	−0.03	0.490
Male sex	−0.32	<0.001	−0.33	0.001
Cardiac medication use*	−0.17	<0.001	−0.15	<0.001
Childhood body mass index			−0.12	<0.001
Childhood systolic blood pressure			−0.07	<0.031
Childhood total cholesterol			−0.17	<0.001
Favorable psychosocial factors score	0.16	<0.001	0.15	<0.001
Model R^2, %		20		24

*Use of antihypertensive medication, lipid-lowering medication, or insulin.

in the online-only Data Supplement). Overall, the findings in raw data were similar in direction and magnitude to those obtained when binary variables were used as the basis for psychosocial factors (see Tables V and VI in the online-only Data Supplement for more specific associations). The interaction analyses suggested no differences by age or sex (table of all interactions is available from the first author). The association between psychosocial factors and ideal cardiovascular health was also examined separately by age and sex group, which showed no substantial differences (Table VII in the online-only Data Supplement).

The findings in imputed data showed that the favorable psychosocial factor score was positively associated with the ideal cardiovascular health index (β=0.12; $P \leq 0.001$; Table IV in the online-only Data Supplement). The favorable psychosocial factors score was associated with the same health metrics in the imputed data as in the complete data (Table V in the online-only Data Supplement). Furthermore, the same childhood psychosocial factors were significant predictors of ideal cardiovascular health in imputed data and in complete data (Table VI in the online-only Data Supplement).

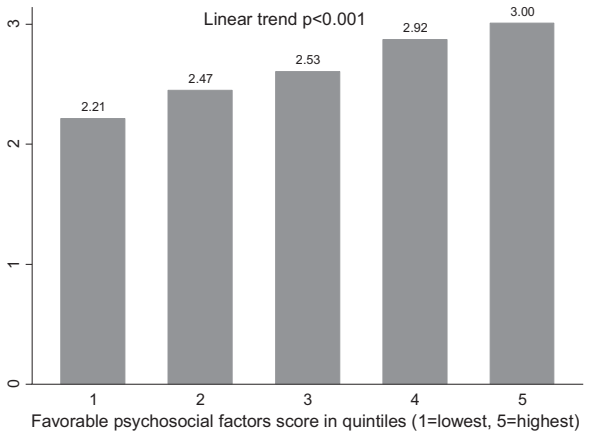

Figure. Mean levels of the ideal cardiovascular health index in adulthood according to quintiles of favorable psychosocial factors in youth.

Table 5. Specific Psychosocial Factors in Youth Predicting the Ideal Cardiovascular Health Index in Adulthood: The Cardiovascular Risk in Young Finns Study (n=1089)*

	Univariate†		Multivariate‡	
Psychosocial Factor	β	*P*	β	*P*
Favorable socioeconomic environment	0.13	<0.001	0.12	<0.001
Favorable emotional family environment	0.06	0.022	0.05	0.098
Favorable health behaviors in the family	0.08	0.003	0.05	0.089
Lack of stressful events	0.02	0.413	0.03	0.268
Self-regulatory behavior	0.09	0.001	0.07	0.004
Social adjustment	0.05	0.098	0.01	0.827

*All models adjusted for age, sex, childhood cardiovascular risk factors, and adult cardiac medication use.

†Psychosocial factors entered into the model separately.

‡Psychosocial factors entered into the model at the same time.

The sensitivity analyses modeling nonrandom missingness suggested that the association between psychosocial factors and ideal cardiovascular health would remain similar even in a situation in which the mechanism for missing data would be not at random (Table VIII in the online-only Data Supplement).

Discussion

This study examined psychosocial origins of the ideal cardiovascular health concept, as outlined by the AHA.[1] Psychosocial factors were chosen from theoretical frameworks[11,14,28] covering aspects of social environment, family exposures, and the child's behaviors. We found that a greater number of favorable psychosocial factors in youth (3–18 years of age) resulted in more ideal cardiovascular health in adulthood. Participants with the most psychosocial advantages in youth had almost an 1 point greater ideal cardiovascular health index in adulthood than participants with the least psychosocial advantages. This difference is comparable to attaining a favorable level in any of the 7 components that comprise the ideal cardiovascular health index (eg, a person would gain 1 point by quitting smoking). We found that psychosocial factors operated across the whole gradient of ideal cardiovascular health. There was no evidence for any threshold point after which the effect of psychosocial factors would become unimportant. This may suggest a wider scope for prevention than has previously been considered because all individuals, not only those at the bottom of the gradient, may benefit from improvements in early-life conditions. In combination with prior work, this evidence begins to suggest that even improving a single factor would likely result in better future cardiovascular health.

The Collaborative Perinatal Project is one of the few studies with a similar prospective design. That study showed that a positive home environment in early childhood (before 7 years of age) predicted healthier cardiovascular profiles in adulthood in an additive fashion.[27] However, in that study, the positive home environment was a composite measure summarizing across emotional, social, and physical aspects of the home. Our study extended that study by including a representative random sample from a non-US population, by considering effects of psychosocial factors

across a broader age range that included children and adolescents, by examining the psychosocial effects across a more articulated set of psychosocial factors, and by using more stringent health metrics for ideal cardiovascular health as the outcome.

Psychosocial factors had a significant effect on 3 components of the ideal cardiovascular health index. Greater exposure to positive psychosocial factors was associated with a 14% to 12% greater likelihood of being normal weight and being a nonsmoker in adulthood. These findings suggest that of the factors comprising ideal health, especially optimal weight development and the prevention of smoking, may be responsive to psychosocial prevention.

In a comparison of the specific psychosocial factors, socioeconomic factors and self-regulative behavior independently predicted adult ideal cardiovascular health. Previously, socioeconomic factors and self-regulation have been associated with better adulthood health,[7,23–27] although their relative contribution to cardiac health has not been examined in the same study. Identifying these specific factors as predictors of future health may be useful for early prevention because some of them (eg, the child's self-regulation ability) may be amenable to modification. However, the novel finding is that a combination of multiple psychosocial influences may have an influence on future cardiovascular health, as suggested by recent theoretical perspectives on accumulative effects of psychosocial factors.[9,12,14,31]

This study did not examine the pathways through which psychosocial exposures produce later health. A commonly proposed pathway involves allostatic load, which is a physiological marker of cumulative wear and tear of the body caused by the physiological systems responding to environmental demands.[29,44] Through allostatic load, cumulative risk may lead to unhealthy cardiovascular stress response and to prolonged cardiovascular recovery from stress.[30] A recently introduced model suggests that positive psychological experiences may increase restorative processes (eg, healthy behaviors) leading to good cardiovascular health while at the same time decreasing deteriorative processes (eg, inflammation), leading to cardiovascular health.[45] Our next step will be to examine these proposed pathways between early-life psychosocial factors and cardiac health outcomes later in life.

Several limitations warrant attention. The original intent of the Young Finns data set was to evaluate early-life determinants of cardiovascular risk in adulthood. Psychosocial factors were assessed already at the beginning of the study, but they were not the primary focus of this collaborative study. Therefore, we had to use nonstandardized scales designed for this particular data set 3 decades ago. Although the scales are predictive of cardiac outcomes and have internal reliability,[25,26] the possibility of comparing our findings with those of other data sets is limited. Moreover, the study population was mainly whites, which limits the generalizability to other ethnic groups or to ethnically more heterogeneous populations.

Attrition in this 27-year follow-up study was considerable, and there were >2000 participants with missing data. If those participants were missing for some systematic reason, they might have caused bias in our estimates. We dealt with potential bias by running multiple imputation analyses to estimate the missing data. The findings in imputed data sets were similar in direction and magnitude to those in the observed data. We also modeled the possibility that the missing data would not be missing at random and found that this had very little effect on the findings. Naturally, these analyses were only estimates of how the findings would change, given that we had all data at hand. Nevertheless, we used current golden-standard methods, which suggested no considerable bias produced by missing data.

Another potential limitation is that psychosocial factors consisted of dichotomous components summed together. Such scores are simplifications of reality, and introducing cutoff points is likely to lose natural variance in the variables.[31] To overcome this limitation, we ran additional analyses in the raw data. These findings reproduced the main findings well, suggesting that the findings were robust against different ways to calculate childhood factors.

A strength of the present study was the prospective design connecting psychosocial factors with outcomes unknown at the time of youth examination. Informants were different in youth (parents) and in adulthood (participant or health professional), thus ruling out common-rater variance. The study included a relatively comprehensive set of psychosocial factors and enabled adjustment for cardiovascular health in youth.

Findings of this study suggest that favorable psychosocial factors in youth may have benefits for cardiovascular health later in life. A constellation of several favorable psychosocial factors in youth may lead to an almost 1-point increase in ideal cardiovascular health index in adulthood. This knowledge suggests that targeting psychosocial factors might facilitate attainment of the AHA goal of improving population health by 2020. The effects seem to persist throughout the range of cardiovascular health, suggesting that favorable psychosocial factors may bring health benefits to all, potentially shifting the population distribution of cardiovascular health rather than simply having effects in a high-risk population.

Acknowledgments

We greatly acknowledge Irina Lisinen and Ville Aalto for their statistical advice.

Sources of Funding

This study was funded by the Academy of Finland, grants 265869 (MIND), 258711, 134309 (Eye), 126925, 121584, 265977, 124282, 129378 (Salve), 117797 (Gendi), and 41071 (Skidi); the Social Insurance Institution of Finland; Kuopio, Tampere, and Turku University Hospital Medical Funds; the Juho Vainio Foundation; the Signe and Ane Gyllenberg Foundation; the Paavo Nurmi Foundation; the Finnish Foundation of Cardiovascular Research; the Finnish Cultural Foundation; Tampere Tuberculosis Foundation; the Emil Aaltonen Foundation; and the Robert Wood Johnson Foundation through a grant (Exploring the Concept of Positive Health) to the Positive Psychology Center of the University of Pennsylvania, Martin Seligman, principal investigator (Dr Kubzansky). The Bothnia Welfare Coalition for Research and Knowledge has supported this study through grants from the Regional Council of Ostrobothnia, the Vaasa Hospital District, the city of Vaasa, the University of Vaasa, and the European Regional Development Fund.

Disclosures

None.

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CLINICAL PERSPECTIVE

Cardiovascular diseases originate early in life, but little is known about the specific childhood psychosocial factors that potentially enhance cardiac health in adulthood. Ideal cardiac health has recently been defined by the American Heart Association by parameters known to predict reductions in incident cardiovascular diseases and reduced mortality. We examined whether positive psychosocial factors in youth predict ideal cardiovascular health in adulthood (eg, normal weight, healthy blood pressure, healthy diet). We identified 6 psychosocial factors in youth: the socioeconomic environment, the emotional environment, health behaviors, life events, self-regulation, and social adjustment. In 1089 participants from the general population of Finland, favorable levels in these psychosocial factors predicted more ideal cardiovascular health 27 years later in adulthood. The association was monotonic so that each additional psychosocial factor brought benefit for cardiac health, and persons having favorable levels in all psychosocial factors in youth had the healthiest cardiac profiles as adults. Especially good self-regulatory skills, socioeconomically advantaged family background, and healthy parental lifestyle were among the factors that promoted long-term cardiac health. These psychosocial factors can be assessed in clinical practice by questionnaires or clinical interview. Although our findings apply only to a white population, we suggest that building on psychosocial strengths in early prevention can be a step toward good cardiovascular health throughout life. Children lacking positive psychosocial factors may be vulnerable to the future development of cardiac risks; therefore, they need more advice and support to be able to attain and maintain good cardiac health.

Cumulative Effect of Psychosocial Factors in Youth on Ideal Cardiovascular Health in Adulthood: The Cardiovascular Risk in Young Finns Study

Laura Pulkki-Råback, Marko Elovainio, Christian Hakulinen, Jari Lipsanen, Mirka Hintsanen, Markus Jokela, Laura D. Kubzansky, Taina Hintsa, Anna Serlachius, Tomi T. Laitinen, Katja Pahkala, Vera Mikkilä, Jaakko Nevalainen, Nina Hutri-Kähönen, Markus Juonala, Jorma Viikari, Olli T. Raitakari and Liisa Keltikangas-Järvinen

Circulation. 2015;131:245-253; originally published online January 12, 2015;
doi: 10.1161/CIRCULATIONAHA.113.007104
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0009-7322. Online ISSN: 1524-4539

Correction

In the article by Pulkki-Råback et al, "Cumulative Effect of Psychosocial Factors in Youth on Ideal Cardiovascular Health in Adulthood: The Cardiovascular Risk in Young Finns Study", which was published in the January 20, 2015 issue (*Circulation*. 2015;131:245-253. DOI: 10.1161/CIRCULATIONAHA.113.007104), an author's name was incorrect. The author's name should have read Tomi T. Laitinen.

The correction has been made to the current online version of the article, which is available at http://circ.ahajournals.org/content/131/3/245.full. The authors regret the error.

(*Circulation*. 2015;131:e403. DOI: 10.1161/CIR.0000000000000201.)

***Circulation* is available at http://circ.ahajournals.org** **DOI: 10.1161/CIR.0000000000000201**

SUPPLEMENTAL MATERIAL FOR ONLINE PUBLICATION

To *Circulation*, 26 November, 2014

SHORT TITLE Pulkki-Råback: Psychosocial factors and ideal cardiovascular health

Supplement table 1. Comparison of the included and the excluded participants on baseline variables of The Cardiovascular Risk in Young Finns study.

Characteristic	Mean (SD) Included (n=1089)	Excluded (n=2507)	p
Age (years) in childhood, mean (SD)	10.8 (5.0)	10.1(4.9)	<0.001
Age (years) in adulthood, mean (SD)	37.8 (5.0)	37.1(4.9)	<0.001
Psychosocial factors in youth			
Favorable socioeconomic environment	1.67 (1.16)	1.46 (1.11)	<0.001
Favorable emotional family environment	2.51 (0.97)	2.42 (0.94)	0.033
Favorable health-behaviors of parents	4.90 (1.15)	4.79 (1.21)	0.017
Lack of stressful events	4.81(0.45)	4.53 (0.76)	0.100
High self-regulatory behavior	6.67(0.72)	6.58 (0.84)	0.003
High social adjustment	2.52(0.68)	2.38 (0.75)	<0.001
Childhood cardiovascular risk factors			
Body-mass index, kg/m2	17.7 (2.9)	17.9 (3.2)	0.021
Systolic blood pressure, mmol/L	111.4 (12.0)	113.1 (12.2)	0.001
Total cholesterol, mmol/L	5.12 (0.85)	5.09 (0.84)	0.316

Supplement table 2 . Desription of the youth psychosocial variables as they appeared in the baseline questionnaire (year 1980) in the Cardiovascular Risk in Young Finns study.

Item	Scoring	Range
Variables of the socioeconomic environment		
Occupational status	1=manual, 2=lower nonmanual, 3=higher nonmanual	1-3
Maternal education	Total number of years of education	3-22
Paternal education	Total number of years of education	2-28
Family income	Total annual income (Finnish marks), 7-point scale	0-7
Maternal employment	0=unemployed, retired, or sick-leave, 1=employed	0-1
Paternal employment	0=unemployed, retired, or sick-leave, 1=employed	0-1
Variables of the emotional environment		
Maternal mental health	0=diagnosis of mental disorder, 1=free of diagnosis	0-1
Paternal mental health	0=diagnosis of mental disorder, 1=free of diagnosis	0-1
Parental caregiving nurturanc	7-item scale (α=0.70):	
	"I lose my nerve with my child. (reversed)"	1-5*
	"My child is burdensome in difficult situations. (reversed)"	1-5*
	"My child takes too much of my time (reversed)"	1-5*
	"My child is important to me."	1-5*
	"I am important to my child."	1-5*
	"I enjoy spending time with my child."	1-5*
	"I am able to self-actualize myself when being with my child."	1-5*
Parental life satisfaction	3-item scale (α=0.71):	
	"I am satisfied with myself as a mother/father."	1-5
	"I am satisfied with myself as a spouse/life companion."	1-5
	"I am satisfied with myself as an employee."	1-5
Maternal alcohol use	Frequency of intoxication, 8-point scale	1-8
Paternal alcohol use	Frequency of intoxication, 8-point scale	1-8
Variables indicating parental health behaviors		
Maternal body-mass index	kg/m^2	
Paternal body-mass index	kg/m^2	
Maternal smoking	0=smoker, 1=non-smoker	0-1
Paternal smoking	0=smoker, 1=non-smoker	0-1
Maternal physical activity	1=no excersice, 2=some (irregular) excersice, 3=regular weekly	1-3
Paternal physical activity	1=no excersice, 2=some (irregular) excersice, 3=regular weekly	1-3

Continues

Continued

Variables indicating stressful events		
Change of residence	0=yes, 1=no	0-1
Change of school	0=yes, 1=no	0-1
Parental divorce/separation	0=yes, 1=no	0-1
Death of family member	0=yes, 1=no	0-1
Long-term hospitalization	0=yes, 1=no	0-1
Variables indicating self-regulatory behavior of the child		
Self-control scale	*Please, choose the option that most accurately describes your chil*	1-4
	1=My child is always on the move, restless, and unable to control him(her)self	
	2=My child is more restless and less controlled than children of same age	
	3=My child is restless/poorly controlled only when tired or bored, but mostly within normal limits.	
	4=My child is very controlled and stays calm even in situations where most children would become restless and out of control.	
Aggression control scale	6-item scale (α=0.60):	
	"Other children say that my child gets easily into fights."	1-2[†]
	"My child hits/pushes other children "by accident."	1-2[†]
	"My child needs a lot of discipline to control aggression."	1-2[†]
	"My child uses swear words very often."	1-2[†]
	"Other children complain often about my child's behavior."	1-2[†]
	"Other parents have complained about my child's behavior."	1-2[†]
Variables indicating social adjustment of the child		
	Please, choose the option that most accurately describes your child:	
	0=I am worried about my child's behavior and I am aftraid he/she WILL become a problem child.	0-1
	1=I am not particularly worried about my child's behaivor.	
	Please, choose the option that most accurately describes your child:	
	0=I am worried about my child's behavior and I am aftraid he/she will become a problem child.	
	1=My child is well-adjusted and copes well with life's challenges	0-1

[*] 1=extremely seldom, 2=seldom, 3=in between, 4=often, 5=very often.

[†] 1=true, 2=not true

Supplement table 3. Multinomial logistic model of favorable psychosocial factors score predicting the ideal cardiovascular health index. The Cardiovascular Risk in Young Finns Study (n=1089).

Outcome variable:				
Level of ideal cardiovascular health index	Adjusted for age, sex, and medication use[†]		+ childhood cardio-vascular risk factors[‡]	
	RRR[*]	p	RRR[*]	p
≤1, ref.	1.00	ref.	1.00	ref.
2	1.06	0.193	1.06	0.188
3	1.14	0.001	1.15	0.001
4	1.17	<0.001	1.18	<0.001
5	1.17	<0.001	1.18	<0.001
≥6	**1.35**	<0.001	1.36	<0.001

[*]Relative risk ratios (RRR) are results of separate logistic regressions for each category of the outcome, e.g., **RRR=1.35** indicates that when psychosocial factors improve by one point, the relative risk for having ≥6 points is 35% higher than the risk of having ≤1 point on the ideal cardiovascualr health index.

[†]Use of antihypertensive medication, lipid-lowering medication, or insulin.

[‡]Body-mass index, systolic and diastolic blood pressure and total cholesterol.

Supplement table 4. Regression models of favorable psychosocial factors in youth predicting the ideal cardiovascular health index in adulthood in two datasets from The Cardiovascular Risk in YoungFinns Study: (1) raw data of pschosocial factors and (2) imputed data.

	Adjusted for age, sex, medication use*		+ childhood cardio-vascular risk factors	
	Beta	p	Beta	p
(1) RAW DATA (n=1089)				
Age, years	-0.13	<0.001	0.03	0.379
Male sex	-0.32	<0.001	-0.34	<0.001
Cardiac medication use†	-0.17	<0.001	-0.15	<0.001
Childhood body-mass index, kg/m2			-0.12	0.001
Childhood systolic blood pressure, mm Hg			-0.07	0.043
Childhood total cholesterol, mmol/L			-0.17	<0.001
Favorable psychosocial factors score	**0.15**	**<0.001**	**0.14**	**<0.001**
Model R^2		19%		24%
(2) IMPUTED DATA (n=3577)				
Age, years	-0.13	<0.001	-0.01	0.630
Male sex	-0.31	<0.001	-0.32	0.001
Cardiac medication use†	-0.13	<0.001	-0.11	<0.001
Childhood body-mass index, kg/m2			-0.15	<0.001
Childhood systolic blood pressure, mm Hg			-0.09	<0.031
Childhood total cholesterol, mmol/L			-0.15	<0.001
Favorable psychosocial factors score	**0.12**	**<0.001**	**0.12**	**<0.001**
Model R^2		17%		21%

*Use of antihypertensive medication, lipid-lowering medication, or insulin.

Supplement table 5. Associations of favorable psychosocial factors in youth with health metrics in adulthood in three datasets from the Young Finns Study: (1) data of this study, (2) raw data of childhood psychosocial factors, and (3) imputed data. *

	BMI <25m^2			Physically active			Healthy diet			Not smoking			Blood pressure <120/80 mm Hg			Glucose <5.6 mmol/L			Total cholesterol <5.17 mmol/L		
	OR†	95% CI	p	Beta	95%CI	p	Beta	95%CI	p	Beta	95%CI	p	Beta	95%CI	p	Beta	95%CI	p	Beta	95%CI	p
(1) DATA OF THIS STUDY (n=1089)																					
	1.14	**1.08-1.20**	**0.001**	1.03	0.99-1.08	0.179	1.09	0.98-1.21	0.109	**1.12**	**1.07-1.19**	**<0.001**	1.03	0.97-1.08	0.332	**1.11**	**1.05-1.17**	**<0.001**	1.02	0.97-1.08	0.442
(2) RAW DATA (n=1089)																					
	1.04	**1.03-1.06**	**<0.001**	1.01	0.99-1.03	0.336	1.04	0.97-1.08	0.073	**1.04**	**1.02-1.06**	**<0.001**	1.01	0.99-1.03	0.161	**1.03**	**1.01-1.05**	**0.001**	1.01	0.97-1.03	0.545
(3) IMPUTED DATA (N=3577)																					
	1.09	**1.05-1.13**	**<0.001**	1.03	0.98-1-06	0.075	0.98	0.92-1.05	0.580	**1.11**	**1.08-1.15**	**<0.001**	1.02	0.98-1.05	0.305	**1.05**	**1.00-1.08**	**0.032**	1.01	0.97-1.04	0.755

*All models adjusted for age, sex, adult medication use and childhood cardiovascular risk factors.

†OR=odds ratio, CI=confidence interval.

Supplement table 6. Specific psychosocial factors in youth predicting the ideal cardiovascular health index in adulthood in two datasets from the Cardiovascular Risk in Young Finns Study: (1) raw data of psychosocial factors and (2) imputed data.[*]

	Univariate[†]		Multivariate[‡]	
	Beta	p	Beta	p
(1) RAW DATA (n=1089)				
Favorable socioeconomic environment	**0.16**	**<0.001**	**0.13**	**<0.001**
Favorable emotional family environment	0.06	0.041	0.07	0.016
Favorable health-behaviors in the family	**0.12**	**<0.001**	**0.08**	**0.004**
Lack of stressful events	0.04	0.166	0.02	0.399
Self-regulatory behavior	**0.10**	**<0.001**	**0.09**	**0.001**
Social adjustment	0.05	0.096	0.05	0.093
(2) IMPUTED DATA (n=3577)				
Favorable socioeconomic environment	**0.15**	**<0.001**	**0.13**	**<0.001**
Favorable emotional family environment	0.07	0.026	0.04	0.221
Favorable health-behaviors in the family	**0.10**	**<0.001**	**0.06**	**0.008**
Lack of stressful events	0.01	0.754	-0.03	0.545
Self-regulatory behavior	**0.12**	**<0.001**	**0.09**	**0.004**
Social adjustment	0.06	0.134	0.01	0.914

[*]All models adjusted for age, sex, childhood cardiovascular risk factors, and adult cardiac medication use.

[†]Psychosocial factors entered into the model separately.

[‡]Psychosocial factors entered into the model at the same time.

Supplement table 7. Regression models of the raw psychosocial factors score predicting the ideal cardiovascular health index in adultood, separately in younger (3-9 years) and older (12-18 years) cohorts and separately in females and males. The Cardiovascular Risk in Young Study.

	Separately by age								**Separately by sex**							
	Younger cohorts (n=539)				**Older cohorts (n=550)**				**Females (n=603)**				**Males (n=486)**			
	Adulthood covariates		+ childhood covariates		Adulthood covariates		+ childhood covariates		Adulthood covariates		+ childhood covariates		Adulthood covariates		+ childhood covariates	
	Beta	p	Beta	p	Beta	p	Beta	p	Beta	p	Beta	p	Beta	p	Beta	p
Age (years)	-0.11	0.006	-0.04	0.297	-0.19	0.662	0.04	0.297	-0.13	0.001	0.02	0.766	-0.14	0.001	0.06	0.326
Male sex	-0.32	<0.001	-0.33	<0.001	-0.34	<0.001	-0.33	<0.001								
Cardiac medication use[†]	-0.12	0.002	-0.09	0.023	-0.21	<0.001	-0.09	0.023	-0.21	<0.001	-0.19	<0.001	-0.15	0.001	-0.13	0.003
Childhood body-mass index			-0.12	0.005			-0.12	0.005			-0.13	0.013			-0.13	0.032
Childhood systolic blood pressure, mm Hg			-0.03	0.533			-0.03	0.533			-0.09	0.033			-0.04	0.488
Childhood total cholesterol, mmol/L			-0.19	<0.001			-0.19	<0.001			-0.16	<0.001			-0.21	<0.001
Raw psychosocial factors score	**0.17**	**<0.001**	**0.16**	**<0.001**	**0.13**	**0.001**	**0.16**	**<0.001**	**0.14**	**<0.001**	**0.14**	**<0.001**	**0.18**	**<0.001**	**0.17**	**<0.001**
Model R^2		16%		21%		20%		21%		9%		14%		9%		14%

[†]Use of antihypertensive medication, lipid-lowering medication, or insulin.

Supplement table 8. Regression coefficients (unstandardized) between favorable psychosocial factors in youth and the ideal cardiovascular health index under the missing at random (MAR) assumption and the not missing at random (NMAR) assumption in 50 imputed datasets.

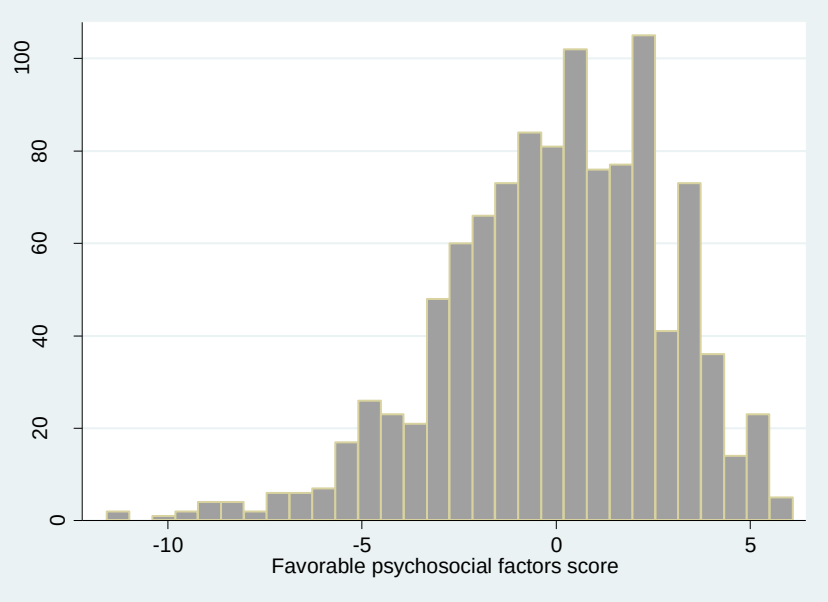
Mechanism of missing data	n	Mean of coefficients*	Standard deviation*
MAR, delta†=0.00	3577	0.054648	0.009686
NMAR			
delta=0.10	3577	0.062869	0.002520
delta=0.20	3577	0.063605	0.000441
delta=0.30	3577	0.063581	0.000079
delta=0.40	3577	0.063582	0.000014
delta=0.50	3577	0.063582	0.000001

*Adjusted for age, sex, medication use and childhood cardiac risk factors.

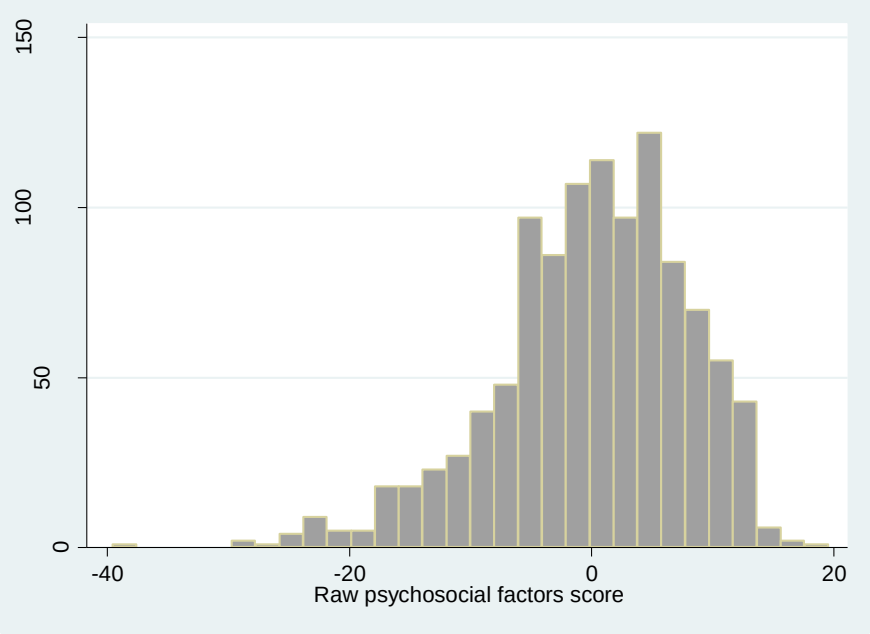
†Delta=assumed departure from the MAR assumption.

Note. The basic multiple imputation model assumes the missing data is missing at random (MAR), which means that the missing data does not depend on unseen data. Here we assessed the sensitivity of the analysis to the possibility that data is not missing at random (NMAR). The first imputaton is conducted under the MAR assumption and the coefficient indicates the pooled estimate over 50 imputations. The subsequent imputations are conducted under the NMAR assumption, where the weights (deltas) depend on the assumed degree of departure from MAR.
To improve accuracy of approximation, 50 imputations is used for each parameter estimation.

Supplement figure 1 (A)



Supplement figure 1 (B)



Supplement Figure 1. The distribution of the favorable psychosocial factors score using the binary variables (A) and using the raw variables (B).