Dietary Intervention in Infancy and Cognitive Function in Young Adulthood: The Special Turku Coronary Risk Factor Intervention Project

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Objective Consumption of saturated fatty acids (SAFAs), polyunsaturated fatty acids (PUFAs), cholesterol, and fiber have been linked with cognitive function in adults. We evaluated these associations from childhood by leveraging data from the Special Turku Coronary Risk Factor Intervention Project (STRIP).

Study design STRIP recruited children aged 5 months and randomly assigned them into intervention/control groups. The intervention introduced a heart-healthy diet, characterized mainly by low consumption of SAFAs and cholesterol, through counseling at least biannually between age 7 months and 20 years. Diet was assessed repeatedly using food diaries. Six years after the end of the intervention phase, at age 26 years, the participants were invited to the first postintervention follow-up, which included cognitive testing that covered learning and memory, verbal memory, short-term working memory, reaction time, information processing, and cognitive flexibility and inhibitory control. We studied the associations of the STRIP intervention and the consumptions of SAFAs, PUFAs, cholesterol, and fiber within these cognitive domains.

Results Participants in the STRIP intervention group had better cognitive flexibility and inhibitory control and were better able to manage conflicting information and ignore task-irrelevant information (0.18 SD higher in the intervention group, adjusted for sex and socioeconomic status). No associations were observed with the dietary components studied.

Conclusions The infancy-onset STRIP intervention, which promoted a heart-healthy diet, was favorably associated with cognitive flexibility and inhibitory control at age 26 years. No associations were found for the intervention targets studied, indicating that these specific dietary components did not underlie the observed effect of the intervention. *(J Pediatr 2022;246:184-90)*.

Cognitive function develops from infancy, reaches its peak in early adulthood,[1] and declines gradually thereafter, with accelerated deterioration in old age. Are there determinants of cognitive function beginning in childhood that enhance the level of cognitive function in young adulthood?

The longitudinal Special Turku Coronary Risk Factor Intervention Project (STRIP), established in 1989, was launched to reduce children's exposure to environmental cardiovascular risk factors from infancy to early adulthood.[2] The focus of the 20-year intervention was to replace saturated fat with unsaturated fat in a child's diet and concomitantly reduce the intake of cholesterol. There is accumulating evidence from adult cohorts on the shared risk factors between atherosclerosis and cognitive function and deficits,[3-8] and this, together with our observations from the Cardiovascular Risk in Young Finns Study linking the same risk factors to cognitive function already from childhood,[9-12] were used to introduce cognitive testing into the STRIP protocol.

AST	Attention Switching Task
CANTAB	Cambridge Neuropsychological Test Automated Battery
(P + M)/S	Ratio of polyunsaturated and monounsaturated fatty acids to saturated fatty acids
PAL	Paired Associates Learning
PUFA	Polyunsaturated fatty acid
RTI	Reaction Time
RVP	Rapid Visual Information Processing
SAFA	Saturated fatty acid
STRIP	Special Turku Coronary Risk Factor Intervention Project
SWM	Spatial Working Memory
VRM	Verbal Recognition Memory

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Financial support was provided by the Academy of Finland, Finland (Grants 206374, 294834, 251360, 275595, 307996, and 322112), the Juho Vainio Foundation, Finland, the Finnish Foundation for Cardiovascular Research, Finland, the Finnish Ministry of Education and Culture, the Finnish Cultural Foundation, Finland, the Sigrid Jusélius Foundation, Finland, Special Governmental grants for Health Sciences Research (Turku University Hospital), the Yrjö Jahnsson Foundation, Finland, the Finnish Medical Foundation, Finland, and the Turku University Foundation. The authors declare no conflicts of interest.

https://doi.org/10.1016/j.jpeds.2022.03.046

Previous observational studies of adult cohorts have highlighted the role of such dietary factors as dietary fatty acids, cholesterol, and fiber on cognitive function. Intervention studies of young adults have reported direct associations between polyunsaturated fatty acid (PUFA) supplementation and the specific cognitive domains of learning and/or memory[13,14] and a direct association with executive function.[15] Two intervention studies of healthy young adults found no beneficial effects of PUFA supplementation on cognitive function.[16,17] The results of observational studies of child/adolescent cohorts suggest inverse associations for the consumption of saturated fatty acids (SAFAs)[18] and cholesterol[19] as well as direct associations for consumption of PUFAs[18] and fiber[20] with cognitive function. Furthermore, previous intervention studies have found a direct association of PUFA supplementation with infant[21,22] and childhood[23] cognitive function.

In the present study, we examined the associations between 20 years of dietary counseling that started in infancy and cognitive function in young adulthood. We also aimed to elucidate the associations between the main STRIP intervention targets—consumption of SAFAs, PUFAs, cholesterol, and fiber beginning in early childhood—and cognitive function at the age when this function is estimated to be at its peak.

Methods

The STRIP study is a prospective, randomized trial that aims to prevent atherosclerosis beginning in infancy.[2] A detailed description of the design and subjects is presented in the **Appendix** (available at www.jpeds.com). In brief, the families of 5-month-old infants born between July 1989 and December 1991 were recruited by nurses at well-baby clinics in Turku, Finland. At age 7 months, 1062 infants (56.5% of the eligible age cohort) were allocated at random into either a dietary intervention group (n = 540) or a control group (n = 522) (**Figure**). The cohort included 2 children with Down syndrome, 2 children with familial hypercholesterolemia, and 5 children who had been randomized into the intervention group but had missed the first study appointments before age 13 months and were later treated as controls. A group of 45 children born between March and July 1989 were recruited similarly and randomized (intervention group, n = 22; control group, n = 23) to first test the study protocols, thus serving as a "pilot" group.

The intervention group received individualized dietary counseling at 1- to 3-month intervals up to age 2 years and biannually thereafter until age 20 years.[24] Counseling was provided to parents until the child reached age 7 years, after which gradually more information was provided directly to the child. The intervention consisted of 30-minute individualized dietary counseling and nutrition education sessions led by a nutritionist. The main target of the counseling was to replace saturated fats with unsaturated fats in the child's diet and concomitantly reduce the intake of cholesterol; a reduction in total fat intake was not the target. The intervention group also received counseling on how to reduce salt consumption and to favor whole grain products instead of more refined options. The counseling further encouraged the inclusion of fruits, vegetables, and berries in the diet. A fixed diet was never specified; the counseling was individualized, and the child's most recent food diary served as the basis for suggestions for dietary changes (eg, replacement of dairy fat–blend spreads with vegetable oil–based spreads). The dietary recommendations were based on the latest version of the Nordic nutrition recommendations.

The key nutritional targets of the intervention, reflecting concurrent nutrition recommendations, were a ratio of polyunsaturated and monounsaturated fat to saturated fat [(P + M)/S] >2:1 (indicative of dietary fat quality) and consumption of SAFAs <10% of energy and cholesterol <200 mg/day (age <18 years) or <300 mg/day (age ≥18 years). As part of the intervention, guidance to avoid smoking was introduced when the participants were 8 years old.[2] A physically active lifestyle was encouraged, but this was not a structured, continuous part of the intervention. The children in the control group received only the basic health education given at Finnish well-baby clinics and school health care. Topics related to the intervention were not discussed.

The first postintervention follow-up of the study participants was conducted between April 2015 and January 2018 when they were age 26 years, 6 years after the intervention had ended[25] (**Figure**). Out of the cohort of 1116 subjects, 1072 were invited to participate, and of these, 551 provided follow-up data (51%; intervention group, n = 263; control group, n = 288). More females (n = 308) than males (n = 288) participated in the follow-up. Five of the participants provided only questionnaire data. The present study includes those individuals who provided data on cognitive function at age 26 years. Attrition analyses have been published previously.[25] In brief, follow-up participants and nonparticipants were similar in terms of dietary components studied, smoking behavior, physical activity, body mass index, blood pressure, and serum lipid levels. Parental socioeconomic status was similar in the participants and nonparticipants.

The study was approved by the ethical authorities of the associated universities and hospital districts. Written informed consent was obtained from parents at study entry and from the participants at age 15, 18, and 26 years.

Cognitive function was tested at the 26-year follow-up study clinical visit. Because blood sampling was part of the study protocol, the participants were instructed to fast overnight before the study visit and to avoid smoking, strenuous physical activity, and alcohol and coffee during the previous evening and the morning of the study visit. Before the cognitive testing, the participants were given a light snack consisting of a whole-meal oat-based biscuit, 2 dL of an oat drink, and weak fruit/berry juice.

Cognitive function was measured using the Cambridge Neuropsychological Test Automated Battery (CANTAB).

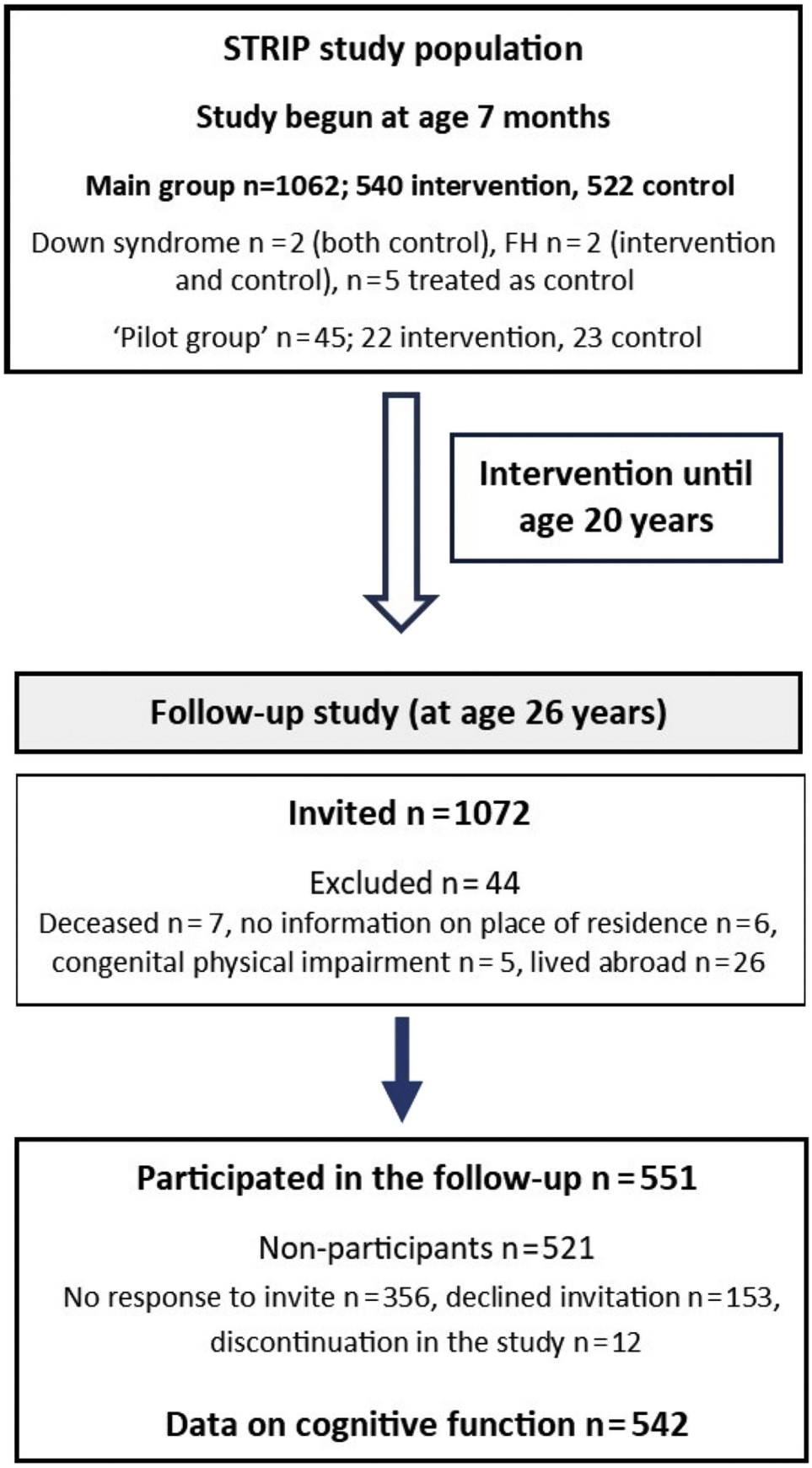

Figure. Flowchart of the STRIP study population. *FH*, familial hypercholesterolemia.

A computerized, predominantly nonlinguistic, and culturally neutral test battery composed of several separate tests of a wide range of cognitive domains, CANTAB has been shown to distinguish cognitively healthy adults.[26] A suitable combination of separate tests can be selected for each particular study and used as a cognitive testing battery, performed on a touch-screen computer system. For the STRIP 26-year follow-up study, 6 separate tests were selected in addition to the Motor Screening Test, which was used as a training/screening tool to indicate difficulties in test execution: (1) the Paired Associates Learning (PAL) test, which measures visual and episodic memory and visuospatial associative learning; (2) the Verbal Recognition Memory (VRM) test, which measures verbal memory with aspects of both immediate and delayed recall; (3) the Spatial Working Memory (SWM) test, which measures short-term and spatial working memory and problem solving; (4) the Reaction Time (RTI) test, which measures reaction and movement speed and attention; (5) the Rapid Visual Information Processing (RVP) test, which measures visual processing, recognition, and sustained attention; and (6) the Attention Switching Task (AST) test (currently termed the Multitasking Test in the CANTAB test battery), which measures cognitive flexibility and inhibitory control. **Table I** (available at www.jpeds.com) presents the numbers of participants in each subtest of the STRIP cognitive testing battery.

Each of the CANTAB tests produced several variables. We first studied the distribution of each variable. At this point, the Motor Screening Test data were excluded from further analyses because of the ceiling effect (ie, all participants had the maximum score). To create cognitive function outcome variables that would gather all the data from each test into a single variable, we used a *z*-score–based classification of the cognitive variables within each test, as in our previous study that leveraged CANTAB data.[27] First, all the individual variables in the cognitive function data were transformed into a standard deviation scale with a mean of 0 and SD of 1. After this, test-wise scores were calculated by summing the individual standardized variables within each separate test and then dividing the sum thus obtained by the number of variables in that particular test. This data reduction procedure resulted in 6 outcome variables, each representing one of the studied cognitive domains. The cognitive tests are described in detail in the **Appendix**.

We confirmed that the cognitive assessment was conducted appropriately in the STRIP study by analyzing the associations between sex and education and each separate cognitive domain variable. For these analyses, we used the self-reported data on education level queried in the STRIP 26-year follow-up study. The participants were categorized into 3 education groups: low education group, comprising participants who had completed vocational studies; intermediate education group, comprising participants with a lower university degree (eg, bachelor's degree) or a degree from a university of applied sciences; and high education group, comprising participants with a higher university degree (eg, master's degree or higher).

Beginning at age 8 months, a food diary was completed before the study visits. Before age 2 years, a 3-day diary was applied, and later a 4-day diary was used. The recorded days were consecutive and included at least 1 weekend day. Portion sizes were estimated using household measures or a food picture booklet. During the study visit, the diary was reviewed for completeness and accuracy. Food and nutrient consumptions were analyzed using the MicroNutrica program developed at the Research and Development Center of the Social Insurance Institution of Finland. The program calculates 66 nutrients in more than 4000 foods and dishes. The databank has been continuously updated by a single dietary technician since the start of data collection.

To study whether the association between the STRIP intervention and cognitive function reflects an association with any of the specific dietary factors that were the key targets of the STRIP intervention, we considered SAFA and PUFA consumption (percentage of energy intake; E%), the ratio of poly- and monounsaturated fatty acids to SAFA [(P+M)/S], and cholesterol (mg) and fiber (g/MJ) consumption. To assess dietary consumption during early childhood (age 13 months to 5 years), childhood (age 6-10 years), early adolescence (age 11-15 years), and adolescence (age 16-20 years), we calculated the mean consumption of each dietary factor in these 4 age windows for those participants who had at least 2 measurements within the age window. We also applied data on the same dietary factors obtained in young adulthood (age 26 years).

The χ^2 test and linear modeling were used to compare the participants and nonparticipants. We used linear regression analyses to study the associations of sex, education, STRIP intervention, and the various dietary factors with cognitive function. Sex and education were considered primary covariates in all the analyses. The analyses were restricted to those participants with data on both primary covariates. In addition, the SAFA, PUFA, cholesterol and fiber analyses were adjusted for each other, and the (P + M)/S analyses were also adjusted for cholesterol and fiber. All available data for each cognitive domain was used, and thus the number of participants varied in the analyses for separate cognitive domains and for separate age windows. **Table I** presents the numbers of participants in each analysis.

Results

During the 26-year follow-up study visit, 99% (n = 542) of the participants (females, n = 304 [56.1%]; males, n = 238 [43.9%]) underwent the cognitive testing. Of these, 258 (47.6%) were from the intervention group and 284 (52.4%) were from the control group. All 542 participants completed the PAL test, VRM test, and SWM test, whereas 541 completed the RTI test, 540 completed the RVP test, and 500 completed the AST test. Of the participants, 187 (34.4%) were in the low education group, 176 (32.4%) in the intermediate group, and 181 (33.3%) in the high education group. The characteristics related to diet, lifestyle, and

cardiometabolic risk factors of the study population at age 26 years have been reported previously.[25] In brief, the intervention and control groups differed in terms of dietary SAFA, (P + M)/S, and consumption of fruits, vegetables, and berries, as well as in terms of their glucose metabolism and serum total cholesterol and low-density lipoprotein cholesterol markers. No differences were observed in physical activity or regular smoking.

As a part of this study, we confirmed the STRIP cognitive assessment by analyzing the associations between sex and education level and the studied cognitive domains (**Table II**; available at www.jpeds.com). The associations between sex and education and cognitive function that we observed in these analyses confirm the appropriate cognitive function assessment introduced to STRIP when the participants were aged 26 years.

The results of the sex-adjusted analyses of the STRIP study group showed that the intervention group had better cognitive flexibility and inhibitory control compared with the control group (AST test: β = 0.181, SE = 0.09, P = .042) (**Table III**). After additional adjustment for educational level, the association was diluted only marginally (β = 0.167, SE = 0.09, P = .057). No associations with other cognitive domains were found.

The possible effect modification of sex on the associations of the STRIP study group was formally tested by introducing a multiplicative interaction term (sex*STRIP study group) into the education-adjusted models for each cognitive domain studied. No significant interactions were observed, indicating that the association of the STRIP intervention for each cognitive domain was similar in males and females.

Further analyses of the dietary factors that were the main focus of the STRIP intervention were conducted using those cognitive domains showing at least a weak association with the STRIP study group: verbal memory, cognitive flexibility, and inhibitory control (**Table IV**). These analyses showed no systematic associations with any of the dietary factors, although some sporadic associations were found. A direct association was found between SAFA consumption in young adulthood and verbal memory (VRM test: β = 0.037, SE = 0.01, P = .008). No other associations were found between dietary consumptions and verbal memory. Fiber consumption in childhood had an inverse association with cognitive flexibility and inhibitory control (AST test: β = −0.317, SE = 0.15; P = .030), whereas cholesterol intake in early adulthood (β = 0.00086, SE = 0.00; P = .003) had a direct association.

Discussion

We found that the participants in the STRIP intervention group performed better in the tests measuring cognitive flexibility and inhibitory control, indicating a better ability to manage conflicting information and ignore task-irrelevant information. However, we did not find any specific dietary component in the key focus of the STRIP intervention to robustly underlie the observed effect of the intervention on cognitive flexibility and inhibitory control. Nevertheless, the present findings suggesting a modest beneficial effect of the intervention for a subdomain of executive function at age 26 years complement our previous findings reporting similar neurodevelopment in the STRIP intervention and control groups at age 5 years.[28]

A previous short-term intervention study of Finnish children suggested that a diet rich in fruit and berries, vegetables, fiber, and low-fat milk products and low in red meat has a positive association with executive function in children aged 6-8 years.[29] In addition, several intervention studies conducted in infant[21,22] and child[23] populations have suggested a beneficial effect of PUFA supplementation for cognitive function, but conflicting findings indicating no association[30-33] or an inverse[34] association have been reported as well. In addition to these findings, previous short-term observational studies have indicated similar results, associating higher consumption of SAFAs[18] and cholesterol[19] as well as lower consumption of PUFAs[18] and fiber[20] with poorer cognitive outcomes among children. In our analyses, the key components of the STRIP intervention (ie, dietary consumption of SAFAs, PUFAs, cholesterol, and fiber) did not explain the direct association that we found between the STRIP intervention and cognitive flexibility and inhibitory control, suggesting the possibility of other explanatory factors, such as the dietary assessment was not sufficiently precise, the study period was more demanding for the intervention group than the for the control group (45 study visits

Table III. Association between STRIP study group and cognitive function

	Sex-adjusted associations		Sex- and education-adjusted associations	
Cognitive function	**β estimate (SE)**	***P* value**	**β estimate (SE)**	***P* value**
Learning and memory (N = 535)	0.081 (0.09)	.347	0.076 (0.09)	.379
Verbal memory (N = 535)	−0.139 (0.08)	.097	−0.143 (0.08)	.087
Spatial working memory (N = 535)	−0.008 (0.09)	.922	−0.015 (0.09)	.861
Reaction and movement time (N = 534)	−0.088 (0.09)	.313	−0.091 (0.09)	.294
Visual information processing (N = 533)	0.105 (0.09)	.222	0.097 (0.08)	.249
Cognitive flexibility and inhibitory control (N = 493)	**0.181 (0.09)**	**.042**	0.167 (0.09)	.057

The β estimates (SEs) and P values are from linear models for the STRIP intervention group (with the control group as the reference group). Significant values are in bold type. The following CANTAB cognitive test battery tests were used: learning and memory: PAL test; verbal memory: VRM test; spatial working memory: SWM test; reaction and movement time: RTI test; visual information processing: RVP test; cognitive flexibility and inhibitory control: AST test.

Table IV. Associations of dietary factors from early childhood to young adulthood with verbal memory and cognitive flexibility and inhibitory control

	Early childhood, age 0-5 y		Childhood, age 6-10 y		Early adolescence, age 11-15 y		Adolescence, age 16-20 y		Young adulthood, age 26 y	
Dietary factors	**β estimate (SE)**	***P* value**	**β estimate (SE)**	***P* value**	**β estimate (SE)**	***P* value**	**β estimate (SE)**	***P* value**	**β estimate (SE)**	***P* value**
Verbal memory										
	n = 497		n = 407		n = 376		n = 333		n = 464	
SAFA, E%	−0.001 (0.03)	.956	−0.004 (0.03)	.890	0.023 (0.03)	.471	0.054 (0.03)	.099	**0.037 (0.01)**	**.008**
PUFA, E%	−0.017 (0.05)	.720	0.020 (0.06)	.731	0.051 (0.05)	.346	0.031 (0.05)	.501	0.023 (0.02)	.259
(P + M)/S	−0.141 (0.17)	.395	−0.115 (0.22)	.609	−0.128 (0.22)	.556	−0.276 (0.23)	.228	−0.160 (0.09)	.066
Cholesterol, mg	0.00030 (0.00)	.845	0.00033 (0.00)	.826	−0.0011 (0.00)	.327	−0.00029 (0.00)	.716	−0.00030 (0.00)	.264
Fiber, g/MJ	−0.115 (0.14)	.415	−0.163 (0.14)	.260	−0.056 (0.14)	.691	0.090 (0.11)	.433	−0.061 (0.06)	.285
Cognitive flexibility and inhibitory control										
	n = 458		n = 378		n = 350		n = 310		n = 427	
SAFA, E%	−0.037 (0.03)	.180	−0.054 (0.03)	.076	0.000 (0.03)	.987	−0.028 (0.03)	.407	−0.007 (0.02)	.628
PUFA, E%	0.005 (0.05)	.917	−0.024 (0.06)	.683	−0.046 (0.06)	.407	0.038 (0.05)	.419	0.023 (0.02)	.284
(P + M)/S	0.157 (0.17)	.371	0.200 (0.23)	.391	−0.040 (0.23)	.859	0.205 (0.23)	.376	0.024 (0.09)	.795
Cholesterol, mg	0.0024 (0.00)	.143	0.0012 (0.00)	.422	−0.00005 (0.00)	.967	0.0012 (0.00)	.156	**0.00086 (0.00)**	**.003**
Fiber, g/MJ	−0.118 (0.15)	.426	**−0.317 (0.15)**	**.030**	0.066 (0.14)	.647	0.201 (0.11)	.082	−0.034 (0.06)	.572

The β estimates (SEs) and *P* values are from linear models. Significant values are in bold type. All analyses are adjusted for sex and education level. In addition, SAFA, PUFA, cholesterol, and fiber are adjusted for one another, whereas (P + M)/S-ratio is adjusted for sex, education, cholesterol, and fiber. E%, percentage of energy intake. CANTAB cognitive test battery tests used: verbal memory: VRM test; cognitive flexibility and inhibitory control: AST test.

vs 28 study visits), or there were unmeasured factors underlying the observed phenomenon.

The findings of our study and of previous studies suggest that early exposures may be linked more to some domains of cognitive function than to others.[1,9-12,35,36] In this study, we found an association between the STRIP intervention and specific subdomains of executive function, namely cognitive flexibility and inhibitory control. Executive function orchestrates high-level cognitive processes and is a part of the neural networks linked to various cognitive tasks. The specific cognitive skills linked to executive function include attention and inhibition control, working memory, and cognitive flexibility, which are anatomically localized in the frontal lobes of the brain.[37,38] Both frontal lobes and their functional properties (ie, executive functions) mature late in the neurodevelopmental and cognitive function continuum. Therefore, it might be that owing to the slow developmental process of the frontal lobes and executive function, these domains are particularly sensitive to early environmental exposures. Finally, because of the central role of executive function in high-level cognitive processes, this specific cognitive domain also may be sensitive to the effect of the STRIP intervention.

Data showing links between childhood lifestyle choices and adulthood cognitive function are scarce owing to the limited number of cohorts in which early exposures have been linked to adulthood cognitive function data. The Cardiovascular Risk in Young Finns Study found that the links between age, sex, and education and cognitive function are already detectable in early adulthood and midlife,[27] and cardiovascular risk factors and lifestyle may start to exert an influence on cognitive function much earlier than previously believed.[9-12] Our present results complement previous findings on the early determinants of adult cognitive function.

The strengths of this study are its intensive, long-term dietary intervention; the longitudinal, meticulously collected dietary data, extending from infancy to young adulthood; and the computerized cognitive function assessment method, which has been shown to adequately distinguish cognitively healthy adults.[26] A limitation of the study is the homogeneity of the population of predominantly healthy Finnish young adults, in which the differences in cognitive performance are very small. Finland is a developed country in which nutritional deficits are rare, which may limit the generalizability of our findings to other, less developed countries. As cognitive flexibility and inhibitory control represents 1 of the subdomains of the multifaceted executive function, our finding that a dietary intervention was specifically associated with only 1 of the subdomains might be random. We also acknowledge that using food diaries to assess dietary data is subject to reporting bias.

Our infancy-onset dietary intervention focused on promoting a heart-healthy diet was positively associated with cognitive flexibility and inhibitory control at age 26 years. The associations between the studied dietary factors and cognitive flexibility and inhibitory control did not reveal any specific dietary components that would explain the observed effect of this intervention on this specific subdomain of executive function. ■

We thank all the STRIP study children and their parents and grandparents for their time, continued efforts, and commitment to STRIP over the years.

Submitted for publication Dec 1, 2021; last revision received Mar 23, 2022; accepted Mar 25, 2022.

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Table I. Study participants

Cognitive functions	Participants in cognitive tests, n	Participants included in analyses, n			
Age of participants	*26 y*	*26 y*	*0-5 y*	*6-10 y*	*11-15 y*	*16-20 y*
Memory and learning	542	470	504	414	383	340
Verbal memory	542	470	504	414	383	340
Spatial working memory	542	470	504	414	383	340
Reaction and movement time	541	469	503	413	382	340
Visual information processing	540	468	502	412	381	339
Cognitive flexibility and inhibitory control	500	433	465	385	357	317

Cognitive domain-specific numbers of participants who completed the cognitive testing and those who were included in the analyses (at least 2 food diaries completed within the specific age window). The following CANTAB cognitive test battery tests were used: learning and memory: PAL test; verbal memory: VRM test; spatial working memory: SWM test; reaction and movement time: RTI test; visual information processing: RVP test; cognitive flexibility and inhibitory control: AST test.

Table II. Associations of sex and education level with cognitive function

		Unadjusted associations		Education-adjusted associations	
Cognitive function		**β estimate (SE)**	***P* value**	**β estimate (SE)**	***P* value**
Sex					
Panel A	Learning and memory (n = 535)	0.067 (0.09)	.440	0.030 (0.09)	.731
	Verbal memory (n = 535)	**0.466 (0.08)**	**<.001**	**0.430 (0.08)**	**<.0001**
	Spatial working memory (n = 535)	**−0.204 (0.09)**	**.019**	**−0.263 (0.09)**	**.003**
	Reaction and movement time (n = 534)	0.006 (0.09)	.948	−0.037 (0.09)	.677
	Visual information processing (n = 533)	**−0.257 (0.09)**	**.003**	**−0.323 (0.09)**	**<.001**
	Inhibitory control (n = 493)	**−0.344 (0.09)**	**<.001**	**−0.413 (0.09)**	**<.0001**
Education level					
Panel B	Learning and memory (n = 535)				
	Low education	**−0.268 (0.10)**	**.011**	**−0.262 (0.11)**	**.014**
	Intermediate education	−0.126 (0.11)	.232	−0.126 (0.11)	.235
	Verbal memory (n = 535)				
	Low education	**−0.320 (0.10)**	**.002**	**−0.232 (0.10)**	**.024**
	Intermediate education	−0.074 (0.10)	.478	−0.067 (0.10)	.509
	Spatial working memory (n = 535)				
	Low education	**−0.335 (0.10)**	**.002**	**−0.389 (0.11)**	**<.001**
	Intermediate education	−0.134 (0.11)	.2062	−0.138 (0.10)	.190
	Reaction and movement time (n = 534)				
	Low education	**−0.211 (0.11)**	**.047**	**−0.218 (0.11)**	**.041**
	Intermediate education	0.055 (0.11)	.6065	0.054 (0.11)	.611
	Visual information processing (n = 533)				
	Low education	**−0.395 (0.11)**	**.0002**	**−0.460 (0.10)**	**<.0001**
	Intermediate education	−0.181 (0.10)	.0841	−0.185 (0.10)	.073
	Cognitive flexibility and inhibitory control (n = 493)				
	Low education	**−0.350 (0.11)**	**.0015**	**−0.436 (0.11)**	**<.0001**
	Intermediate education	−0.122 (0.11)	.2671	−0.126 (0.11)	.239

The β estimates (SEs) and *P* values are from linear models. Significant values are in bold type. In the analyses for sex, the values are for females (with males as the reference group), whereas for education level, the values are for low and intermediate education levels (with high education level as the reference group). The following CANTAB cognitive test battery tests were used: learning and memory: PAL test; verbal memory: VRM test; spatial working memory: SWM test; reaction and movement time: RTI test; visual information processing: RVP test; cognitive flexibility and inhibitory control: AST test.