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1 **The Effects of a 2-year Individualized and Family-based Lifestyle Intervention on**
2 **Physical Activity, Sedentary Behavior and Diet in Children**

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28 **Abstract**

29 **Objective:** To investigate the effects of a long-term, individualized and family-based lifestyle
30 intervention on physical activity, sedentary behavior and diet quality in children.

31 **Methods:** We carried out a 2-year intervention study in a population sample of 506 children
32 aged 6-8 years in Finland in 2007-2012. We allocated the participants at baseline in the
33 intervention and control group. We assessed physical activity and sedentary behavior by
34 questionnaires and diet by food records.

35 **Results:** Total physical activity (+9 min/d in intervention group vs. -5 min/d in control group,
36 $p=0.001$ for time*group interaction), unsupervised physical activity (+7 min/d vs. -9 min/d,
37 $p<0.001$) and organized sports (+8 min/d vs. +3 min/d, $p=0.001$) increased in the intervention
38 group but not in the control group. Using computer and playing video games increased less in
39 the intervention group than in the control group (+9 min/d vs. +19 min/d, $p=0.003$).
40 Consumption of vegetables (+12 g/d vs. -12 g/d, $p=0.001$), high-fat vegetable-oil based
41 margarine (+10 g/d vs. +3 g/d, $p<0.001$) and low-fat milk (+69 g/d vs. +11 g/d, $p=0.042$) and
42 intake of dietary fiber (+1.3 g/d vs. +0.2 g/d, $p=0.023$), vitamin C (+4.5 mg/d vs. -7.2 mg/d,
43 $p=0.042$) and vitamin E (+1.4 mg/d vs. +0.5 mg/d, $p=0.002$) increased in the intervention
44 group but not in the control group. Consumption of butter-based spreads increased in the
45 control group but not in the intervention group (+2 g/d vs. -1 g/d, $p=0.002$).

46 **Conclusions:** Individualized and family-based lifestyle intervention increased physical
47 activity, attenuated increase in sedentary behavior and enhanced diet quality in children.

48 **Trial registration.** ClinicalTrials.gov: NCT01803776

49 **Key words:** intervention, children, physical activity, diet, sedentary behavior

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52

53

54

55 **Abbreviations**

56 BMI body mass index

57 BMI-SDS body mass index – standard deviation score

58 PANIC Physical Activity and Nutrition in Children

59

60 Introduction

61 The prevalence of overweight and obesity in children and adolescents has increased in most
62 developed countries, including Finland, during the past decades [1,2,3]. Over 15% of girls
63 and over 10% of boys at preschool or primary school age are overweight or obese in Finland
64 [3,4]. Overweight has been associated with the clustering of cardiometabolic risk factors,
65 including insulin resistance, glucose intolerance, dyslipidaemia, elevated blood pressure,
66 mildly elevated liver enzymes and arterial stiffness in children [5,6,7]. The clustering of
67 cardiometabolic risk factors in childhood has been related to the increased risk of metabolic
68 syndrome, type 2 diabetes and cardiovascular diseases in adulthood [8,9,10,11].

69 Lifestyle changes, such as increasing physical activity, decreasing sedentary behavior and
70 improving diet, since childhood are the cornerstone for the prevention of overweight, type 2
71 diabetes and cardiovascular diseases [12,13,14]. Lifestyle interventions have been rather
72 effective in the treatment of childhood overweight, obesity and other cardiometabolic risk
73 factors in the short term [15], but the effects have been modest in the long-term [16,17]. The
74 reason for the weak long-term effects of these interventions may be that the lifestyle changes
75 have been small or they have not been maintained throughout the intervention period among
76 children with overweight, obesity or other cardiometabolic risk factors.

77 There are few intervention studies on the effects of physical activity and diet on
78 cardiometabolic risk factors in general populations of children [18,19,20,21,22]. Many of
79 these studies have reported little or no effect of lifestyle interventions on cardiometabolic risk
80 factors among children [22,23,24]. The explanation for this may be that few interventions
81 have increased physical activity, decreased sedentary behavior or enhanced diet quality in
82 order to improve health among children [18,19,25,26]. One reason for the modest effects in
83 most studies may be that the intensity and duration of the lifestyle interventions have been
84 insufficient [27,28,29]. Not emphasizing the individual needs of families and parental
85 involvement may also have decreased adherence to the interventions [28,29,30].

86 Scientific evidence from long-term lifestyle intervention studies in large population samples
87 of children is important for developing effective strategies to increase physical activity,
88 decrease sedentary behavior and enhance diet quality in childhood. Such evidence could be
89 used in the prevention of overweight, type 2 diabetes and cardiovascular diseases since
90 childhood. The aim of this study was to investigate the effects of a 2-year, individualized and

91 family-based lifestyle intervention on physical activity, sedentary behavior and diet quality in
92 children.

93 **Methods**

94 *Participants*

95 The present data are from the Physical Activity and Nutrition in Children (PANIC) Study,
96 which is a controlled physical activity and diet intervention study aimed at decreasing
97 cardiometabolic risk in a population sample of children from the city of Kuopio, Finland. We
98 invited 736 children 6–8 years of age who were registered for the 1st grade in the 16 primary
99 schools, selected out of all 26 primary schools of Kuopio, in 2007–2009 (Figure 1). We
100 received the contact information of the children’s principal custodians from the city of
101 Kuopio and sent them the invitation letters by mail. Of the 736 invited children, 512 (70%)
102 participated in the baseline study. According to the school health examination data, the
103 participants did not differ in age, gender distribution or body mass index - standard deviation
104 score (BMI-SDS) from all children who started the 1st grade in the primary schools of
105 Kuopio during years 2007–2009 (data not shown). We excluded 6 children at baseline from
106 the intervention study because of severe physical disability or withdrawal during baseline
107 examinations.

108 We allocated the 506 eligible children to the intervention group (306 children, 60%) or the
109 control group (200 children, 40%) by matching them according to the location (urban vs.
110 rural) and size (large vs. small) of the schools to minimize differences in baseline
111 characteristics between the groups. Children from 9 schools were allocated to the intervention
112 group and children from 7 schools were allocated to the control group. Dividing the children
113 in the intervention or control group according to schools made us possible to organize after
114 school exercise clubs conducted at schools only for the intervention group and to avoid non-
115 intentional intervention in the control group. We included more children in the intervention
116 group than in the control group because of a larger number of drop-outs expected in the
117 intervention group and to have sufficient statistical power for comparison between the
118 groups.

119 Of the 506 children who participated in the baseline study, 440 (87%) also attended in the 2-
120 year follow-up study (Figure 1). The median (interquartile range) follow-up time was 2.1
121 (2.1-2.2) years in both groups. Data on variables used in analyses dealing with physical

122 activity and sedentary behavior were available for 503 children (244 girls, 259 boys) at
123 baseline and for 431 children (210 girls, 221 boys) at 2-year follow-up. Data on variables
124 used in analyses dealing with diet were available for 425 children (208 girls, 217 boys) at
125 baseline and for 391 children (187 girls, 204 boys) at 2-year follow-up.

126 The study protocol was approved by the Research Ethics Committee of the Hospital District
127 of Northern Savo. Both children and their parents gave their written informed consent.

128 *Intervention group*

129 The physical activity and diet intervention aimed at decreasing cardiometabolic risk in
130 children by increasing physical activity, decreasing sedentary behavior and enhancing diet
131 quality. Children and their parents in the intervention group had 6 physical activity
132 counseling sessions of 30-45 minutes and 6 dietary counseling sessions of 30-45 minutes
133 during the 2-year intervention period. The physical activity and dietary counseling sessions
134 were conducted 0.5, 1.5, 3, 6, 12 and 18 months after baseline. The children and their parents
135 received individualized advice from a specialist in exercise medicine and an authorized
136 clinical nutritionist of the study on how to increase physical activity, decrease sedentary
137 behavior and enhance diet quality in children in everyday conditions. Each counseling
138 session had a specific topic of physical activity, sedentary behavior and diet quality according
139 to the goals of the intervention (Table 1) and included practical tasks on these topics for the
140 children. The children and their parents were also given fact sheets on physical activity,
141 sedentary behavior and diet quality, verbal and written information on opportunities to
142 exercise in Kuopio and some financial support for physical activity, such as exercise
143 equipment and tickets for indoor sports. Moreover, the children were encouraged to
144 participate in after school exercise clubs organized as a part of the intervention in all 9
145 intervention schools by the PANIC Study and supervised by trained exercise instructors. In
146 the exercise clubs, the children had the opportunity to learn different kinds of physical
147 activities. The physical activity intervention was based on the Finnish Recommendations for
148 Physical Activity of School-aged Children [31] and the diet intervention was based on the
149 Finnish Nutrition Recommendations [32].

150 *Control group*

151 The children and their parents in the control group received verbal and written advice on
152 health improving physical activity and diet according to the Finnish recommendations [9, 10]
153 but no active intervention at baseline.

154 *Assessment of physical activity and screen-based sedentary behavior*

155 We assessed physical activity and screen-based sedentary behavior during a usual week at
156 baseline and at 2-year follow-up using the PANIC Physical Activity Questionnaire that we
157 have validated in a subsample of children from the PANIC study by the Actiheart[®] monitor
158 [33]. The types of physical activity in the questionnaire included organized sports, organized
159 exercise other than sports, unsupervised physical activity, physically active school
160 transportation and physical activity during recess. The duration of total physical activity was
161 calculated by summing the amount of all types of physical activity. All children in the
162 primary schools of Finland had 90 minutes of physical education per week that was added to
163 the duration of total physical activity. The types of screen-based sedentary behavior in the
164 questionnaire included watching TV and videos, using a computer and playing video games
165 and playing mobile games and was expressed in minutes per day. The duration of total
166 screen-based sedentary behavior was calculated by summing the durations of all types of
167 sedentary behaviors.

168 *Assessment of diet*

169 We assessed the consumption of foods and drinks and the intake of nutrients at baseline and
170 at 2-year follow-up using food records administered by the parents. The consumption of
171 foods and drinks were recorded on consecutive days, including two weekdays and two
172 weekend days, three weekdays and one weekend day or two weekdays and one weekend day
173 [4]. We analyzed the food records and calculated the intake of nutrients using the Micro
174 Nutrica[®] dietary analysis software, Version 2.5 (The Social Insurance Institution of Finland),
175 that utilizes Finnish and international data on the nutrient content of foods [34].

176 *Other assessments*

177 Body height and weight were assessed by trained research personnel. Body height was
178 measured to accuracy of 0.1 cm by a wall-mounted stadiometer in the Frankfurt plane. Body
179 weight was measured to accuracy of 0.1 kg after overnight fasting, empty-bladdered and
180 standing in underwear using an InBody 720[®] device (Biospace, Seoul, Korea). Body mass
181 index (BMI) was calculated by dividing body weight (kg) by body height (m) squared. BMI-
182 SDS was calculated using Finnish references [35].

183 *Sample size calculations*

184 We determined the number of children required to detect at least 0.30 standard deviation
185 difference between the intervention group (60% of children) and the control group (40% of
186 children) with a power of 80% and a 2-sided p-value for the difference between the groups of
187 0.05 allowing for a 20% loss to follow-up or missing data. These power calculations provided
188 a required sample size of at least 275 children in the intervention group and 183 children in
189 the control group.

190 *Statistical analyses*

191 Statistical analyses were performed using the IBM SPSS Statistics[®], Version 21 (IBM Corp.,
192 Armonk, NY, USA). Differences in demographic characteristics and anthropometrics
193 between the intervention and control group at baseline were compared by the T-test for
194 independent samples. We studied the effects of the 2-year intervention on physical activity,
195 sedentary behavior and diet using linear mixed model analysis by entering study group
196 (intervention, control group), time (baseline, 2-year follow-up) and the group*time
197 interaction as fixed factors and participant and school as random effects in the models to
198 account for intra-participant and intra-school correlations between the repeated measures and
199 adjusting data for age and gender. Differences in physical activity, sedentary behavior and
200 diet between the intervention and control group at baseline were also analysed using the
201 linear mixed model. Differences and interactions with the p-values of <0.05 were considered
202 statistically significant. We used the Bonferroni correction for multiple testing in analyses
203 dealing with dietary factors because of the large number of analyses performed. The
204 threshold of statistical significance with the Bonferroni correction was 0.0012 computed as
205 the p-value of 0.05 divided by the number of variables used.

206 **Results**

207 *Baseline characteristics*

208 There were no differences in the gender distribution, age, body height, body weight or BMI-
209 SDS between the intervention and control group at baseline (Table 2). Children in the
210 intervention group had higher levels of organized exercise other than sports (p=0.003) and
211 physically active school transportation (p=0.017) than children in the control group adjusted
212 for age and gender at baseline (Table 3). Children in the intervention group also had a lower
213 consumption of high-fat milk (p=0.013) and a lower intake of vitamin C (p=0.027) than
214 children in the control group adjusted for age and gender at baseline (Table 4).

215 *Effects of intervention on physical activity and sedentary behavior*

216 Total physical activity increased in the intervention group but decreased slightly in the
217 control group (+9 min/d in the intervention group vs. -5 min/d in the control group, $p=0.001$
218 for time*group interaction) adjusted for age and gender (Table 3). Unsupervised physical
219 activity increased in the intervention group but decreased in the control group (+7 min/d vs. -
220 9 min/d, $p<0.001$ for time*group interaction). Organized exercise other than sports decreased
221 more in the intervention group than in the control group (-4 min/d vs. -1 min/d, $p=0.011$ for
222 time*group interaction). Organized sports increased more in the intervention group than in
223 the control group (+8 min/d vs. +3 min/d, $p=0.001$ for time*group interaction). Physically
224 active school transportation decreased in the intervention group but did not change in the
225 control group (-3 min/d vs. +1 min/d, $p=0.015$ for time*group interaction). Using computer
226 and playing video games increased less in the intervention group than in the control group
227 (+9 min/d vs. +19 min/d, $p=0.003$ for time*group interaction).

228 *Effects of intervention on food consumption and nutrient intake*

229 The consumption of vegetables increased in the intervention group but decreased in the
230 control group (+12 g/d in the intervention group vs. -12 g/d in the control group, $p=0.001$ for
231 time*group interaction) adjusted for age and gender (Table 4). The consumption of low-fat
232 milk increased in the intervention group but did not change in the control group (+69 g/d vs.
233 +11 g/d, $p=0.042$ for time*group interaction). The consumption of butter and butter-based
234 spreads decreased slightly in the intervention group but increased in the control group (-1 g/d
235 vs. +2 g/d, $p=0.002$ for time*group interaction). The consumption of high-fat vegetable oil-
236 based margarine increased more in the intervention group than in the control group (+10 g/d
237 vs. +3 g/d, $p<0.001$ for time*group interaction). The intake of dietary fibre increased in the
238 intervention group but did not change in the control group (+1.3 g/d vs. +0.2 g/d, $p=0.023$ for
239 time*group interaction). The intake of vitamin C increased slightly in the intervention group
240 but decreased slightly in the control group (+4.5 mg/d vs. -7.2 mg/d, $p=0.042$ for time*group
241 interaction). The intake of vitamin E increased more in the intervention group than in the
242 control group (+1.4 mg/d vs. +0.5 mg/d, $p=0.002$ for time*group interaction). The
243 interactions between time and group for the changes in the consumption of vegetables and
244 high-fat vegetable oil-based margarine remained statistically significant even after Bonferroni
245 correction for multiple testing.

246 **Discussion**

247 We found that the 2-year individualized and family-based lifestyle intervention aimed at
248 increasing physical activity, decreasing sedentary behavior and enhancing diet quality
249 improved these health behaviors in a population sample of children. Total and unsupervised
250 physical activity increased in the intervention group but decreased in the control group.
251 Organized sports increased more and using computer and playing video games increased less
252 in the intervention group than in the control group. The consumption of vegetables and low-
253 fat milk and the intake of dietary fibre and vitamin C increased and the consumption of butter
254 and butter-based spreads decreased in the intervention group but not in the control group. The
255 consumption of high-fat vegetable oil-based margarine and the intake of vitamin E increased
256 more in the intervention group than in the control group.

257 Previous studies have reported that physical activity decreases with increasing age among
258 children [36], which is in line with the findings in the children of the control group in the
259 present study. However, our lifestyle intervention was successful in that total and
260 unsupervised physical activity and organized sports increased among children in the
261 intervention group, whereas total and unsupervised physical activity decreased in the control
262 group. Total physical activity increased on average by 9 minutes per day in the intervention
263 group but decreased on average by 5 minutes per day in the control group, which corresponds
264 to about one hour increase per week in the intervention group and about half an hour decrease
265 per week in the control group. The difference in the change of physical activity between the
266 intervention and control group in our study was much larger than reported in a systematic
267 review of physical activity intervention studies among children [37]. The increase of physical
268 activity in the intervention group is also notable considering the study population of healthy
269 children 6-8 years of age who typically have relatively high levels of spontaneous physical
270 activity and whose physical activity tends to decline with increasing age [36]. We aimed at
271 increasing total physical activity among children in the intervention group by an
272 individualized and family-based lifestyle intervention and did not focus on any particular type
273 of physical activity. We paid special attention to the individual needs of the families and
274 parental involvement in the intervention and encouraged the children to find the type of
275 physical activity that they enjoyed most.

276 Unsupervised physical activity has decreased more than other types of physical activity
277 among children in developed countries during the last decades [38]. One reason for this trend
278 is that it is nowadays more difficult for children to exercise without supervision because of

279 increased traffic and other environmental risks. These environmental changes have resulted in
280 increased transportation of children to schools by cars. We found that our family-based
281 lifestyle intervention was successful in increasing unsupervised physical activity in children.
282 Moreover, we recently showed that unsupervised physical activity had a stronger inverse
283 association with cardiometabolic risk than other types of physical activity in children [33].
284 This finding emphasizes actions to increase unsupervised physical activity among children.

285 Organized sports increased among children in the intervention group. We informed the
286 children and their parents in the intervention group about the opportunities to engage in
287 organized exercise and sports in the city of Kuopio. Our results suggest that physical activity
288 interventions involving parents help families find a suitable organized sport to attend for
289 children.

290 Physically active school transportation decreased slightly among children in the intervention
291 group, but this change had little effect on the change in total physical activity. Physical
292 activity during recess decreased in the intervention and control group. One explanation for
293 this finding could be that physically active playing decreases during the first school years.
294 Another reason may be that we had a family-based and not school-based intervention and did
295 not particularly aim at increasing physical activity at school.

296 Sedentary behavior has been reported to increase with increasing age in children [36]. We
297 also found that screen-based sedentary behavior increased both in the intervention group and
298 in the control group. The increase in screen-based sedentary behavior corresponds to about
299 three hours per week in the control group and about two hours per week in the intervention
300 group. However, only time spent using a computer and playing video games increased
301 statistically significantly less in the intervention group than in the control group, the
302 difference in the increase being about one hour per week. It may be easier for parents to
303 control their children's computer use and video game playing than other types of sedentary
304 behavior. Whereas all screen-based sedentary behaviors increased among children in our
305 study, some earlier intervention studies have succeeded in reducing screen time among
306 children [39,40,41,42]. One explanation for this difference may be that time spent in screen-
307 based sedentary behaviors in our population sample of Finnish children was shorter than
308 among children in other studies that have primarily been conducted among overweight
309 children or in the U.S.A [39,40,41,42].

310 The increased consumption of vegetables in the intervention group is in line with the findings
311 of some other previous family-based diet intervention studies [43,44]. The increased
312 consumption of vegetables also resulted in the increased intake of dietary fibre and vitamin
313 C. Previous studies have shown that the consumption of fruit and vegetables in children can
314 be increased by improving knowledge on recommendations [45], increasing the consumption
315 of these foods among parents [46] and increasing the availability of them at home [47].
316 Together with these findings our results indicate that interventions that increase parental
317 involvement are effective in increasing the consumption of fruit and vegetables among
318 children.

319 We found that children in the intervention group decreased the consumption of high-fat milk
320 products but increased the consumption of low-fat milk products and high-fat vegetable-oil
321 products. In one earlier diet intervention study, the proportion of high-fat dairy products of all
322 dairy products decreased from 88% to 14% in response to parental dietary counseling [48].
323 Moreover, dietary counseling has been reported to decrease the intake of total and saturated
324 fat among children in other family-based diet intervention studies [49,50,51]. We found
325 however, no differences in the changes of the intake of energy from total, saturated,
326 monounsaturated or polyunsaturated fat between the groups. The intake of vitamin E
327 increased more in the intervention group than in the control group. One explanation for this is
328 that the consumption of high-fat vegetable oil-based margarine that contains more vitamin E
329 than other fat products increased more in the intervention group than in the control group.

330 We found no differences in the change of the consumption of foods that contain lots of sugar,
331 such as sugar-sweetened beverages, dairy products and candies, or the intake of sucrose
332 between the intervention and control group. The results of previous studies also suggest that
333 it is difficult to decrease the intake of sucrose among children [43]. One explanation for these
334 observations may be that the consumption of sugar-sweetened products that are often eaten as
335 snacks is poorly controlled by the parents. Moreover, we found no difference in the change of
336 the consumption of foods containing lots of salt or salt intake between the groups. This
337 observation is also in line with the results of earlier diet intervention studies [52,53].

338 *Study strengths and limitations*

339 The strengths of our study are a relatively large population sample of children, a carefully
340 conducted, individualized and family-based physical activity and diet intervention with a long
341 follow-up, a detailed assessment of physical activity and sedentary behavior and their

342 components and the assessment of food consumption and nutrient intake using food records.
343 A weakness of the study is that we did not randomly allocate the children in the intervention
344 and control group. However, we divided the children into groups by matching them
345 according to the location and size of the schools. This allowed us to perform after school
346 exercise clubs at schools that minimized the non-intentional intervention in the control group.
347 The parents in the intervention group may have misreported their children's health behaviors
348 towards recommendations at 2-year follow-up to please the researchers. However, they may
349 also have misreported the health behaviors at baseline that is a common phenomenon in all
350 lifestyle-related studies. Moreover, some differences in the health behaviors at baseline and
351 follow-up between the groups could be explained by differences in environmental,
352 socioeconomic and sociodemographic factors between the neighborhoods of the city of
353 Kuopio. We therefore controlled for the possible random effect of the schools in the mixed
354 model analyses. We used a questionnaire rather than an objective measure to assess physical
355 activity and sedentary behavior at baseline and 2-year follow-up. The questionnaire was
356 developed for the assessment of health behavior in children and allowed us to assess changes
357 in different types of physical activity and sedentary behavior in our study sample. We have
358 shown that physical activity assessed by the questionnaire is strongly correlated with physical
359 activity assessed by the Actiheart[®] monitor [33].

360 *Conclusions*

361 We found that the 2-year individualized and family-based physical activity and diet
362 intervention increased physical activity, attenuated the increase in sedentary behavior and
363 enhanced diet quality among primary school children. Further investigation is needed to
364 evaluate whether the improved health behavior can be maintained for a longer period of time
365 and whether it reduces cardiometabolic risk among children.

366 **Competing interests:** The authors declare that they have no competing interests

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559 Figure 1. Flow chart of the PANIC Study in children between 2007 and 2012 in Finland.
560 PANIC, Physical Activity and Nutrition in Children.

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Table 1. Goals of physical activity and diet intervention in the PANIC Study between 2007 and 2012 in Finland

Goals of physical activity and diet intervention

- 1) to increase total physical activity by emphasizing its diversity
 - 2) to decrease total and particularly screen-based sedentary behavior
 - 3) to decrease the consumption of foods containing much saturated fat and particularly high-fat dairy and meat products
 - 4) to increase the consumption of foods containing much unsaturated fat and particularly high-fat vegetable-oil-based margarines, vegetable oils and fish
 - 5) to increase the consumption of vegetables, fruit and berries
 - 6) to increase the consumption of foods containing much fiber and particularly whole grain products
 - 7) to decrease the consumption of foods containing much sugar and particularly sugar-sweetened beverages, sugar-sweetened dairy products and candies
 - 8) to decrease the consumption of foods containing much salt and the use of salt in cooking
 - 9) to avoid excessive energy intake
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Table 2. Demographic characteristics and anthropometrics at baseline between 2007 and 2009 in Finland

	Intervention group (n=306)	Control group (n=200)	p-value
Gender			
Girls (n, %)	144 (47.1)	101 (50.5)	
Boys (n, %)	162 (52.9)	99 (49.5)	0.449
Age (y)	7.6 (0.4)	7.6 (0.4)	0.421
Body height (cm)	129 (5.5)	129 (5.9)	0.480
Body weight (kg)	27.0 (4.8)	26.8 (5.3)	0.694
BMI-SDS	-0.16 (1.1)	-0.21 (1.1)	0.632

The data are means (standard deviations) and P-values from the *T*-test for independent samples for continuous variables and from Chi-Square test for sex. BMI-SDS = body mass index - standard deviation score based on Finnish reference values [35].

Table 3. Physical activity and sedentary behavior at baseline study between 2007 and 2009 and at 2-year follow-up study between 2009 and 2012 in Finland

	Intervention group				Control group				
	Baseline n=304	2-year follow-up n=255	2-year change in mean	p-value	Baseline n=199	2-year follow-up n=176	2-year change in mean	p-value	p for time*group interaction
Total physical activity (min/d)	109 (99-118)	117 (107-127)	+9 (+8%)	0.001	109 (97-120)	103 (92-115)	-5 (-5%)	0.085	0.001
Unsupervised physical activity (min/d)	44 (38-50)	51 (45-57)	+7 (+15%)	0.001	54 (47-60)	45 (38-52)	-9 (-16%)	<0.001	<0.001
Organized exercise other than sports (min/d)	8 (6-10)	4 (2-6)	-4 (-48%)	<0.001	4 (1-6)	3 (0-5)	-1 (-26%)	0.318	0.011
Organized sports (min/d)	8 (4-12)	16 (12-20)	+8 (+105%)	<0.001	8 (3-12)	11 (6-16)	+3 (+44%)	0.001	0.001
Physically active school transportation (min/d)	20 (17-23)	18 (15-21)	-3 (-13%)	0.015	15 (11-18)	16 (13-20)	+1 (+10%)	0.252	0.015
Physical activity during recess (min/d)	22 (21-23)	23 (22-24)	0 (+1%)	0.538	22 (21-23)	22 (21-23)	0 (-1%)	0.721	0.505
Screen-based sedentary behavior (min/d)	103 (97-109)	119 (113-126)	+16 (+16%)	<0.001	99 (91-106)	123 (116-131)	+25 (+25%)	<0.001	0.133
Watching television and videos (min/d)	69 (64-74)	75 (69-80)	+5 (+8%)	0.041	68 (62-74)	73 (67-79)	+5 (+8%)	0.093	0.996
Using a computer and playing video games (min/d)	32 (28-36)	41 (37-45)	+9 (+28%)	<0.001	27 (22-32)	47 (42-51)	+19 (+72%)	<0.001	0.003
Playing mobile games (min/d)	2 (1-3)	4 (3-5)	+2 (+79%)	0.009	4 (2-5)	4 (3-5)	0 (+2%)	0.913	0.114

Values are means (95% confidence intervals) of physical activity and sedentary behaviour at baseline and after 2-year follow-up, the 2-year changes in the means and p-values for the differences between the means at baseline and 2-year follow-up from the linear mixed models adjusted for age and gender. Study group, time and their interaction were included as fixed factors into the model and participant and school were included as random effects into the model. The P-values of <0.05 are bolded.

Table 4. Food consumption and nutrient intake at baseline between 2007 and 2009 and at 2-year follow-up between 2009 and 2012 in Finland

	Intervention group				Control group				
	Baseline (n=256)	2-year follow-up (n=231)	2-year change in mean	p-value	Baseline (n=169)	2-year follow-up (n=160)	2-year change in mean	p-value	p for time* group inter- action
Food consumption (g/day)									
High-fibre ($\geq 5\%$) products (g/d)	63 (56-70)	76 (69-83)	+13 (+20%)	<0.001	61 (53-69)	75 (67-83)	+14 (+23%)	0.001	0.864
Low-fibre (<5 %) products (g/d)	112 (102-122)	108 (98-118)	-4 (-4%)	0.367	117 (106-129)	103 (91-114)	-15 (-13%)	0.009	0.151
Potatoes (g/d)	77 (70-84)	76 (69-82)	-2 (-2%)	0.679	79 (71-87)	77 (68-85)	-2 (-3%)	0.642	0.924
Vegetables (g/d)	95 (85-105)	107 (97-117)	+12 (+13%)	0.007	110 (98-121)	97 (86-109)	-12 (-11%)	0.024	0.001
Fruit and berries (g/d)	106 (93-119)	109 (96-121)	2 (2%)	0.697	112 (97-127)	96 (81-111)	-16 (-15%)	0.033	0.059
High-fat ($\geq 1\%$) milk (g/d)	172 (145-198)	98 (71-124)	-74 (-43%)	<0.001	225 (192-257)	188 (156-220)	-36 (-16%)	0.038	0.101
Low-fat (<1 %) milk (g/d)	399 (359-440)	468 (427-508)	+69 (+17%)	<0.001	341 (294-389)	352 (305-399)	+11 (+3%)	0.621	0.042
High-fat ($\geq 1\%$) sour milk products (g/d)	87 (78-97)	65 (56-75)	-22 (-25%)	<0.001	80 (68-92)	66 (54-78)	-14 (-18%)	0.061	0.408
Low-fat (<1 %) sour milk products (g/d)	20 (13-27)	19 (12-26)	-1 (-4%)	0.865	17 (8-25)	17 (8-25)	0 (+1%)	0.979	0.898
Cheese (fat>17%) (g/d)	7 (5-9)	7 (5-9)	0 (-3%)	0.832	8 (6-10)	10 (8-12)	+1 (+17%)	0.179	0.241
Cheese (fat \leq 17%) (g/d)	8 (6-10)	10 (8-12)	+2 (+29%)	0.016	8 (6-11)	8 (5-10)	-1 (-7%)	0.637	0.057
Ice cream and pudding (g/d)	23 (16-29)	23 (17-30)	+1 (+4%)	0.737	30 (23-38)	24 (17-31)	-6 (-21%)	0.045	0.078
Fish (g/d)	16 (13-20)	19 (15-23)	+2 (+15%)	0.214	18 (13-22)	18 (13-22)	0 (-1%)	0.928	0.389
Red meat (g/d)	56 (51-60)	60 (55-64)	+4 (+7%)	0.186	58 (52-63)	63 (57-68)	+5 (+9%)	0.162	0.813
Sausages (g/d)	22 (18-25)	21 (18-25)	0 (-2%)	0.848	22 (18-27)	20 (16-25)	-2 (-9%)	0.417	0.614
Poultry (g/d)	16 (13-20)	22 (19-26)	+6 (+37%)	0.005	18 (14-23)	20 (15-24)	+1 (+6%)	0.658	0.144
Butter and butter-based spreads (g/d)	6 (5-7)	5 (4-6)	-1 (-18%)	0.090	6 (5-7)	8 (7-9)	+2 (+32%)	0.011	0.002
Vegetable oil-based margarine (fat <60 %) (g/d)	4 (3-5)	2 (1-3)	-2 (-55%)	<0.001	4 (2-5)	3 (2-4)	-1 (-22%)	0.190	0.114
Vegetable oil-based margarine (fat 60-80 %) (g/d)	7 (5-9)	17 (16-19)	+10 (+148%)	<0.001	8 (6-9)	10 (8-12)	+3 (+36%)	0.021	<0.001
Vegetable oils (g/d)	4 (4-5)	4 (4-5)	0 (+4%)	0.665	4 (3-5)	4 (4-5)	+1 (+14%)	0.237	0.525
Sugar-sweetened beverages (g/d)	128 (101-155)	139 (111-166)	+10 (+8%)	0.319	145 (113-177)	154 (122-185)	+9 (+6%)	0.496	0.913
Fruit juices (g/d)	33 (22-44)	36 (25-48)	+3 (+10%)	0.547	39 (26-53)	44 (30-57)	+4 (+11%)	0.530	0.919
Sugar and honey (g/d)	10 (9-11)	7 (6-8)	-3 (-31%)	<0.001	10 (8-11)	7 (6-8)	-3 (-28%)	0.001	0.742
Candy (g/d)	21 (17-25)	24 (20-28)	+3 (+14%)	0.130	20 (16-25)	23 (19-28)	+3 (+14%)	0.202	0.983
Chocolate and hot chocolate powder (g/d)	9 (8-11)	11 (9-12)	+1 (+15%)	0.232	9 (7-12)	11 (9-13)	+2 (+21%)	0.161	0.748
Salty snacks (g/d)	4 (2-5)	7 (5-8)	+3 (+76%)	0.009	4 (2-6)	7 (5-9)	+3 (+86%)	0.013	0.784
Energy and nutrient intake									
Energy (kcal/d)	1614 (1564-1665)	1689 (1639-1740)	+75 (+5%)	0.002	1669 (1610-1728)	1679 (1621-1738)	+11 (+1%)	0.719	0.092
Total fat (% of energy intake)	29.6 (28.8-30.4)	31.1 (30.3-31.9)	+1.5 (+5%)	<0.001	30.3 (29.3-31.3)	31.9 (30.9-32.8)	+1.6 (+5%)	0.002	0.907
Saturated fat (% of energy intake)	11.9 (11.5-12.4)	11.7 (11.2-12.1)	-0.3 (-2%)	0.173	12.3 (11.9-12.8)	12.5 (12.1-13.0)	+0.2 (+2%)	0.459	0.150

Monounsaturated fat (% of energy intake)	9.8 (9.6-10.1)	10.9 (10.6-11.2)	+1.1 (+11%)	<0.001	10.0 (9.7-10.3)	10.9 (10.5-11.2)	+0.9 (+9%)	<0.001	0.446
Polyunsaturated fat (% of energy intake)	4.9 (4.7-5.2)	5.8 (5.6-6.1)	+0.9 (+18%)	<0.001	4.9 (4.6-5.2)	5.6 (5.3-5.9)	+0.7 (+13%)	<0.001	0.287
Carbohydrates (% of energy intake)	52.0 (51.1-53.0)	50.5 (49.5-51.4)	-1.6 (-3%)	<0.001	51.6 (50.5-52.6)	50.0 (48.9-51.1)	-1.5 (-3%)	0.002	0.949
Sucrose (% of energy intake)	12.6 (12.0-13.3)	11.2 (10.6-11.8)	-1.4 (-11%)	<0.001	12.7 (12.0-13.4)	11.7 (11.0-12.4)	-1.0 (-8%)	0.004	0.307
Protein (% of energy intake)	16.9 (16.4-17.3)	17.0 (16.5-17.4)	+0.1 (+1%)	0.579	16.8 (16.3-17.3)	16.7 (16.2-17.3)	-0.1 (0%)	0.796	0.581
Fibre (g/d)	14.4 (13.8-14.9)	15.6 (15.1-16.2)	+1.3 (+9%)	<0.001	14.3 (13.6-15.0)	14.5 (13.8-15.1)	+0.2 (+1%)	0.642	0.023
Vitamin C (mg/d)	82.7 (77.0-88.5)	87.2 (81.5-93.0)	+4.5 (+5%)	0.217	93.0 (86.0-100.0)	85.8 (78.9-92.7)	-7.2 (-8%)	0.104	0.042
Vitamin D (µg/d)	5.7 (5.0-6.4)	8.3 (7.6-9.0)	+2.6 (+45%)	<0.001	6.0 (5.2-6.9)	7.9 (7.1-8.8)	+1.9 (+31%)	<0.001	0.071
Vitamin E (mg/d)	6.6 (6.3-6.9)	8.0 (7.7-8.3)	+1.4 (+21%)	<0.001	7.0 (6.6-7.4)	7.5 (7.1-7.8)	+0.5 (+7%)	0.046	0.002
Folate (µg/d)	189 (180-198)	191 (182-199)	+1.8 (+1%)	0.661	196 (18-206)	188 (178-198)	-7.7 (-4%)	0.114	0.134
Sodium (mg/d)	2409 (2335-2482)	2522 (2449-2595)	+113 (+5%)	0.009	2438 (2349-2528)	2560 (2472-2648)	+121 (+5%)	0.020	0.902
Calcium (mg/d)	1161 (1107-1215)	1176 (1123-1230)	+16 (+1%)	0.481	1171 (1108-1234)	1138 (1075-1201)	-33 (-3%)	0.220	0.163
Iron (mg/d)	8.2 (7.9-8.5)	8.5 (8.3-8.8)	+0.3 (+4%)	0.029	8.3 (8.0-8.7)	8.3 (8.0-8.6)	-0.1 (-1%)	0.747	0.100

Values are means (95% confidence intervals) of food consumption and nutrient intake at baseline and after 2-year follow-up, the 2-year changes in the means and p-values for the differences between the means at baseline and 2-year follow-up from the linear mixed models adjusted for age and gender. Study group, time and their interactions were included as fixed factors into the model and participant and school were included as random effects into the model. The threshold of statistical significance with Bonferroni correction is 0.0012 (assuming 42 tests and 0.05 significance). The P-values of <0.05 are bolded.