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Title: Associations of dietary carbohydrate and fatty acid intakes with cognition among children

Year: 2020

Version: Accepted version (Final draft)

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Please cite the original version:

Sehrish, N., Venäläinen, T., Eloranta, A.-M., Erkkilä, A. T., Jalkanen, H., Lindi, V., Lakka, T. A., & Haapala, E. A. (2020). Associations of dietary carbohydrate and fatty acid intakes with cognition among children. *Public Health Nutrition*, 23(9), 1657-1663.

<https://doi.org/10.1017/s1368980019003860>

1 **Associations of dietary carbohydrate and fatty acid intakes with cognition among children**

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| Running title | Dietary intakes and cognition among children |
| Keywords | Diet, fatty acid, carbohydrate, children, brain, cognition |
| Acknowledgement | I acknowledge the work of all authors especially Dr. Haapala and Prof. Timo Lakka for their throughout support in completion of the paper. |
| Financial support | This study was financially supported by grants from the Jenny and Antti Wihuri Foundation, the Sinikka and Sakari Sohlberg Foundation, the Ministry of Social Affairs and Health of Finland, the Ministry of Education and Culture of Finland, the Finnish Innovation Fund Sitra, the Social Insurance Institution of Finland, the Finnish Cultural Foundation, the Juho Vainio Foundation, the Yrjö Jahnsson Foundation, the Foundation for Pediatric Research, the Paavo Nurmi Foundation, the Paulo Foundation, the Diabetes Research Foundation Kuopio, the Kuopio University Hospital (EVO-funding number 5031343) and the Research Committee of the Kuopio University Hospital Catchment Area (the State Research Funding), Yrjö Jahnsson Foundation. |
| Authorship | Naveed S, Lakka TA and Haapala EA were responsible for study design; SN drafted the manuscript and analyzed the data. Venäläinen T, Eloranta AM, Arja T, Jalkanen H, Lindi V, and Lakka TA collected the data and contributed the intellectual content and interpretation of the results. |

Lakka TA is the principal investigator of the PANIC Study.

Conflict of interest

The manuscript has been approved by all authors, and there are no conflicts of interest regarding it.

Ethical Standards Disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Research Ethics Committee of the Hospital District of Northern Savo, Kuopio. Written informed consent was obtained from the parents of all subjects.

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37 **ASSOCIATIONS OF DIETARY CARBOHYDRATE AND FATTY ACID INTAKES WITH**
38 **COGNITION AMONG CHILDREN**

39 **ABSTRACT**

40 **Objective:** To investigate the cross-sectional associations of dietary carbohydrate and fatty
41 acid intakes with cognition in mid-childhood.

42 **Design:** Dietary carbohydrate and fatty acid intakes were assessed using 4-days food records
43 and cognition was evaluated using the Raven's Coloured Progressive Matrices (RCPM)
44 Score. The cross-sectional associations of dietary carbohydrate and fatty acid intakes with
45 cognition were investigated using linear regression analyses adjusted for age, sex, body fat
46 percentage, household income, parental education, and daily energy intake.

47 **Setting:** The baseline examinations of the Physical Activity and Nutrition in Children
48 (PANIC) study.

49 **Participants:** A population-based sample of 487 children (250 boys, 237 girls) aged 6–8
50 years living in the city of Kuopio, Finland.

51 **Results:** A higher dietary intake of fructose (standardized regression coefficient $\beta = 0.24$, $P <$
52 0.001), total fibre ($\beta = 0.16$, $P = 0.02$), and soluble fibre ($\beta = 0.15$, $P = 0.02$) were associated
53 with a higher RCPM score in boys. Other dietary carbohydrates and fatty acids including total
54 carbohydrates, glucose, sucrose, starch, insoluble fibre, total fat, SFAs, monounsaturated fatty
55 acids, PUFAs, palmitic acid (C16), stearic acid (C18), linoleic acid (C18:2), alpha-linoleic
56 acid (C18:3), arachidonic acid (C20:4), EPA (C20:5 n-3), and DHA (C22:6 n-6) were not
57 associated with the RCPM score in boys. Dietary carbohydrates or fatty acids were not
58 associated with the RCPM score in girls.

59 **Conclusion:** Higher dietary fructose and fibre intakes were associated with better cognition in
60 boys, but not in girls. Dietary fatty acids were not related to cognition in boys or in girls.

61

62 **Key words:** Diet, fatty acid, carbohydrate, children, brain, cognition

63 INTRODUCTION

64 Childhood is a period of rapid neural and cognitive development (1,2) that involves the
65 myelination of various brain areas (3,4) and the acquisition of higher order cognitive abilities
66 to regulate goal-directed activity, emotions, and decision-making (5,6). A sufficient quantity
67 and quality of various nutrients, particularly carbohydrates and fatty acids (FAs), are vital for
68 optimal cognitive development in children (7). A modern era has introduced a poor diet
69 quality, including a low intake of fibre and a high intake of refined sugars and saturated fatty
70 acids (SFAs), among children (8). A poor diet quality may impair neural and cognitive
71 development in children (9,10), but such evidence in general population of school-aged
72 children without nutritional deficiencies or learning disabilities is limited (11,12).

73

74 Glucose is the most studied carbohydrate in association with cognition, as it is main source of
75 energy for brain cells (13). The results of previous studies indicate that increased blood
76 glucose after breakfast improves attention, memory, and information processing in
77 preadolescent children (14). A higher total dietary fibre intake has been associated with better
78 verbal memory (15) and higher dietary intake of soluble and insoluble fibre have been linked
79 to better selective attention and inhibition (16) in preadolescent children. Furthermore, a
80 recent cross-sectional study found that a lower dietary intake of simple carbohydrates and a
81 higher dietary intake of fibre were associated with better cognition in preadolescent children
82 (17). However, most of the existing studies on the associations of dietary intakes of
83 carbohydrates with cognition have only assessed blood glucose levels after meals (18,19).
84 Moreover, evidence on the associations of dietary intakes of other carbohydrates with
85 cognition, particularly in children, is limited (15,16).

86

87 A higher dietary intake of SFAs and trans fatty acids and a lower dietary intake of omega-3
88 polyunsaturated fatty acids (PUFAs) have been related to poorer cognition in some (20) but
89 not all (21) cross-sectional studies among children. A meta-analytic study exhibited that
90 omega-3 fatty acid supplements improved cognition in infants but not in older children (22).
91 However, recent dietary (23) and supplementary (24) intervention studies suggest that
92 increased intakes of omega-3 and omega-6 PUFAs and especially increased intakes of
93 eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are linked to improved
94 cognitive skills in children 8–11 years of age. Nevertheless, there is limited knowledge on the
95 associations of dietary intakes of other FAs than EPA and DHA with cognition.

96

97 We investigated the association of dietary intakes of carbohydrates and FAs with cognition in
98 a population sample of school children aged 6–8 years. We hypothesized that higher intakes
99 of fibre and PUFAs and lower intakes of SFAs and refined carbohydrates are related to better
100 cognition in children.

101

102 **METHODS**

103 **Study population and design**

104 The present analyses are based on the baseline data from the Physical Activity and Nutrition
105 in Children (PANIC) Study, that is a controlled physical activity and dietary intervention
106 study in a population sample of children from the city of Kuopio, Finland. We invited 736
107 children 6–9 years of age who started the first grade in 16 primary schools of Kuopio in
108 2007–2009 to participate in the study. Altogether 512 children (248 girls, 264 boys), who
109 accounted for 70% of those invited, participated in the baseline examinations in 2007–2009.
110 The participants did not differ in age, sex, or body mass index standard deviation score (BMI-

111 SDS) from all children who started the first grade in the city of Kuopio in 2007–2009 based
112 on data from the standard school health examinations performed for all Finnish children
113 before the first grade. After excluding children with developmental disabilities and attention
114 deficit hyperactivity disorder, 487 (237 girls, 250 boys) children had complete data used in
115 the analyses.

116

117 **Assessment of dietary intakes of carbohydrates and fatty acids**

118 We assessed energy and nutrient intakes by food records filled out by the parents on four
119 predefined consecutive days (25). Of the food diaries, 99.5% included two weekdays and two
120 weekend days and 0.5% included three weekdays and one weekend day. A clinical nutritionist
121 instructed the parents to record all food and drinks consumed by their children at home, at
122 school, in afternoon care, and elsewhere outside home using household or other measures,
123 such as tablespoons, decilitres, and centimetres. She reviewed the food records at return and
124 completed the records with the parents using a picture booklet of portion sizes (26), if needed.
125 A clinical nutritionist also asked the catering company about the details of food and drinks,
126 such as menus, cooking fat, and spread on bread, served at schools and in afternoon care.
127 Moreover, she disaggregated all prepared foods and mixed dishes into ingredients according
128 to the recipes used. We calculated total energy and nutrient intakes from the collected food
129 record data by using the Micro Nutrica[®] dietary analyses software, Version 2.5 (The Social
130 Insurance Institution of Finland), that utilizes Finnish and international data on nutrient
131 concentrations of foods (27).

132 The current analyses include the daily intakes of energy (kcal), total carbohydrates, glucose,
133 fructose, sucrose, starch, total fibre, soluble fibre, insoluble fibre, total fat, SFAs,
134 monounsaturated fatty acids, PUFAs, palmitic acid (C16), stearic acid (C18), linoleic acid

135 (C18:2), alpha-linoleic acid (C18:3), arachidonic acid (C20:4), EPA (C20:5 n-3), and DHA
136 (C22:6 n-6).

137 **Assessment of cognition**

138 We assessed non-verbal reasoning by using Raven's Coloured Progressive Matrices (RCPM)
139 (28) that was administered by one trained researcher. The RCPM includes three sets of 12
140 items. Each test page includes a large item or a pattern of items and six small items. The
141 children were asked to select the correct small item, which completes the large item or the set
142 of items. The test score was the number of correct answers, ranging from zero to 36.

143

144 **Assessment of body size and composition**

145 A research nurse measured body weight twice the children being fasted for 12 hours and
146 emptied the bladder and standing in light underwear by a calibrated InBody 720[®] bioelectrical
147 impedance device (Biospace, Seoul, Korea) to accuracy of 0.1 kg. We used the mean of these
148 two values in the analyses. A research nurse measured stature three times the children being
149 in the Frankfurt plane without shoes by a wall-mounted stadiometer to accuracy of 0.1 cm.
150 We measured body fat percentage and lean body mass with the Lunar[®] dual-energy X-ray
151 absorptiometry device (GE Medical Systems, Madison, WI, USA) (25,29).

152

153 **Other assessments**

154 The parents were asked to report their annual household income (30,000 €, 30,001–60,000 €,
155 and 60,001 €) and their highest completed or ongoing educational degrees (vocational school
156 or less, polytechnic, and university) in a questionnaire. We used the educational degree of the

157 more educated parent in the analyses. The parents were also asked to report the medically
158 diagnosed developmental disorders and attention deficit-hyperactivity disorder of their
159 children.

160

161 **Statistical methods**

162 We analysed the data using the SPSS Statistics for Windows software, Version 21.0 (IBM
163 Corp., Armonk, NY, USA). We used the Student's t-test and the Chi-Square test to compare
164 basic characteristics between boys and girls and multivariate linear regression analyses
165 adjusted for age, sex, body fat percentage, household income, parental education, total
166 physical activity, and daily energy intake to investigate the associations of the dietary intakes
167 of carbohydrates and FAs with the RCPM score. Because the results of previous studies
168 suggest that the associations of the components of diet quality with cognition are stronger in
169 boys than in girls (11), we conducted the analyses separately for boys and girls. However, we
170 performed the analyses also for all children, because sex did not statistically significantly
171 modify the associations of the measures of diet quality with the RCPM score ($P > 0.05$ for
172 interactions).

173

174 **RESULTS**

175 **Basic characteristics**

176 Boys were taller, had lower body fat percentage, and came from families with higher annual
177 household income than girls (**Table 1**). Boys had a higher daily energy intake and higher
178 intakes of total carbohydrates, sucrose, starch, total fibre, insoluble fibre, and total fat than
179 girls. Boys also had higher intakes of most FAs, except EPA and DHA, than girls (**Table 2**).

180

181 **Associations of dietary carbohydrate and fatty acid intakes with cognition**

182 In all children, a higher intake of fructose was associated with a higher RCPM score (adjusted
183 $r^2 = 0.049$) after adjustment for age, sex, body fat percentage, household income, parental
184 education, total physical activity, and daily energy intake (**Table 3**). This association was
185 slightly weakened after further adjustment for the consumption of fruit and berries ($\beta=0.11$,
186 $p=0.100$). None of the dietary FAs was associated with the RCPM score in all children.

187

188 In boys, higher intakes of fructose (adjusted $r^2 = 0.045$), total fibre (adjusted $r^2 = 0.011$), and
189 soluble fibre (adjusted $r^2 = 0.012$) were related to a higher RCPM score after adjustment for
190 age, body fat percentage, household income, parental education, total physical activity, and
191 daily energy intake (Table 3). Further adjustment for the consumption of fruit juices ($\beta=0.15$,
192 $p=0.02$; adjusted $r^2 = 0.025$) strengthened the association of soluble fibre with the RCPM
193 score. Similarly, further adjustment for the consumption of high-fibre bread ($\beta=0.21$, $p=0.01$;
194 adjusted $r^2 = 0.015$) or fruit juices ($\beta=0.16$, $p=0.02$; adjusted $r^2 = 0.025$) strengthened the
195 association of the intake of total fibre with the RCPM score. However, adjustment for the
196 consumption of fruit and berries ($\beta=0.19$, $p=0.040$) or fruit juices ($\beta=0.23$, $p=0.006$) slightly
197 attenuated the association of the intake fructose with the RCPM score. Similarly, further
198 adjustment for the consumption of fruit and berries ($\beta=0.07$, $p=0.37$) or vegetables ($\beta=0.12$,
199 $p=0.08$) attenuated the association of the intake of total fibre with the RCPM score. Further
200 adjustment for the consumption of fruit and berries ($\beta=0.03$, $p=0.72$), vegetables ($\beta=0.11$,
201 $p=0.12$) or high-fibre bread ($\beta=0.16$, $p=0.03$) attenuated the association of the intake of
202 soluble fibre with the RCPM score. None of the dietary FAs was related to the RCPM score in
203 boys.

204
205 In girls, the intakes of carbohydrates or FAs were not associated with the RCPM score after
206 adjustment for age, body fat percentage, household income, parental education, total physical
207 activity, and daily energy intake (Table 3).

208 **DISCUSSION**

209 We found that higher dietary intakes of fructose, total fibre, and soluble fibre were associated
210 with better cognition in boys but not in girls. However, dietary FAs were not related to
211 cognition in boys or in girls.

212
213 Our finding on the association between a higher dietary intake of fructose and better cognition
214 in boys is in contrast to previous observations on an inverse association between dietary fructose
215 and cognition in adults (30). One reason for these contrasting findings may be that a higher
216 intake of fructose from refined sugars may impair cognitive performance, whereas a higher
217 intake of fructose from natural sources, such as fruits, vegetables, and grain products, may be
218 neuroprotective and support cognitive functions (31–33). We have previously observed in the
219 present study population of children that the carbohydrates were mainly obtained from low-
220 fibre grain products and the main sources of fibre were high-fibre bread and vegetables (25)
221 and that fruit and fruit juice consumption was directly related to cognition (11). Natural sources
222 of fructose, such as fruits, include also other neuroprotective nutrients, such as B vitamins and
223 antioxidants, which may partly explain these observations (32,33). Accordingly, we found that
224 the consumption of fruit and berries partly explained the positive association between dietary
225 fructose and the RCPM score.

226

227 Our observation on the positive associations of dietary total and soluble fibres with cognition
228 in boys is in accordance with few previous findings in children (16) and in older adults (34).
229 We have previously found that a higher consumption of high-fibre grain products was related
230 to better cognition in children (11). A higher intake of fibre may support normal cognitive
231 development, because it has been observed to amplify the effect of neuroprotective brain-
232 derived neurotrophic factor (35). A higher dietary fibre intake has also been associated with a
233 decreased concentration of neuroinflammatory markers, such as interleukin 1 beta and tumour
234 necrosis factor alpha, in the brain (36).

235

236 We found positive associations of dietary fructose and fibre with cognition in boys but not in
237 girls. The results of some previous studies suggest that dietary factors have a stronger effect
238 on brain development in boys than in girls (7,37). Isaacs and co-workers observed that a
239 higher use of protein-enriched formula during infancy was associated with a larger volume of
240 caudate nucleus and intelligence quotient in adolescence among boys but not among girls (7).
241 The explanation of these sexually dimorphic findings is not known, but they may relate to
242 differences in the stage and rate of neural maturation between boys and girls (7). However,
243 few studies have reported their data in boys and girls separately. Therefore, further studies on
244 sex differences in the associations of dietary factors with cognition are warranted.

245

246 We observed no associations of dietary glucose, sucrose, starch, or insoluble fibres with
247 cognition in children. One explanation may be that different carbohydrates have varying
248 effects on diverse types of cognition. Papanikolaou and co-workers found that a carbohydrate-
249 rich meal with a high glycaemic index was associated with deterioration in verbal memory but
250 not working memory, measured by a digit span test, among adults (38). Another study in
251 children showed that working memory was poorer after consuming a meal with a high

252 glycaemic index than after a meal with a low glycaemic index (18). However, neither of these
253 meals had effects on sustained attention (18).

254

255 We found no statistically significant associations of dietary FAs with cognition in children.

256 Our observations are in line with those of some previous studies that the dietary intake or
257 supplementation of FAs had weak if any association with cognitive performance in well-
258 nourished children with no psychological or reading disabilities (12,24,39,40). It is possible
259 that the intake of FAs (25) and the proportion of plasma FAs (41) among children in our study
260 was adequate to support normal development of cognition (6,42).

261

262 The other reason for no associations of dietary FAs with cognition in the present study may be
263 that dietary FAs have different impacts on various cognitive domains. The dietary intake of
264 omega-3 FAs has been directly associated with relational memory but not with item memory
265 in children (20). Furthermore, the dietary intake of SFA has been inversely associated with
266 relational and item-memory in children aged 7–9 years (20,43). The reason for these
267 observations may be that PUFAs, such as omega-3 FAs, have a pronounced positive effect on
268 cognitive functions that are regulated in hippocampus, such as relational memory, whereas
269 SFAs have more global negative effects on memory (43).

270

271 The strengths of the present study include a relatively large population sample of children and
272 valid methods used to assess dietary factors and cognition. The parents were asked to record
273 all food and drinks consumed by their children at home, at school, in afternoon care, and
274 elsewhere outside home on four predefined and consecutive days, including two weekdays
275 and two weekend days, which provides a better view on overall nutrition than using weekdays
276 only. Moreover, a clinical nutritionist reviewed the food records at return and completed the

277 records with the parents using a picture booklet of portion sizes (26), if needed. Our analyses
278 are based on cross-sectional data, and we therefore cannot provide evidence for a causal link
279 between dietary factors and cognition. We neither had dietary data from infancy or early
280 childhood, which are important phases of cognitive development (6) and could therefore have
281 an effect on our results. Furthermore, it would have been optimal to use multiple cognitive
282 tests to study the associations of dietary factors with different aspects of cognition.

283

284 In conclusion, higher dietary intakes of fructose, total fibre, and soluble fibre were associated
285 with better cognition in boys 6–8 years of age. However, dietary fats were not associated with
286 cognition in children. These findings suggest that increasing the consumption of fruit and fruit
287 juices, which are natural sources of fructose, and high-fibre food products, such as grain
288 products, may support normal cognition in boys. Longitudinal studies, and optimally dietary
289 intervention studies, are needed to provide further evidence for the role of dietary
290 carbohydrates and fats in cognition to investigate whether gender modifies the associations of
291 dietary factors with cognition.

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TABLE 1

Characteristics of children.

| <i>Variables</i> | <i>All (n=487)</i> | <i>Boys (n=250)</i> | <i>Girls (n=237)</i> | P value for difference |
|--|--------------------|---------------------|----------------------|-------------------------------|
| <i>Age (years)</i> | 7.6 (0.37) | 7.6 (0.37) | 7.6 (0.39) | 0.23 |
| <i>Height (cm)</i> | 128.7 (5.6) | 129.6 (5.5) | 127.8 (5.6) | 0.001 |
| <i>Weight (kg)</i> | 26.9 (5.1) | 27.2 (4.9) | 26.5 (5.1) | 0.10 |
| <i>Total physical activity (min/day)</i> | 15.8 (5.9) | 16.2 (6.1) | 15.5 (5.7) | 0.24 |
| <i>Body fat percentage (%)</i> | 18.7 (8.2) | 15.0 (8.0) | 20.5 (7.7) | 0.001 |
| <i>Household income (%)</i> | | | | 0.02 |
| <30,000€ | 19.6 | 17.1 | 22.3 | |
| 30,000-60,000€ | 41.9 | 39.0 | 45.0 | |
| >60,000€ | 35.8 | 40.2 | 31.1 | |
| <i>Parental education (%)</i> | | | | 0.10 |
| <i>Vocational school or less</i> | 19.2 | 19.9 | 18.5 | |
| <i>Polytechnic</i> | 44.0 | 37.1 | 51.3 | |
| <i>University degree</i> | 35.6 | 41.4 | 29.4 | |
| <i>RCPM score</i> | 23.9 (5.1) | 23.8 (5.2) | 24.1 (4.9) | 0.57 |

Data are means (standard deviations) from the Student's t-test for continuous variables and numbers (percentages) from the Chi-square test for categorical variables.

Abbreviation: RCPM, Raven's Coloured Progressive Matrices

TABLE 2

Energy and nutrient intakes in children.

| <i>Variables</i> | <i>All</i> | <i>Boys</i> | <i>Girls</i> | <i>P value for difference</i> |
|---|--------------|--------------|--------------|-------------------------------|
| <i>Energy intake (kcal/day)</i> | 1625 (310.0) | 1709(310.6) | 1537 (284.4) | <0.001 |
| <i>Carbohydrate Intake (g/day)</i> | | | | |
| <i>Total carbohydrate</i> | 210.2 (45.7) | 219.6 (47.6) | 200.3 (41.4) | <0.001 |
| <i>Sucrose</i> | 51.2 (19.8) | 53.5 (21.3) | 48.7 (17.7) | <0.001 |
| <i>Glucose</i> | 11.3 (5.0) | 11.7 (5.3) | 11.0 (4.6) | 0.12 |
| <i>Fructose</i> | 9.6 (4.8) | 9.7 (5.2) | 9.5 (4.4) | 0.75 |
| <i>Starch</i> | 96.2 (23.8) | 101.0 (25.2) | 91.1 (21.0) | <0.001 |
| <i>Fibre Intake (g/day)</i> | | | | |
| <i>Total fibre</i> | 14.2 (4.1) | 14.6 (4.3) | 13.8 (3.8) | 0.04 |
| <i>Soluble fibre</i> | 3.3 (1.0) | 3.4 (1.0) | 3.2 (0.9) | 0.20 |
| <i>Insoluble fibre</i> | 6.3 (2.0) | 6.5 (2.1) | 6.0 (1.8) | 0.006 |
| <i>Fat Intake (g/day)</i> | | | | |
| <i>Total fat</i> | 54.6 (14.9) | 57.8 (14.5) | 51.1 (14.5) | <0.001 |
| <i>Saturated fatty acids</i> | 22.1 (7.1) | 23.4 (6.9) | 20.7 (7.1) | <0.001 |
| <i>Monounsaturated fatty acids</i> | 18.1 (5.1) | 19.2 (5.0) | 16.9 (5.0) | <0.001 |
| <i>Polyunsaturated fatty acids</i> | 8.9 (2.8) | 9.5 (3.0) | 8.3 (2.6) | <0.001 |
| <i>Palmitic acid (C16)</i> | 9.0 (3.1) | 9.6 (3.1) | 8.4 (3.1) | <0.001 |
| <i>Stearic acid (C18)</i> | 4.1 (1.6) | 4.4 (1.6) | 3.7 (1.5) | <0.001 |
| <i>linoleic acid (C18:2)</i> | 6.6 (2.4) | 7.0 (2.5) | 6.1 (2.3) | <0.001 |

Table 2 continued

| <i>Variables</i> | <i>All</i> | <i>Boys</i> | <i>Girls</i> | <i>P value for difference</i> |
|--|------------|-------------|--------------|-------------------------------|
| <i>Alpha-linoleic acid (C18:3)</i> | 1.4 (0.5) | 1.5 (0.5) | 1.3 (0.4) | <0.001 |
| <i>Arachidonic acid (C20:4)</i> | 0.09 (0.1) | 0.1 (0.1) | 0.08 (0.1) | <0.001 |
| <i>Eicosapentaenoic acid (C20:5 n-3)</i> | 0.04 (0.1) | 0.04 (0.1) | 0.03 (0.1) | 0.14 |
| <i>Docosahexaenoic acid (C22:6 n-6)</i> | 0.1 (0.1) | 0.1 (0.1) | 0.1 (0.1) | 0.11 |

Data are means (standard deviations) from the Student's t-test.

TABLE 3

Association of dietary intakes with the RCPM score.

| <i>Variables</i> | <i>All children</i> | | <i>Boys</i> | | <i>Girls</i> | |
|---|---------------------|--------------|-------------|--------------|--------------|----------|
| | β | <i>P</i> | β | <i>P</i> | β | <i>P</i> |
| <i>Daily carbohydrate intake (g/day)</i> | | | | | | |
| <i>Total Carbohydrate</i> | 0.15 | 0.09 | 0.21 | 0.10 | 0.07 | 0.55 |
| <i>Glucose</i> | 0.06 | 0.23 | 0.11 | 0.13 | 0.002 | 0.97 |
| <i>Sucrose</i> | 0.04 | 0.50 | -0.002 | 0.98 | 0.08 | 0.33 |
| <i>Fructose</i> | 0.14 | 0.002 | 0.24 | 0.000 | 0.03 | 0.57 |
| <i>Starch</i> | -0.02 | 0.72 | -0.02 | 0.81 | 0.02 | 0.79 |
| <i>Daily fibre intake (g/day)</i> | | | | | | |
| <i>Total fibre</i> | 0.08 | 0.08 | 0.16 | 0.02 | -0.004 | 0.95 |
| <i>Soluble fibre</i> | 0.07 | 0.13 | 0.15 | 0.02 | -0.02 | 0.77 |
| <i>Insoluble fibre</i> | 0.02 | 0.58 | 0.08 | 0.21 | -0.05 | 0.40 |
| <i>Daily fat intake (g/day)</i> | | | | | | |
| <i>Total fat</i> | -0.104 | 0.14 | -0.18 | 0.05 | -0.006 | 0.96 |
| <i>Saturated fatty acids</i> | -0.12 | 0.07 | -0.09 | 0.16 | 0.04 | 0.68 |
| <i>Monounsaturated fatty acids</i> | -0.06 | 0.35 | -0.11 | 0.19 | -0.005 | 0.96 |
| <i>Polyunsaturated fatty acids</i> | -0.02 | 0.61 | -0.01 | 0.88 | 0.04 | 0.55 |
| <i>Palmitic acid (C16)</i> | -0.08 | 0.19 | -0.16 | 0.06 | 0.003 | 0.97 |
| <i>Stearic acid (C18)</i> | -0.07 | 0.19 | -0.11 | 0.14 | -0.04 | 0.52 |
| <i>linoleic acid (C18:2)</i> | -0.02 | 0.72 | -0.01 | 0.86 | 0.01 | 0.85 |
| <i>Alpha-linoleic acid (C18:3)</i> | 0.02 | 0.68 | 0.05 | 0.46 | -0.02 | 0.72 |
| <i>Arachidonic acid (C20:4)</i> | -0.07 | 0.13 | -0.04 | 0.55 | -0.10 | 0.12 |
| <i>Eicosapentaenoic acid (C20:5 n-3)</i> | 0.02 | 0.61 | 0.07 | 0.28 | -0.02 | 0.73 |

Table 3 continued

| <i>Variables</i> | <i>All children</i> | | <i>Boys</i> | | <i>Girls</i> | |
|---|---------------------|-------------|-------------|----------|--------------|----------|
| | β | <i>P</i> | β | <i>P</i> | β | <i>P</i> |
| <i>Docosahexaenoic acid (C22:6 n-6)</i> | 0.02 | 0.66 | 0.08 | 0.20 | -0.04 | 0.51 |

The values are from linear regression models after adjustment for age, sex, body fat percentage, household income, parental education, total physical activity, and daily energy intake. P-values <0.05, indicating statistically significant associations, are bolded.