Introduction

Patterns of breakfast intake among children are a public health concern. Breakfast is one of the principal meals for children since it ends their long nocturnal fast and provides them with the necessary nutrients to face a morning of play and/or studies. Numerous studies have suggested that a deficient breakfast or its omission, even in populations with a good general nutritional status, can interfere with intellectual functions (cognition) and with the normal development of learning in school. Nevertheless, it has yet to be well established which are the metabolic, hormonal, or neurotransmitter factors involved in the relationship between breakfast and cognitive functions.

Abstract

Objectives: Nutritional aspects of breakfast, plasma levels of glucose and β-hydroxybutyrate, body mass index and academic performance have been studied in urban and rural children (Extremadura, Spain).

Methods: Representative samples of schoolchildren (3 to 12 years old, random cluster-sampling in schools).

Results: Children’s mean caloric intake with breakfast was 331 kcal. Rural population ingested more carbohydrates (46.9 ± 12.3% versus 43.3 ± 13.2% of the total caloric intake) and fewer lipids (40.5 ± 11.8% versus 43.9 ± 12.8% of the total caloric intake) than the urban population. Academic performance was significantly better in the children inhabiting the rural zone than in those of the urban zone. The glycaemia was higher in the urban than in the rural children, and that the contrary was the case for the β-hydroxybutyrate values. Neither glucose nor β-hydroxybutyrate levels were correlated with academic performance values. BMI was significantly increased in the urban versus rural children.

Conclusion: The present results emphasize the importance of breakfast and life style in the weight and the academic performance of children.


Original

Breakfast, plasma glucose and β-hydroxybutyrate, body mass index and academic performance in children from Extremadura, Spain

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Resumen

Objetivos: En poblaciones rurales y urbanas de niños de Extremadura, España, se han estudiado aspectos nutricionales del desayuno, los niveles plasmáticos de glucosa y de β-hidroxibutirato, el índice de masa corporal y el rendimiento académico.

Métodos: Se tomaron muestras representativas de los niños (3 a 12 años de edad) aleatoriamente en las diferentes clases de los colegios seleccionados.

Resultados: La ingesta media de calorías en el desayuno fue de 331 kcal. La población rural ingería más carbohidratos y menos lípidos que la población urbana. El rendimiento académico fue significativamente mejor en los niños rurales. En conclusión los resultados presentados enfatizan la importancia del desayuno y el estilo de vida en el peso y en el rendimiento académico de los niños.

depends partly on the life-style of children in a given area and on family traditions. The present study was designed to further explore the relationship between breakfast, overweight and school learning. It was analyzed the nutritional aspects of breakfast, the plasma levels of glucose and β-hydroxybutyrate, and the academic performance in two populations of children, one from an urban area (the city of Badajoz, 150,000 inhabitants, whose principal economical activity is agriculture), separated by 25 km, and both belonging to the Autonomous Community of Extremadura, Spain.

Methods

Representative samples of schoolchildren (3 to 12 years old) were selected in two cities (Badajoz, 150,000 inhabitants, and Olivenza, 10,000 inhabitants, at a distance of 25 km from each other) of the Autonomous Community of Extremadura, Spain, during the 2005-2006 school year. The children were selected by means of random cluster-sampling in schools. At a first stage, one school was selected in each city; at the second stage, the classes and the pupils were selected. Children reported by their parents to be suffering from any chronic disease were excluded from the study.

The study protocol was in accordance with the Helsinki Declaration guidelines and the European and Spanish statutory provisions governing research on human subjects. The research protocol was formally approved by the Research Ethics Committee of the University of Extremadura. The study design was presented to the Board of Governors (Consejo Escolar) of each school, and then a letter containing complete information about the study and securing their written authorization was circulated to the parents of the children invited to participate in the study. The children were given the opportunity to refuse prior to the day of the survey, and their participation in the study was rewarded with a gift. At the school, anthropometry and nutritional data were collected by a field team trained in anthropometry and in the use of an adapted food-frequency questionnaire (FFQ) previously validated in Spain. This team conducted the survey and obtained the relevant information from the children’s parents. The nutrient database software used for the study was that corresponding to the Spanish database. The diagnostic of obesity was base software used for the study was that corresponding information from the children’s parents. The nutrient data.

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<table>
<thead>
<tr>
<th>Table I</th>
<th>Number of subjects, age, blood levels of glucose and β-hydroxybutyrate (β-OHB), academic performance and BMI measured in the studied children</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Total</td>
</tr>
<tr>
<td>Age (years)</td>
<td>78 ± 26</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>187 ± 122</td>
</tr>
<tr>
<td>β-OHB (mmol/l)</td>
<td>0.44 ± 0.8</td>
</tr>
<tr>
<td>Academic performance</td>
<td>3.6 ± 0.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>17.7 ± 47</td>
</tr>
</tbody>
</table>

* P < 0.05; ** P < 0.01; *** P < 0.001.
and the urban children was maintained when the absolute value of carbohydrate consumption was considered (table II). Total fat intake was 42.3 ± 12.2% of the energy intake overall, and was significantly lower (P < 0.05) in the rural (40.5 ± 11.8%) than in the urban (43.9 ± 12.8%) children. With respect to the distribution of the different types of fat, the greater consumption of total fats by the boys was maintained in a greater consumption of all the types of fat, including cholesterol (table II).

The intake of vitamins and minerals during breakfast was similar in boys and girls. The significant differences found in the intake of vitamins and minerals between the rural and the urban groups are given in table III. The breakfast of the rural children contained greater quantities of the vitamins thiamine, riboflavin, niacin, cyanocobalamin, folates, and vitamin D, and of the minerals iron, magnesium, and phosphorus.

Milk was part of the breakfast of 91.0% of the rural and 82.9% of the urban children (fig. 1). A typical breakfast of the children in the study consisted of milk with powdered cocoa and sugar, and a choice of biscuits, breakfast cereals, or bread. Some children (between 7 and 13%) consumed margarine or butter. Almonds, breakfast cereals, or bread. Some children (between 7 and 13%) consumed margarine or butter. Almonds, breakfast cereals, or bread. Some children (between 7 and 13%) consumed margarine or butter.

F<sub>β</sub>Breakfast, plasma glucose and β-hydroxybutyrate, body mass index and academic performance in children...

Discussion

Numerous studies have suggested that children’s intake of nutrients with breakfast contributes to creating a favourable nutritional environment for the learning process and for physical exercise. It is not clear, however, which are the mechanisms that link the nutritional quality of breakfast with cognitive activities in school. The learning process is complex, and depends on a multitude of non-nutritional as well as nutritional factors, including social, emotional, psychological, and life-style factors. In order to obtain more data on this interesting problem, it has been studied two populations of children in the Autonomous Community of Extremadura, Spain, with good nutritional and health status. One group of children were pupils of a school in Badajoz (a city of 150,000 inhabitants, service economy, a more modern life-style, and where most women are solely occupied with household tasks). The other children were pupils of a school in Olienza (town of 10,000 inhabitants, agricultural economy, more traditional life-style, and where most women are solely occupied with household tasks).

The BMI distribution of the sample corresponded to that expected for this population group. Rural children, carrying a most active life style, presented the lower index of overweight and obesity. In the present study was not found any significant correlation between total energy intake with breakfast and overweight. In those children with the lowest energetic breakfast (N = 39; 164.2 ± 31.9 Kcal) was detected a 10.2% of obesity and in that one with the highest energetic breakfast (N = 59; 164.2 ± 31.9 Kcal) was detected a 20.2% of obesity. The levels of glycaemia measured three hours after breakfast were within the normal fasting limits of glycaemia. It was noteworthy that the levels in the urban children were significantly greater (P < 0.001) than in the rural children (table I). There were also significant differences (P < 0.05) in the values of ketone bodies, but this time the values were higher in the rural than in the urban children. Academic performance (arbitrary units) also presented a higher value (P < 0.01) in the rural (3.8 ± 0.4) than in the urban (3.5 ± 0.9) children.

most no child included fruit in their breakfast, whether whole or in juices.

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The vitamin and mineral content of breakfast consumed conform in general to that recommended by most studies. Significant between-group differences were found only in the content of thiamine, riboflavin, niacin, vitamin B12, folic acid, iron, magnesium, and phosphorus between rural and urban children. In general, given the nutritional data and the type of food consumed (fig. 1), the breakfast consumed by the rural children is higher in the urban than in the rural zone. Neither the glucose nor the β-hydroxybutyrate levels were correlated with the values of academic performance. It is possible that this parameter is also influenced by chronic nutritional factors and by the children’s lifestyle15.

Acknowledgements

The study was made possible through a grant from Junta de Extremadura. The generous collaboration of the participating teachers, students and parents of the school “Francisco Ortiz Lopez” of Olivencia and the school “Nuestra Señora de la Soledad” of Badajoz are gratefully acknowledged.

References


Table III

Differences in vitamin and mineral content in breakfast between rural and urban children

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamin (mg)</td>
<td>0.21 ± 0.28</td>
<td>0.22 ± 0.28</td>
<td>0.17 ± 0.17**</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0.52 ± 0.59</td>
<td>0.59 ± 0.53</td>
<td>0.47 ± 0.25**</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>1.7 ± 1.2</td>
<td>2.1 ± 2.2</td>
<td>1.3 ± 1.5**</td>
</tr>
<tr>
<td>Vitamin B12 (µg)</td>
<td>0.62 ± 0.81</td>
<td>0.76 ± 1.1</td>
<td>0.51 ± 0.44*</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>20.3 ± 25.1</td>
<td>24.6 ± 30.1</td>
<td>15.6 ± 19.1**</td>
</tr>
<tr>
<td>Vitamin D (µg)</td>
<td>0.32 ± 0.54</td>
<td>0.43 ± 0.68</td>
<td>0.23 ± 0.39**</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.57 ± 1.2</td>
<td>1.74 ± 1.22</td>
<td>1.19 ± 0.88**</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>43.1 ± 18.7</td>
<td>46.1 ± 19.9</td>
<td>40.8 ± 17.5*</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>261 ± 113</td>
<td>291 ± 127</td>
<td>236 ± 94***</td>
</tr>
</tbody>
</table>

*P < 0.05; **P < 0.01; ***P < 0.001.