MEPI

MESTRADO EM EPIDEMIOLOGIA

UNIVERSIDADE DO PORTO
FACULDADE DE MEDICINA

Ana Sofia Mourão Vilela

Determinants of high energy-dense food consumption among preschool children

Porto, 2012

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DETERMINANTS OF HIGH ENERGY-DENSE FOOD CONSUMPTION AMONG PRESCHOOL CHILDREN

Dissertação de candidatura ao grau de Mestre em Epidemiologia apresentada à Faculdade de Medicina da Universidade do Porto

Orientador: Professora Doutora Carla Lopes
Departamento de Epidemiologia Clínica, Medicina Preditiva e Saúde Pública da Faculdade de Medicina da Universidade do Porto e Instituto de Saúde Pública da Universidade do Porto.

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Ao meu avô

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LIST OF ABBREVIATIONS

ALSPAC - The Avon Longitudinal Study of Pregnancy and Children

BMI – body mass index

DAFNE - Data Food Networking

DALYs – disability adjusted life years

FFQ – food frequency questionnaire

HBSC - The Health Behaviour in School-aged Children study

IOTF – International Obesity Task Force

NDNS - National Diet and Nutrition Survey

NHANES - National Health and Nutrition Examination Survey

SSB – Sugar sweetened beverages

USA – The United States of America

WHO – World Health Organization

RESUMO

Contextualização e objetivos

O consumo de alimentos de elevada densidade energética tem aumentado em todo o mundo, especialmente em crianças. Este aumento resulta de uma intensa globalização da alimentação que ocorreu nas últimas décadas, acompanhando a tendência crescente da prevalência de obesidade. Outros efeitos adversos na saúde têm sido associados a um elevado consumo deste tipo de alimentos, tais como, caries dentárias, diabetes tipo 2, doenças cardiovasculares e até um menor rendimento escolar. A avaliação do desenvolvimento de hábitos alimentares em crianças e os seus determinantes são elementos chave para compreender esta epidemia.

Esta tese pretende estudar os determinantes de consumo de alimentos de elevada densidade energética em crianças de idade pré-escolar. Para responder a esta questão principal dois objetivos específicos foram definidos, resultando em dois artigos:

1. Quantificar a associação entre características socioeconómicas e a estrutura da família e o consumo de alimentos de elevada densidade energética em crianças de 2 anos (artigo I).

2. Avaliar prospectivamente a influência do consumo de alimentos de elevada densidade energética aos 2 anos no consumo de grupos de alimentos específicos e na qualidade alimentar aos 4 anos de idade (artigo II).

Métodos

A informação utilizada foi obtida no âmbito da coorte de nascimento Geração XXI, recrutada entre 2005 e 2006 em 5 unidades de maternidade públicas da área do Porto, Portugal. Após o parto, as mães foram convidadas a participar no estudo. Das mães convidadas, 91.4% aceitaram participar. Um total de 8647 crianças, correspondendo a 8495 mães, foram incluídas na coorte de nascimento.

Quando as crianças tinham 2 anos de idade uma subamostra de 855 crianças e respetivas mães foram convidadas para participarem numa reavaliação.

Aos 4-5 anos de idade o primeiro follow-up da coorte total foi realizado e 86% das crianças (n=7458) foram reavaliadas. A informação foi recolhida em ambos os momentos por entrevistadores treinados, usando questionários estruturados. Os questionários incluíram informação sobre características socioeconómicas dos pais e avós, estado de saúde e estilos de vida da criança. As avaliações antropométricas foram realizadas por

profissionais treinados seguindo procedimentos padronizados. Utilizando informação alimentar recolhida através de questionários de frequência alimentar (QFA) aos 2 e aos 4 anos, foram definidos quatro grupos de alimentos de elevada densidade energética: refrigerantes (bebidas açucaradas carbonadas e outras bebidas açucaradas), doces (chocolate e guloseimas), bolos (com creme e sem creme e pastéis doces) e *snacks* salgados (batatas fritas de pacote, pizza e hambúrguer). Foi também construído, com base no QFA aplicado aos 4 anos, um índice de alimentação saudável para avaliar a adesão a recomendações alimentares da Organização Mundial de Saúde para crianças (2006). Foram obtidos quartis de consumo para grupos de alimentos de interesse e uma pontuação entre 1 e 4 foi atribuída (uma pontuação de 4 foi atribuída ao quartil superior ou inferior de consumo de alimentos saudáveis ou menos saudáveis, respetivamente). A pontuação final variou entre 7 e 25 e foi estratificada pelo valor da mediana (17). Adicionalmente, os grupos de alimentos incluídos neste índice foram também avaliados individualmente utilizando como ponto de corte a mediana de consumo aos 4 anos.

No artigo I as associações entre as variáveis socioeconómicas e os 4 grupos de alimentos de elevada densidade energética (3 categorias: nunca, menos de uma vez por semana e pelo menos uma vez por semana) foram avaliadas através de modelos de regressão logística multinomial [odds ratio (OR) e intervalos de confiança a 95% (IC95%)]. No artigo II as associações entre o consumo dos 4 grupos de alimentos de elevada densidade energética aos 2 anos e o consumo alimentar aos 4 anos (avaliado através de grupos de alimentos e de um índice de alimentação saudável) foram quantificadas através de modelos de regressão de Poisson [razão de taxas de incidência (RTI) e intervalos de confiança a 95% (IC95%)].

Resultados

Artigo I

Após ajuste para potenciais confundidores, uma maior idade e escolaridade materna, uma maior escolaridade dos avós, um rendimento mensal do agregado familiar superior e uma profissão materna mais especializada associaram-se inversamente com o consumo de refrigerantes e doces. Este efeito não foi encontrado entre as características socioeconómicas e consumo de bolos e *snacks* salgados. Ter irmãos mais velhos foi um preditor para um maior consumo de todos os alimentos de elevada densidade energética avaliados. As crianças que eram cuidadas por um infantário ou outros familiares, comparativamente com as que eram cuidadas pelos pais, tinham menor probabilidade de ter um consumo elevado de refrigerantes (OR=0,35, IC95%: 0,17-0,71; OR=0,47, IC95%: 0,24-0,93, respetivamente).

Quando foi avaliado o efeito das características socioeconómicas no consumo de refrigerantes, doces, bolos e *snacks* salgados num só grupo, observou-se uma associação inversa com níveis elevados de idade e escolaridade materna, níveis de rendimento mensal do agregado e escolaridade dos avós. Crianças cujas mães tinham mais que 12 anos de escolaridade tiveram uma menor probabilidade de consumir diariamente este tipo de alimentos aos 2 anos de idade (OR=0,19, IC95% 0,09-0,41) e também aquelas com avós e avôs com mais de 5 anos de educação (OR=0,36, IC95%: 0,19-0,68; OR=0,52, IC95%: 0,29-0,94, respetivamente). Crianças com irmãos mais velhos apresentaram uma maior probabilidade de terem um consumo diário de qualquer alimento de elevada densidade energética (OR=1,92, IC95%: 1,12-3,28).

Artigo II

Em análise multivariada, um maior consumo de alimentos de elevada densidade energética aos 2 anos de idade associou-se com um maior consumo dos mesmos alimentos, aos 4 anos de idade. Foram encontradas associações inversas entre o consumo aos 2 anos de refrigerantes (RTI=0,74, IC95%: 0,58-0,95), *snacks* salgados (RTI =0,80, IC95%: 0,65-1,00) e doces (RTI =0,73, IC95%: 0,58-0,91) e o consumo de fruta e vegetais aos 4 anos de idade. Um consumo semanal e diário de alimentos de elevada densidade energética aos 2 anos, comparativamente com um consumo mensal, associou-se com uma menor ingestão de fruta e vegetais (RTI=0,77, IC95%: 0,59-0,99; IRR=0,61, IC95%:0,44-0,83, respetivamente) e com uma menor pontuação no índice de alimentação saudável aos 4 anos de idade (RTI=0,75, IC95%: 0,58-0,96; RTI=0,56, IC95%:0,41-0,77, respetivamente). Não se encontraram associações estatisticamente significativas entre o consumo de alimentos de elevada densidade energética aos 2 anos e o consumo dos restantes grupos de alimentos aos 4 anos (lacticínios, carne gorda & produtos cárneos e carne magra & peixe).

Conclusões

Uma posição socioeconómica desfavorável, não apenas dos pais mas também dos avós, associou-se com um maior consumo de alimentos de elevada densidade energética aos 2 anos de idade. Adicionalmente, um maior consumo deste tipo de alimentos em idades precoces influencia negativamente a qualidade alimentar dois anos mais tarde, estando particularmente relacionado com uma diminuição do consumo de fruta e vegetais.

Palavras-chave: alimentos de elevada densidade energética; determinantes; crianças pré-escolares; qualidade alimentar.

ABSTRACT

Background and aims

The consumption of high energy-dense foods has increased worldwide, especially among children. This increase results from an intense food globalization occurred in the last decades, tracking positively with obesity prevalence. A high consumption of this type of foods has been also associated with other adverse health effects, such as dental caries, type 2 diabetes, cardiovascular diseases and even lower attainment scores. The evaluation of the development of children's dietary habits and their determinants are key factors to understand this epidemic.

This thesis aims to study determinants of consumption of high energy-dense foods among preschool children. To answer this main question two specific objectives were defined, resulting in two papers:

1. To quantify the association between socio-economic characteristics and family's structure and consumption of high energy-dense foods among 2-year-old children (paper I).

2. To prospectively evaluate the influence of high energy-dense food consumption at 2 years of age on consumption of specific food groups and dietary quality at 4 years of age (paper II).

Methods

Data was obtained from the birth cohort Generation XXI, assembled between 2005 and 2006 at 5 public maternity units, covering the metropolitan area of Porto, Portugal. After delivery, mothers were invited to participate in the study. Of the invited mothers, 91.4% accepted to participate. A total of 8647 children, corresponding to 8495 mothers, were enrolled in the birth cohort.

When the children were 2 years of age a subsample of 855 children and respective mothers were invited to attend a re-evaluation. At 4-5 years of age was conducted the first follow-up of the entire cohort. Overall, 86% of children (n=7458) were re-evaluated at 4-5 years of age. Data was collected by trained interviewers, using structured questionnaires. The questionnaires comprised questions on parental socio-economic characteristics, child's health status and lifestyles. Anthropometric evaluations were performed by trained professionals following standard procedures. Using dietary information gathered through food frequency questionnaires (FFQ) at 2 and at 4 years of age, four groups of high energy-dense food were defined: soft drinks (sweetened carbonated drinks and other sweetened drinks), sweets (chocolate and candies), cakes (creamy and not creamy cakes and sweet

pastry) and salty snacks (crisps, pizza and burger). Based on the 4-years-FFQ it was also constructed a healthy eating index to evaluate the adherence to the World Health Organization dietary recommendations for children (2006). Quartiles of consumption were obtained from food groups of interest, scoring from 1 to 4 (4 was assigned to the upper or lower quartile of healthy or unhealthy food consumption, respectively). The final score ranged from 7 to 25 and was stratified by the median (17). Additionally, the food groups included in the index were evaluated individually using the median of consumption as cut-off point.

In paper I the associations between socio-economic variables and the high energy-dense food groups (3 categories: never, less than once a week and at least once a week) were evaluated through multinomial logistic regression models [odds ratio (OR) and 95% confidence intervals (95%CI)]. In paper II the associations between consumption of high energy-dense food at 2 years of age and food consumption at 4 years of age (evaluated through food groups and a healthy eating index) were quantified through Poisson regression models [incidence rate ratio (IRR) and 95% confidence intervals (95%CI)].

Results

Paper I

After adjustment for potential confounders, increasing maternal age and education, grandparent's education, household monthly income and more specialized maternal occupation were inversely associated with consumption of soft drinks and sweets. This effect was not found between socio-economic characteristics and consumption of cakes and salty snacks. Having older siblings was a predictor factor for a higher consumption of all groups of high energy-dense foods evaluated. Children being taken care by a kindergarten or other family member, comparing to those being taken care by parents, were less likely to have a higher consumption of soft drinks (OR=0.35, 95%CI: 0.17-0.71; OR=0.47, 95%CI: 0.24-0.93, respectively). The effect of socio-economic characteristics on the consumption of soft drinks, sweets, cakes and salty snacks (combined in the same group) was also evaluated and an inverse association was observed with higher maternal age and education, household monthly income and grandparent's education. Children whose mothers had more than 12 years of education were less likely to have a daily consumption of this type of foods at 2 years of age (OR=0.19, 95%CI: 0.09-0.41); the same effect was observed for those whose grandmother and grandfather had more than 5 years of education (OR=0.36, 95%CI: 0.19-0.68; OR=0.52, 95%CI:0.29-0.94, respectively), compared with less educated counterparts.

Children with older siblings were more likely to have a daily consumption of any high energy-dense foods (OR=1.92, 95%CI: 1.12-3.28).

Paper II

In multivariate analysis, a higher consumption of high energy-dense foods at 2 years of age was associated with a higher consumption of the same foods at 4 years of age. Inverse associations between the intake at 2 years of age of soft drinks (IRR=0.74, 95%CI: 0.58-0.95), salty snacks (IRR=0.80, 95%CI: 0.65-1.00) and sweets (IRR=0.73, 95%CI: 0.58-0.91) and the consumption of fruit and vegetables at 4 years of age were found. A weekly and a daily consumption of high energy-dense foods at 2 years of age, versus a monthly consumption, were associated with a lower intake of fruit and vegetables (IRR=0.77, 95%CI: 0.59-0.99; IRR=0.61, 95%CI:0.44-0.83, respectively) and a lower score in the healthy eating index at 4 years of age (IRR=0.75, 95%CI: 0.58-0.96; IRR=0.56, 95%CI: 0.41-0.77, respectively). No statistical significant association was found between high energy-dense food consumption at 2 years of age and consumption of the remaining food groups at 4 years of age (dairies, red meat & meat products and lean meat & fish).

Conclusions

A disadvantaged socio-economic status, from both parents and grandparents, was associated with a higher intake of high energy-dense foods by 2-years-old children. Moreover, a higher consumption of these types of foods at early ages influences negatively the quality of diet 2 years later, namely by a decreased fruit and vegetables intake.

Keywords: High energy-dense food; determinants; preschool children, diet quality.

INTRODUCTION

The Nutritional transition and obesity

The industrial revolution occurred in the last 200 years has introduced radical changes in methods of food production, processing, storage and distribution (1). Additionally, over the past few decades significant changes have taken place in eating habits and home environments (2). The resulting shifts in global dietary patterns led to a world dominated by highly processed diets (3). Dietary habits have shifted in all age groups in the modern societies and seems to be converging to a diet pattern high in saturated fat, sugar and refined foods but low in fibre – often termed the 'Western diet' (4, 5). One example of these shifts is the reduction of water and milk from the diets of children and its replacement with sugar-sweetened beverages (3, 6). Moreover, the world has increased its proportion of intake of food that is sweetened and highly processed and has reduced intake of many key components of a healthy diet, such as vegetables, fruits and legumes (7, 8).

Parallel to these changes in diet and nutrition status (included in the 'nutrition transition'), wide-reaching changes in disease patterns and life expectancy have occurred during the last century. These changes are thought to occur as three separate transition processes. The nutrition transition is closely related to the demographic and epidemiologic transitions. The demographic transition is characterized by a shift from a pattern of high fertility and high mortality to one of low fertility and low mortality (9). On the other hand, the epidemiological transition, first portrayed by Omran (10), described a shift from a pattern of high prevalence of infectious diseases associated with malnutrition, famine and poor environmental sanitation, to a pattern of high prevalence of chronic and degenerative diseases associated with urban–industrial lifestyles. Popkin et al. (11) refers to the nutrition transition occurring in five stages. In figure 3 the last three stages of the nutrition transition are described (11). In stage 3, termed 'receding famine', famine begins to retrocede as income rises, leading to marked shifts in diet. Activity patterns start to shift and inactivity and leisure become part of the lives of more people. Stage 4, 'degenerative disease', is characterized by a diet high in total fat, cholesterol, sugar and other refined carbohydrates, often accompanied by an increased sedentary life. These changes in diet and activity pattern results in increased prevalence of obesity and contribute to the degenerative diseases that characterized the final epidemiological transition stage. In stage 5, a new dietary pattern appears to be emerging as a result of changes in food consumption, associated with the desire to prevent or delay degenerative diseases and prolong health (5, 11).

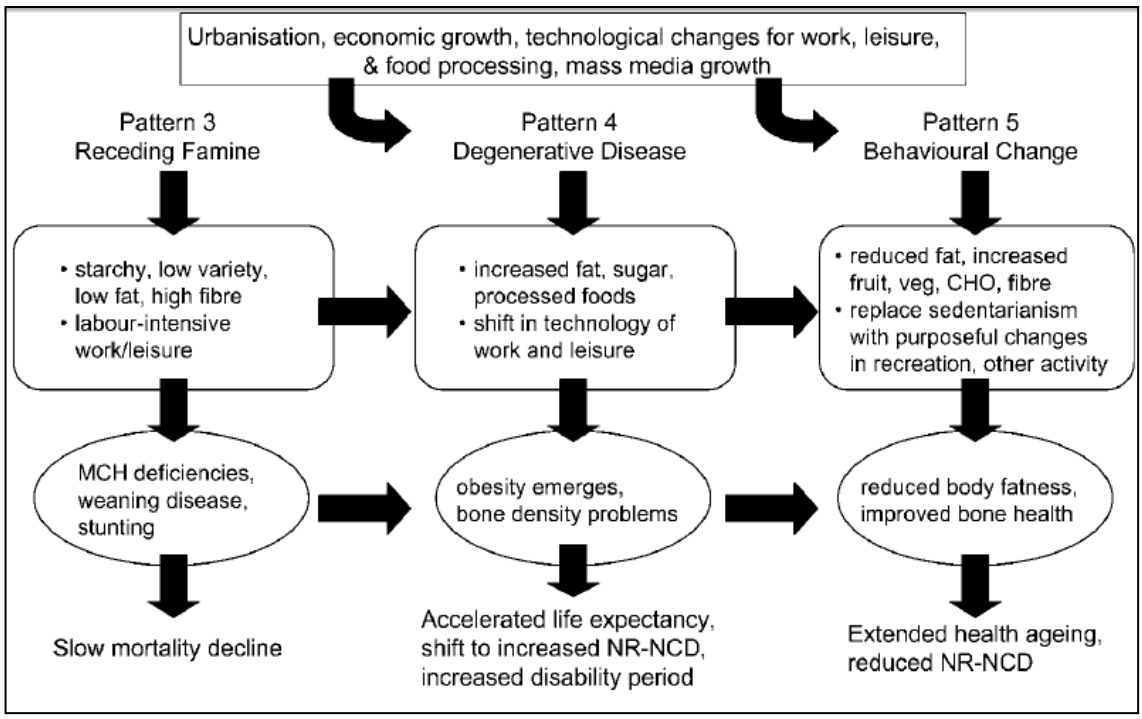

Figure 1. Stages of the nutrition transition (11).

Portugal may be localized between stages 4 (increase in degenerative disease and diet related non-communicable diseases, mainly obesity and type 2 diabetes) and 5 (behavioural change and decreases in diet related non-communicable diseases) of the nutrition transition (12).

All the changes in diet and lifestyles (e.g. increases in intake of energy and sedentary lifestyles) that occurred in the past decades, are believed to be the major driving forces for the obesity epidemic (13).

Obesity has been described by the World Health Organization (WHO) as a “global epidemic” due to its high and increasing prevalence (14). Globally, it is estimated that up to 200 million school-aged children are either overweight or obese, of those 40-50 million are classified as obese (15). Particularly, childhood overweight and obesity seem to be increasing throughout the past two decades worldwide. Among preschool children (<5 years of age), the worldwide prevalence of overweight and obesity, increased from 4.2% in 1990 to 6.7%, in 2010. This trend is expect to reach 9.1%, representing 60 million children, in 2020 (16).

In Europe, according to the International Obesity Task Force (IOTF) the prevalence of childhood overweight and obesity rose from 9% in 1980 to 24% in 2002, five points higher than what was expected based on trends from the 1980s. Particularly, it is estimated that 14

million school-aged children in Europe are overweight and 3 million are obese (17). In Portugal the prevalence of childhood overweight and obesity was described around 21% and 8%, respectively, in 2-6 year-old children and 20% and 11%, respectively, in 7-9 year-old children (18, 19).

Childhood obesity is a complex disease with potentially devastating consequences, including psychological, social and health consequences (20, 21). Poor self-esteem, depression and eating disorders have been associated to childhood obesity (22-25). Moreover, obese children are more susceptible to cardiovascular disease risk factors such as hypertension, dyslipidaemia, chronic inflammation, endothelial dysfunction and insulin resistance (26-32). Particularly, a high prevalence of prediabetic state, consisting of glucose intolerance and insulin resistance, has been described among severely obese children irrespective of ethnic group (33). Pulmonary complications has also been associated to childhood obesity, as obstructive sleep apnoea disorder (34), asthma (35) and reduction of cardiorespiratory exercise function (36). These pulmonary complications could restrict physical activity in obese children and thus contributing for further weight gain or preventing weight loss.

One of the most important long-term consequence of childhood obesity is its persistence into adulthood (37). It is estimated that 50-80% of obese adolescents will remain obese in adulthood (38, 39). Many of the health complications linked to obesity seems to be more severe if the obesity has been present for a long time; early onset obesity was suggested as a risk factor for morbidity and mortality later in life, especially in the development of chronic illnesses, i.e. cardiovascular disease, cancer and type 2 diabetes (40).

Worldwide, at least 2.8 million people die each year as result of being overweight or obese (41). The situation has become so alarming that obesity is predicted to shorten life expectancy of the average American 2 to 5 years, by mid-century, unless aggressive efforts are made to slow this epidemic (42). In addition to previously shown mortality and morbitity information, other indicators such as disability adjusted life years (DALYs) and economic costs should be considered towards a better understanding of the burden of obesity. The DALYs is a measure of overall disease burden, combining the number of years lost due to an early death and the years of healthy life lost due to disability. One DALY represents the loss of one equivalent year of full health. It is estimated that 35.8 million (2.3%) of global DALYs are caused by overweight or obesity (41).The World Health Report described that overweight and obesity are responsible for 8% to 15% of DALYs lost in Europe (43) and it is foreseen a

one-third increase in the loss of healthy life as result of overweight and obesity in 2020 compared with 2000 (43).

Furthermore, the economic costs of obesity are massive (44). The worldwide economic burden of obesity accounts for 0.7% to 2.8% of a developed country's total healthcare expenditures. Moreover, obese individuals, comparing to their normal weight peers, could have greater medical costs up to 30% (45).

The influence of genetic in obesity is clear; data suggest that 60% to 80% of the observed variance in body mass index (BMI) may be explained by genetic factors (46). However, obesity is also an environment disease, our genetic endowments have changed minimally during the last decades, yet prevalence of overweight and obesity in children has greatly increase, which can only be explained by changes in external factors (47). Obesity has been described as a multi-factorial abnormality with a genetic basis which requires environmental influences to manifest (13). The Ecological Systems Theory highlights the importance of considering the contextual influences on childhood obesity, including family and school, which are embedded in the community and society at large (48). Research has suggested that infancy and early childhood may be a particularly sensitive period for predicting obesity later on life (49) and focus should be on early life prevention of overweight and obesity.

A review of systematic reviews (50) appointed as early-life determinants of obesity factors related with genetics (e.g. parental obesity), maternal characteristics (gestational diabetes and smoking), family (socioeconomic status, family size, child care), sleep duration, birth weight and rapid infant growth and levels of physical activity. Furthermore, food consumption was also appointed as important early-life determinant of obesity, highlighting the role of breastfeeding and sugar sweetened beverages consumption.

High energy-dense foods and health

Highly processed food are food generally high in energy but with a low nutrient-dense content (51). The consequences on health of this type of food have been studied through different components. Some studies focus more in foods high in sugar like sugar-sweetened beverages (SSB) (52-54), candies (55, 56), confectionery (57) and chocolate (58-60). Others are more interested in foods with high-fat content like snacks (61) and fast food (62, 63).

Regardless of the type of component chosen to study the effect of these foods, the results are consensual in their adverse effect on health in both children and adults.

Overall, an energy-dense, low-fibre, high-fat diet is associated with higher fat mass and greater odds of excess adiposity in childhood (64). Particularly, greater intake of salty snacks, SSB and increased portion size of snacks have been observed as potential contributors to the daily energy intake (65), and consequently, may play an important role in childhood obesity (66). These effects could be explained by the high energy density and palatability of fat of these foods which may promote excess energy intake (65) and decrease satiating effect (67). Usually, these foods are also high in refined starch and added sugars which have a high glycemic index and a high glycemic load (68). High glycemic load meals seems to induce a sequence of hormonal events that might stimulate appetite for other non-nutrition foods or suppress satiety (69).

Particularly, consumption of SSB may be a key contributor to the epidemic of overweight and obesity because of its high added sugar content, low satiety and incomplete compensation for total energy (67, 70, 71). SSB's consumption seems to have an important role in triggering obesity as a greater intake of these beverages was associated with a more pronounced genetic predisposition to an elevated BMI and an increased risk of obesity, among USA women and men (72). A previous systematic review and meta-analysis (73) found a clear and consistent association between soft drinks consumption and increased energy intake and body weight. Consumption of soft drinks has been associated with an increase of energy intake greater than what could be explained by consumption of beverages alone (73).

More frequent snacking has been also positively associated with increased energy intake and body weight in children (74, 75). Particularly, a systematic review (62) described an association between fast food consumption with increased caloric intake and their trajectory towards weight gain and obesity. Characteristics of fast food associated to excess energy intake or adiposity include massive portion size, high energy density, high palatability, excessive amounts of refined starch and added sugars, high fat content and low levels of dietary fibre (69, 76-78).

Other diseases have been associated with consumption of high energy-dense food. For instance, SSB may also increase the risk of type 2 diabetes and cardiovascular diseases, independently of obesity, as contributor for a high dietary glycemic load and increased fructose metabolism, leading to inflammation, insulin resistance, impaired β-cell

functions (79), and high blood pressure, promoting the accumulation of visceral adiposity, dyslipidemia and ectopic fat deposition (80). In a meta-analysis published in 2010 (53), participants in the highest category of intake of SSB had a 26% and 20% greater risk of developing type 2 diabetes and metabolic syndrome, respectively, than those in the lowest category of intake.

Moreover, a previous study (81) using data collected in the National Health and Nutrition Examination Survey III (NHANES III, 1988-94), among children aged 2-10 years, found that a high consumption of carbonated soft drinks by young children was a risk indicator for dental caries in the primary dentition. Snacking habits (sugar-containing snacks and chips/crisps) has been also associated with caries in pre-school children living in a low-socioeconomic status (82).

The influence of high energy-dense food on health outcomes can be explained also by its influence on other behaviours, such as dietary quality. Children who drink more SSB also tend to eat more fast food and to watch more television (83). Previous studies also showed that consumption of fast food is directly related to total energy intake and inversely related to diet quality (63, 84-86).

Dietary habits are established in early life and can have a significant effect on long term health of individuals (87-89). As mentioned by WHO most of type 2 diabetes cases, 80% of cases of cardiovascular diseases and 30% of all the cases of cancers could be avoided with healthy lifestyle practice, such as, healthier diet and regular physical activity (90). Healthy dietary behaviours of children are important because they promote optimal childhood health, growth and intellectual development (91, 92). For instance, a “junk food” dietary pattern at 3 years of age was inversely associated with the later attainment scores (92). Moreover, diet in childhood influences not only the immediate health of the child but can also impact later health outcomes (93). In addition, behaviour patterns acquired during childhood and adolescence are likely to track into adulthood (94). Therefore, it is important to understand determinants of children’s diet.

High energy-dense food consumption

The consumption of high energy-dense food, particularly SSB, has been increased considerably worldwide, tracking positively with rising obesity prevalence (95).

Nationally representative surveys of food intake in USA children showed large snacking increases in the last decades (96). The largest increases have been in salty snack (crackers, chips, pop corns and pretzels) and candy consumption, while desserts and SSB remain the major sources of calories from snacks (96). Children aged 2-6 years accounted for the highest amount of snacks per day and the largest increase from 1977 to 2006 (approximately 1.41 events more) (96). Among children aged 2-5 years, per-capita daily caloric contribution from SSB increased from 107 kcal/day in 1988-1994 to 124 kcal/day in 1999-2004 (6).

In Europe, a review (97) of data on food consumption of Southern European's adolescents showed a frequency of eating out in fast food restaurants much lower than in the USA and some Nordic countries. The National Diet and Nutrition Survey (NDNS) of young people aged 4-18 years, the largest and most detailed survey conducted to evaluate the diet and nutritional status of young people in Britain, included, among other information, a seven-day weighed intake dietary record of foods and beverages consumed inside and outside the home (98). Eighty percent of children aged 4-6 years were consuming savoury snacks, potato chips and chocolate confectionery at least once a week. Carbonated soft drinks were the most popular drink, with three-quarters of the group consuming standard versions and less than half drinking low calorie versions (99).

The Health Behaviour in School-aged Children (HBSC) study is a WHO-coordinated project multicentre collaborative survey on lifestyle factors and health behaviour determinants in young people (100). It is carried out every four years in a growing number of European countries (including Portugal), Canada and the USA and has been monitoring the health and well-being of young people aged 11, 13 and 15 years since 1982 (100). Among many other relevant topics, a module of dietary habits has been incorporated in the study. The surveys carried on in 2001/2002 and 2005/2006 found a daily consumption of soft drinks among 11-year-old ranging from 4% in Finland to 50% in Bulgaria (101). Almost one third of the children eat sweets or chocolate on a daily basis (102). In Portugal the daily frequency was of 21% for girls and 30% for boys of soft drinks and around 20% for sweets (101, 102).

In Portugal the only Portuguese National Dietary Survey was carried out in 1980 and its results are out of date. Therefore, Portugal has no representative data on its dietary habits at individual level. One good alternative for nutritional purposes is the information obtained through household budget surveys, which are carried out every 5 years in Portugal.

Figure 1 presents information of availability of some high energy-dense food in Portugal, data obtained in the Data Food Networking (DAFNE) databank project (103). An increase of availability of soft drinks, bakery and sugar products is showed. The highest increase was found for soft drinks, with an increase of 44 ml availability per person and per day, between 1990 and 2000. Another previous analysis (104), using the same data, reported an increase of 76% of non-alcoholic beverages' availability (including soft drinks) in Portugal, between 1990 and 2000.

However, when we compare the Portugal's mean availability of soft drinks with other European countries (figure 2), Portugal has one of the lowest quantity per person and per day.

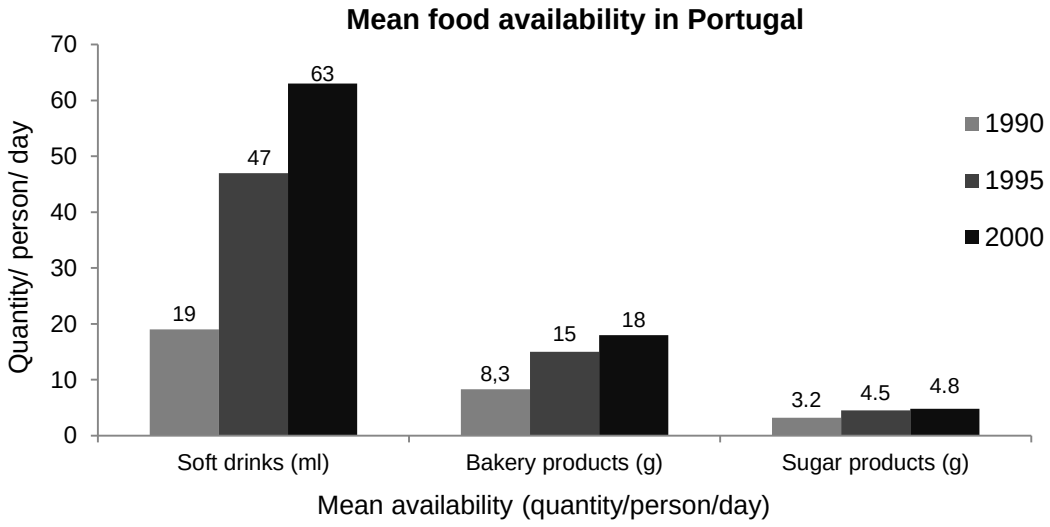

Figure 2. Average per capita of availability of soft drinks, bakery and sugar products, in Portugal in 1990, 1995 and 2000.(Source: the DAFNE databank).

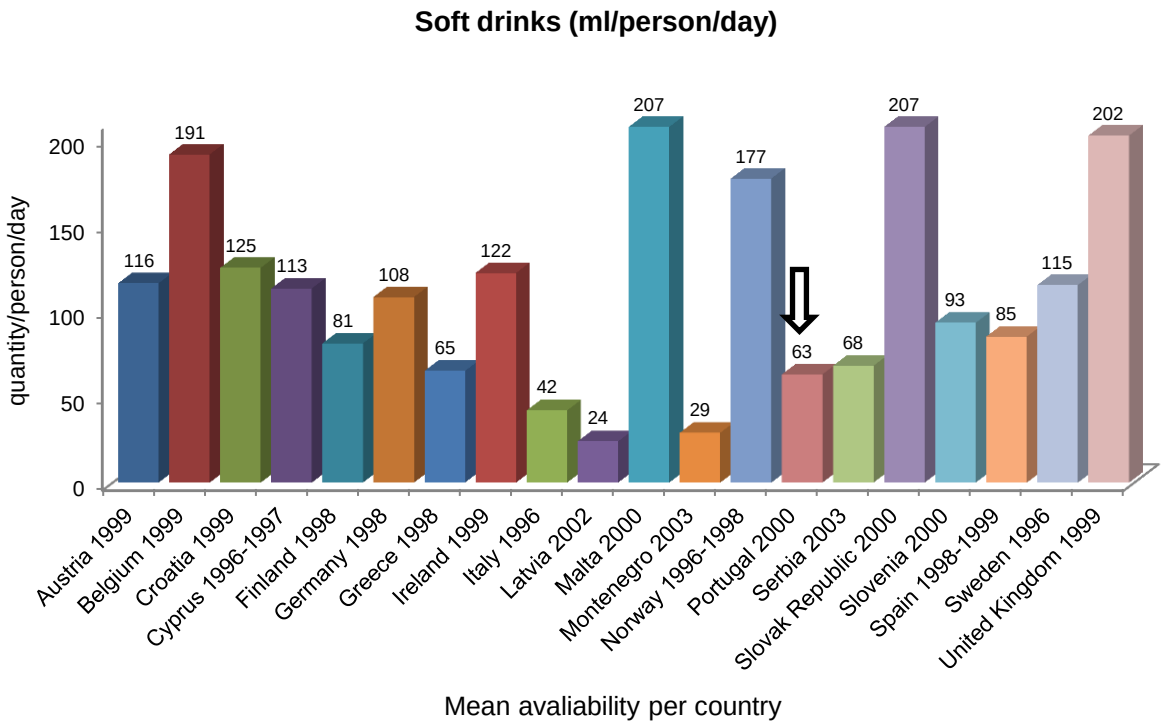

Figure 2. Average per capita of availability of soft drinks in Europe during the 1990s. Source: the DAFNE databank.

Determinants of children's food habits

Children develop their eating habits as they grow (105). Determinants of eating habits are complex, may interact and could also change throughout life, especially during childhood. In early years of life, parents have a central role in shaping the family's food environment and eating experiences (106). As providers of the children's food, family members are also relevant role models and establish rules and norms related to food and eating practices. Older children, in contrast, have greater autonomy over their food intake and progressively start making their own choices (107). Therefore, as children grow and start school, teachers, peers and other people at school as well as media and social leaders became more important (108).

Eating behaviour has been conceptualized as a function of individual and environmental influences (109). The family socio-demographic background seems to have a high impact on child's diet. Low maternal educational and age and unfavourable working

conditions have been associated with unhealthy child's dietary intake (110, 111). Parents who are overweight or who are concerned about their children's risk for overweight/obesity may adopt inadequate child-feeding practices (112). Parental influences can be transmitted directly through the offered food, and indirectly, through transmission of behavioural models and social norms to the child (113, 114). Factors in early life, such as the relationship between birth weight and gestational age have been associated with chronic diseases later in life, such as obesity, cardiovascular diseases and type 2 diabetes (115-118). Early diet could be one part of the explanation for these associations as low or high birth weight could influence early food preferences or change the way parents feed their children. Additionally, a previous study (119) showed an inverse association between birth weight and saturated fat intake among 43-month-old children.

There have been several studies conducted with the objective of accessing the adverse effects of high energy-dense food consumption in adults and children but much less has been studied regarding the determinants of consumption, particularly in young children.

A previous study (120), which aimed to determinate socio-demographic predictors of added sugar intake in a national representative sample of North American 2 to 5-year-old children, found an inverse association between the household income and education level of the female head of household and the children's sugar intake. Moreover, having more than two children within the family, low maternal educational and unfavourable working conditions were all associated with a higher excess of high energy-dense food intake (including sweet and savoury snacks, sweetened beverages and French fries*)*, among Flemish preschoolers children (110).

Among the cohort studies, stands out the research carried on in the English birth cohort *The Avon Longitudinal Study of Pregnancy and Children* (ALSPAC), an on-going longitudinal cohort study designed to investigate the health and development of children (121). Within this cohort it was studied the correlation between some socio-demographic characteristics and dietary patterns among 3-year-old children (122). The authors conducted a principal component analysis and the first component obtained (called "junk") had high positive loading for snacks foods such as crisps, sweets and chocolate and also foods higher in fat, such as pizza, chips and burgers. The children with higher scores in this pattern were the ones with younger and less educated mother, with a smaller income and with older siblings (122). Furthermore, at 4 and 7 years old it was also found a component describing a diet based on junk type food with high fat processed foods and high in sugar. At both time points, the junk pattern was positively associated with the number of older siblings the child

had, decreasing levels of maternal education and age and being a boy (111). A recent study (123) also reported an association between socioeconomic status and intake of soft drinks among Canadian preschool children.

Most of the studies which evaluated determinants of high energy-dense foods in school aged children and less research has been performed among young preschool children. Moreover, few studies have been conducted in children from Southern Europe where consumption has been increasing and where a higher variability in exposures is expected. More research is need on evaluation of food habits through childhood using prospective approaches, to be able to intervene early in life.

AIMS

This study aims to evaluate determinants of consumption of high energy-dense food among Portuguese preschool children. To answer this main objective, data was used from a Portuguese birth cohort (Generation XXI) and the following specific objectives were defined and pursued, resulting in two papers:

1. To quantify the association between socioeconomic characteristics and family's structure and the consumption of high energy-dense food among 2-year-old children (paper I).

2. To evaluate prospectively the influence between the consumption of high energy-dense foods at 2 years of age and the consumption of specific food groups and dietary quality at 4 years of age (paper II).

PAPERS

Paper I

Socioeconomic determinants of high energy-dense food consumption among two-year-old children

Abstract

Background: Adverse effect on heath has been described for a high consumption of high energy-dense food, among children and adults. Studies conducted mainly among school-aged children showed a great influence of socioeconomic characteristics on children's food habits. Limited research has been performed among young preschool children.

Objective: To evaluate the association between different socioeconomic characteristics and consumption of high energy-dense foods among 2-year-old children.

Methods: The sample includes 808 2-year-old children (49.4% girls) from the Portuguese birth cohort Generation XXI. Data was obtained from questionnaires administered by interviewers to parents/caregivers at birth and at 2 years of age. Four groups of high energy-dense foods were defined based on food frequency questionnaires: soft drinks (sweetened carbonated drinks and other sweetened drinks), sweets (chocolate and candies), cakes (creamy and not creamy cakes and sweet pastry) and salty snacks (crisps, pizza and burger). Categories of consumption were classified as 'at least once a week', 'less than once a week' and 'never'. Multinomial logistic regression models [odds ratio (OR) and 95% confidence intervals (95%CI)] were performed to evaluate association between socioeconomic variables and consumption of high energy-dense food.

Results: Moderate weekly frequencies of consumption were found for soft drinks (37.5%) and sweets (50.9%). High energy-dense food was consumed daily by 32% of the 2-year-old children. Increasing maternal age and education, grandparents' education and household monthly income and also more specialized maternal occupation were all inversely associated with consumption of soft drinks and sweets. Having older siblings was associated with a higher consumption of all the high energy-dense food evaluated. This effect was not found between socioeconomic characteristics and cakes and salty snacks. Children being taken care of by a kindergarten or other family member, comparing to those being taken care of by the parents, were less likely to have a consumption of at least once a week of soft drinks (OR=0.35, 95%CI: 0.17-0.71; OR=0.47, 95%CI: 0.24-0.93, respectively). No association was found between socioeconomic characteristics and a consumption of cakes and sweets lower than once a week. Higher levels of maternal age and education, higher levels of household monthly income and grandparent's education were associated with a lower intake of soft drinks, sweets, cakes and salty snacks combined in the same group. Children with older siblings were more likely to have a daily consumption of any high energy-dense food (OR=1.92, 95%CI: 1.12-3.28).

Conclusions: Independent associations were observed between a better socioeconomic status and a lower consumption of high energy-dense food by 2-year-old children, mainly soft drinks and sweets. This influence is not only from parents' background but also from the preceding generations.

Keywords: High energy-dense foods; socioeconomic determinants; preschool children

Introduction

Adverse effects of high energy-dense foods on health, in both children and adults, were previously described (1-3). Results from a systematic review (1) supported a link between the consumption of sugar sweetened beverages (SSB) and the risk of overweight and obesity in children and adults. Other systematic review (3) published in 2008, found an association between fast food intake and weight gain and obesity. Besides obesity, other multifactor diseases have been associated with the consumption of these types of foods. In 2010 a meta-analysis (2) reported that participants in the highest category of SSB's intake had a 26% and 20% greater risk of developing type 2 diabetes and metabolic syndrome, respectively, compared to those in the lowest category of intake.

Low socioeconomic position has been associated with inequalities in health such as increases in disease burden in later life (4, 5). It is possible that these inequalities are explained to some extent by certain dietary practices, which has been shown to vary with socioeconomic status (6, 7). Moreover, studies among North American and European children showed an important impact of parental characteristics on child's diet, mainly socioeconomic characteristics. Positive associations were described between parents' low socioeconomic status and consumption of high energy-dense food among children, particularly low levels of income, unfavourable working conditions and low levels of maternal education (8-12). Also, children of non-smokers and more highly educated mothers tend to have a healthier diet (13). Moreover, the structure and size of the family influence children's diet: having more than two children and/or older siblings was also positively associated with a higher intake of this type of foods among children (10-12). Grandparents seem also to influence in some extent the eating habits of the children (14).

Food habits and particularly consumption of unhealthy food, among children, are influenced to a great extent by parental socio-demographic characteristics. Mostly of the studies which approach these topics in children focus in school-aged children and limited research has been conducted among young preschool children. It is likely that determinants of eating habits vary across age groups (15). In early years of life, parents have a more central role in shaping the family food environment and eating experiences (16). Older children, in contrast, have greater autonomy over their food intake and progressively start making their own choices (17). These discrepancies may result in different risk factors for consumption of high energy-dense food through childhood. Therefore, this study will evaluate the association of different socioeconomic characteristics on consumption of high energy-dense foods among 2-year-old children. The use of a prospective approach will give a better insight of what determinate consumption of unhealthy food in early life. Identify groups with

poor habits as early as possible in the life course allows intervening as soon as possible, resulting in meaningful changes on long term health.

Methods

Study design

The present study is based on Generation XXI - the first prospective Portuguese population-based birth cohort, which has been described previously (18, 19). A total of 8647 children and 8495 mothers were enrolled during 2005-2006 at 5 public maternity units covering the metropolitan area of Porto, Portugal. Of the invited mothers 91.4% accepted to participate. At 2 years of age a subsample of 855 children was re-evaluated. Data was collected by trained interviewers using structured questionnaires that gathered information on parents' demographic and social conditions, child health status, health care system, type of caregiver, lifestyles (including eating habits and physical activity) and anthropometric measures.

The present study sample included 808 children re-evaluated at 2 years of age with complete information on food consumption. Moreover, only data from singletons was included.

Data Collection

Food consumption

Information on consumption of high energy-dense food at 2 years of age was gathered through a qualitative food frequency questionnaire (FFQ) administered by trained interviewers. Parents and/or caregivers were asked on how many times his/her child was currently consuming each food item (e.g. sweetened beverages, chocolate and pizza) and answers were on a six-point scale, ranging from 'never' to 'every day'. Daily consumption frequencies were calculated, and the conversion were the following: 'every day' as 1 time per day, '3-6 per week' as 0.707 times per day, '1-2 per week' as 0.214 times per day, '1-3 per month' as 0.067 per day, 'less than once a month' as 0.017 times per day and 'never' as 0.

For the present analysis, 4 high energy-dense food groups were defined: soft drinks (sweetened carbonated drinks and other sweetened drinks), salty snacks (crisp, pizza and burgers), cakes (creamy cakes or not, including sweet pastries) and sweets (chocolate and candies, including lollipop, gum and chewing gum). The frequency of consumption was categorized as 'at least once a week', 'less than once a week' and 'never'.

Co-variables

At baseline data was collected within 72 hours after delivery, during the hospital stay, in face-to-face interviews. Clinical records were also reviewed at birth to retrieve data on complications of pregnancy, birth weight and gestational age of the newborn. The following characteristics were obtained at baseline: child's sex, mothers' birth date, maternal education level (≤6, 7-9, 10-12, 13+ years); maternal working condition, defined as professional occupations, non-manual skilled occupations, manual and skilled occupations and others (housewife, student, unemployed); and the monthly household income (≤1000, 1001-1500, 1500+ euros). Maternal grandparents' education was evaluated at baseline by asking the mother what was the high level of education achieved by her parents (≤5, >5 years). The pre-pregnancy weight of the mother was obtained by recall information to the nearest 0.1 kg. At baseline, mother's height was measured (without shoes) by the interviewers to the nearest 0.1 cm. When measurement was not possible, height was reported by the mother as registered in the identity card. Mothers' body mass index (BMI) was categorized using World Health Organization (WHO) (20) reference data and re-categorized into normal <50 kg/m2, and overweight/obese ≥25.0 kg/m2. Child's gestational age was defined based on ultrasound and if not available, it was based on last menstrual period. Body height was measured to the nearest tenth of a kilogram using a digital scale. Birth weight and gestational age were used to define small for gestational age (SGA) and large for gestational age (LGA) as $<10^{th}$ and $>90^{th}$ percentile, respectively, of sex-specific Kramer growth charts (21), while adequate for gestational age (AGA) was estimated to be within those thresholds.

The evaluation at 2 years of age was also conducted using face-to-face interviews. The following variables, obtained from the 2-year-old re-evaluation, were used in the present analysis: child's current caregiver (parents, other family, kindergarten and babysitter/others) and siblings (none, younger, older). It was considered the age of the mother at 2-year-old re-evaluation, calculated using birth date and interview's date (<30, 30-35, 35+ years of age at 2-year evaluation).

Ethics

The project Generation XXI was approved by the Ethical Committee of São João Hospital/ University of Porto Medical School and complies with the Helsinki Declaration and the current national legislation. The project was approved by the Portuguese Authority of Data Protection. Legal representatives of each participant were informed about the benefits and potential discomfort and written informed consent was obtained for the collection of information at baseline and re-evaluations.

Statistical analysis

Continuous variables were compared through student's t-test. Categorical variables were compared with the chi-square test.

After categorization of the outcome variables, the associations between socioeconomic variables and food consumption (3 categories: at least once a week, less than once a week and never) were obtained by using multinomial logistic regression models [odds ratio (OR) and 95% confidence intervals (95%CI)]. All potential variables were examined to estimate the independent associations between food consumption and determinants. Education, maternal occupation and household monthly income were entered separately in the final model due to potential co-linearity effects between the variables.

Analyses were performed using SPSS 20.0 software (SPSS INC. 2011, Chicago, Illinois, USA).

Results

Table 1 shows the differences between the study sample and the remaining cohort. No statistical significant differences were found regarding the child's sex. However, significant differences were found for the socio-demographic characteristics. Mothers included in the present sample were slightly older (30.4 years, SD=5.10 vs. 29.4 years, SD=5.51, $p<0.001$) and more educated (11.1 years, SD=4.25 vs. 10.4 years, SD=4.25, $p<0.001$).

The consumption of high energy-dense foods according to three frequency categories is shown in figure 1. Sweets were consumed at least once a week by half of the 2-year-old children. Most of the children consumed cakes and salty snacks less than once a week. Soft drinks were consumed at least once a week by 37.5% of the children.

Thirty-two percent of the children had a daily consumption of any high energy-dense food (7.8% of soft drinks, 14.1% of sweets, 1.4% of cakes and 0.2% of salty snacks)

Table 2 and 3 present the crude and adjusted associations between socioeconomic variables and consumption of each energy-dense food.

After adjustment, increasing maternal age and education, grandparents' education and household monthly income and also more specialized maternal occupation were all associated with a lower consumption of both soft drinks and sweets. A significant association of socioeconomic variables was not found with cakes or salty snacks. Having older siblings was positively associated with a consumption of at least once a week of soft drinks

(OR=2.00, 95%CI: 1.24-3.20), sweets (OR=2.52, 95%CI: 1.44-4.41), cakes (OR=1.75, 95%CI: 1.02-2.99) and salty snacks (OR=1.78, 95%CI: 1.02-3.10), comparatively to children with no siblings. Children being taken care of by a kindergarten and other family member than the parents were less likely to have a consumption equal or higher than once a week of soft drinks, comparing to children being taken care of by parents (OR=0.35, 95%CI: 0.17-0.71; OR=0.47, 95%CI: 0.24-0.93, respectively). Being a girl was positively associated with a frequency of sweets consumption equal or higher than once a week (OR=1.63, 95%CI: 1.01-2.64). Children of mothers with a non-manual/skilled occupation or unemployed, students or domestic were more likely to have a consumption lower than once a week of salty snacks (OR=1.81, 95%CI: 1.08-3.03; OR=2.93, 95%CI: 1.24-6.93, respectively). After adjustment, a consumption of cakes and sweets lower than once a week was not significantly associated with any socio-demographic variable.

Table 4 presents the association between socioeconomic characteristics and a weekly and daily consumption of any high energy-dense food. Higher levels of maternal age and education, household monthly income and maternal grandparents' education were associated with a lower consumption of this type of foods. Presence of older siblings was associated with a daily intake of high energy-dense foods (OR=1.92, 95%CI: 1.12-3.28).

Discussion

The frequency of consumption of high energy-dense foods (soft drinks, sweets, cakes and salty snacks) found in our sample was globally lower than the frequency described in other developed countries (22, 23). In 2008 a survey was conducted in a national random sample of US children from birth up to age of 4 year. The daily frequency of consumption, obtained from 24h dietary recalls, among 21-23.9 month-children, was of: sweetened beverages, 38.2%; candy, 31.8%; cake, 2.5%; pizza, 12.4% and salty snacks, 23.7% (22). The results from the National Diet and Nutrition Survey (NDNS), designed to be representative of the UK population (2008-09), showed a higher median intake per day, among children aged 4-10 year, of soft drink (86g), buns, cakes, pastries and fruit pie (16g), sugar, preserves and confectionery (10g) and crisps and savoury snacks (boys, 7g and girls 10g) (23).

Even though the frequency of consumption is different in our sample the same pattern was found, since sweetened beverages and candies/sweets were the most consumed among the studied food groups. Moreover, in 2006 the American Heart Association highlighted that between 2 and 6 years of age, sweetened beverages and other snacks high in sugar are a major source of caloric intake (24).

In the present study, higher levels of maternal age, education and occupation and also higher levels of household monthly income were inversely associated with consumption of most of the high energy-dense food studied, which resonate with findings of previous studies among older children. Research carried out with data from the English birth cohort ALSPAC (25), showed that 3-year-old children with higher scores in a pattern denominated as “junk” (characterized by high positive loading for snacks foods and food high in fat) were the ones with younger and less educated mother and with a smaller income (11). Additionally at 4 and 7 years old it was also found a component describing a diet based on junk type food which was positively associated with low levels of maternal education and age (12). Moreover, a study (9) conducted among 2 to 5-year-old North American children showed a negative association between the household income and education level of the female head of the household with children’s sugar intake. Low maternal education and unfavourable working conditions were all associated with a higher excess of high energy-dense food intake among Flemish children (10).

These results enhance the prominent role of the mother shaping the children’s food habits since early life. As the characteristics of the father were not included in the present study, it is not possible to discuss fathers’ influence on children consumption. Nevertheless, as mothers usually spend significantly more time in direct interactions with the children in diverse familial situations, including mealtime, they seem to influence more the children’s eating habits than the fathers (16).

The observed effect of grandparents’ education supports a long term influence of socioeconomic circumstances on children’s consumption. This life-course approach is in favour of a social environment influences on the parents when they were a child and then on their own children. Few studies have examined the influence of social background of grandparents on children’s food habits, focusing only on the nutritional needs of the grandparents (26) or carried on in cultures greatly family-oriented (14).

Having older siblings was a risk factor to a higher consumption of soft drinks, sweet snacks and salty snacks. These findings are in accordance with previous studies (11, 12) among children, which also showed a positive association between having older siblings and consumption of junk food high in fat and sugar. The older sibling could influence the youngest bring into the household “kid-appreciated” foods such as sweetened beverages, crisps and nutrient-poor snacks. Furthermore, bearing in mind that these foods require little preparation time and culinary knowledge, mothers who have more than one child within the family might find difficulties in making time to produce a healthy meal.

A consumption of high energy-dense food lower than a weekly consumption seems to be less influenced by socioeconomic factors than a high consumption. A consumption of less than once a week of unhealthy food could be integrated in a healthy dietary pattern and

hence it might not share the same determinants as a high consumption, which usually associates with a poor diet in general (27). Predictors of core (fruit and vegetables) and non-core food (snacks and sweetened beverages) were previously described as different, being only the maternal intake, among the characteristics studied, the common predictor (28).

The children being taken care of by a kindergarten were less likely to consume soft drinks comparing to the children who were being taken care of by the parents. A recent study (29) described that the food offered to children at home is less healthful than those offered at child-care centres in EUA. Moreover, among the sixteen child-care centres included in the study no one reported providing soft drinks to the children. However, our own results could be, at some extent, biased. The FFQs were mainly answered by the parents who might not be aware of the all food eaten by their children when being taken care of by others.

Girls consumed significantly more sweets than boys but no significant associations were found for the remaining food groups. This result are not in agreement with previous ones in which being a boy was associated with a high consumption of high energy-dense foods (8, 12).

This study presents some other strengths and limitations that should be discussed and consequently results should be interpreted with caution.

Some strengths of this study were the use of a sample of very young children which is not so commonly described in previous studies. Even though we performed a cross sectional analysis at 2 years of age, due to the nature of socioeconomic characteristics and since most of them were evaluated in the context of a cohort and therefore gathered at baseline, which allowed us to establish a temporal sequence.

Our sample derived from a population-based cohort, with similar sex distribution, but with a higher representativeness of older and higher educated mothers. However, the magnitude of differences do not seem to be relevant and the statistical significance might be the result of a high sample size and therefore of a high statistical power.

The use of a qualitative FFQ for dietary data collection could be pointed out as one limitation of this study. We assume that ‘frequency’ was equal to ‘quantity’, which could underestimate the consumption of high energy-dense foods if the children usually eat more than one portion each time. Nevertheless, in 2 year-old children is less likely that this could occur. Additionally, Willet (30) highlighted that portion sizes are positively correlated with frequency of use and for most food groups portion sizes vary less among individuals than do frequencies of use.

All data was reported by the parents/caregivers in personal interviewers and therefore subject to social desirability bias, which for instance could leave to a lower reported of unhealthy foods’ consumption than the reality. Thus, the associations found may be even stronger if the intake was reported with more accuracy.

In conclusion, independent associations were observed between socioeconomic characteristics and consumption of high energy-dense foods, namely with soft drinks and sweets in 2-year-old children. These findings support the influence of social and family structure on consumption of unhealthy food since early stages of life. Moreover, an influence of socioeconomic environment in the course of life was shown with the inclusion of grandparents' education. An unfavourable socioeconomic environment has a long-term undesirable influence on preschool children's food consumption, and this influence starts even before the child was born.

It is necessary nutrition education and support of healthy food habits to be targeted at specific subpopulations. Preschool children are at the age where they are learning to eat properly and are acquiring family's dietary behaviour, therefore being the perfect age to intervene.

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Table 1. Comparison between characteristics of eligible participants and the remaining cohort evaluated at baseline.

	Sample (n=808)	Remaining cohort (n=7839)	*p*
	Mean (SD)		
Maternal age (years)	30.4 (5.10)	29.4 (5.51)	<0.001
Maternal education (years)	11.1 (4.25)	10.4 (4.25)	<0.001
	n (%)		
Child's sex (girl)	399 (49.4)	3843 (49.0)	0.847
Maternal occupation			
Manual/unskilled	142 (17.7)	1721 (22.2)	
Non manual/skilled	370 (46.2)	3706 (47.8)	
Superior/intermediate	223 (27.8)	1771 (22.8)	
Others	66 (8.2)	560 (7.4)	0.001
Household monthly income (euros)			
≤ 1000	248 (36.0)	2776 (41.1)	
1001- 1500	211 (30.7)	1894 (28.1)	
> 1500	229 (33.3)	2078 (30.8)	0.035

SD, standard deviation.

Note: in each variable, the total may not add to 808/7839 due to missing data.

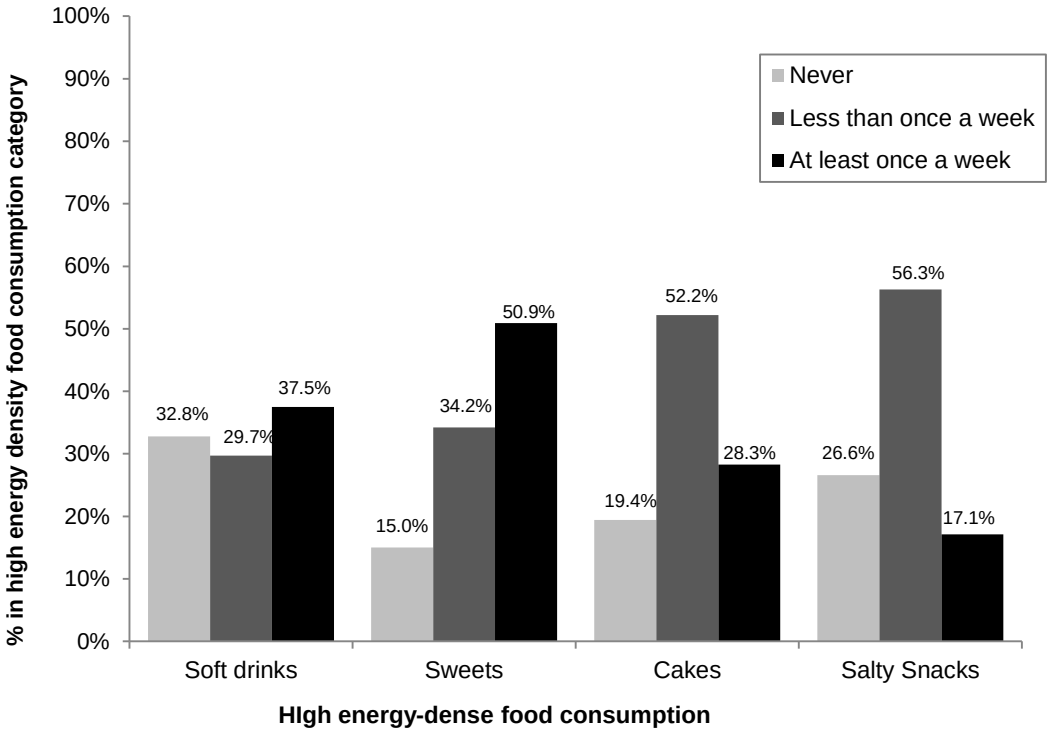

Figure 1. Proportion of high energy-dense food group consumption according to 3 categories (never, less than once a week and at least once a week), in 2-year-old children.

Table 2. Multinomial associations of socioeconomic characteristics with consumption of soft drinks and sweets in 2-year-old children.

	Soft drinks				Sweets			
	<1/week vs. never OR (95%CI)		≥1/week vs. never OR (95%CI)		<1/week vs. never OR (95%CI)		≥1/week vs. never OR (95%CI)	
	Crude	Adjusted[a]	Crude	Adjusted[a]	Crude	Adjusted[a]	Crude	Adjusted[a]
Maternal age (years)								
<30	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
30-35	0.79 (0.51-1.25)	0.62 (0.35-1.10)	0.30 (0.20-0.45)	0.22 (0.13-0.39)	1.34 (0.78-2.32)	1.31 (0.66-2.59)	0.52 (0.31-0.85)	0.38 (0.20-0.73)
> 35	0.59 (0.36-0.99)	0.45 (0.23-0.87)	0.26 (0.16-0.42)	0.15 (0.08-0.28)	0.89 (0.48-1.63)	0.67 (0.31-1.45)	0.46 (0.26-0.80)	0.21 (0.10-0.44)
Maternal education (years)								
≤ 6	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
7-9	1.20 (0.66-2.20)	1.82 (0.90-3.69)	0.87 (0.50-1.49)	0.85 (0.44-1.65)	0.86 (0.40-1.87)	1.04 (0.43-2.52)	0.54 (0.26-1.12)	0.51 (0.22-1.18)
10-12	0.90 (0.51-1.59)	1.08 (0.55-2.11)	0.55 (0.33-0.92)	0.52 (0.28-0.98)	0.89 (0.41-1.92)	1.14 (0.47-2.76)	0.64 (0.31-1.32)	0.65 (0.28-1.48)
> 12	0.47 (0.27-0.81)	0.59 (0.30-1.16)	0.15 (0.09-0.26)	0.23 (0.12-0.43)	0.55 (0.27-1.27)	0.69 (0.30-1.60)	0.19 (0.10-0.37)	0.25 (0.11-0.55)
Maternal grandmother education (years) [c]								
≤ 5	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
> 5	0.58 (0.36-0.95)	0.46 (0.26-0.81)	0.57 (0.36-0.90)	0.47 (0.27-0.81)	0.75 (0.43-1.30)	0.64 (0.34-1.19)	0.49 (0.29-0.84)	0.46 (0.25-0.86)
Maternal grandfather education (years) [c]								
≤ 5	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
> 5	0.52 (0.33-0.83)	0.50 (0.30-0.84)	0.48 (0.31-0.74)	0.49 (0.29-0.82)	0.66 (0.39-1.10)	0.67 (0.37-1.20)	0.43 (0.26-0.72)	0.47 (0.26-0.83)
Maternal occupation								
Manual/unskilled	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Non manual/skilled	0.54 (0.31-0.93)	0.65 (0.34-1.21)	0.47 (0.28-0.78)	0.56 (0.30-1.03)	0.78 (0.39-1.55)	0.79 (0.36-1.76)	0.64 (0.34-1.21)	0.66 (0.31-1.40)
Superior/intermediate	0.32 (0.18-0.56)	0.34 (0.18-0.68)	0.16 (0.09-0.29)	0.26 (0.13-0.52)	0.61 (0.31-1.23)	0.65 (0.28-1.50)	0.26 (0.14-0.51)	0.36 (0.16-0.81)
Others	0.94 (0.38-2.36)	0.87 (0.31-2.45)	1.47 (0.64-3.36)	1.20 (0.46-3.11)	1.75 (0.51-5.98)	1.47 (0.39-5.47)	1.67 (0.52-5.39)	1.25 (0.36-4.35)

Household monthly income (euros)								
≤ 1000	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
1001- 1500	0.65 (0.39-1.06)	0.69 (0.39-1.21)	0.33 (0.21-0.52)	0.44 (0.25-0.76)	0.75 (0.38-1.47)	0.95 (0.45-2.00)	0.51 (0.27-0.97)	0.89 (0.44-1.82)
> 1500	0.45 (0.28-0.74)	0.57 (0.33-0.99)	0.19 (0.12-0.30)	0.30 (0.18-0.52)	0.43 (0.23-0.78)	0.62 (0.32-1.21)	0.20 (0.11-0.36)	0.35 (0.18-0.66)
Children Sex								
Boy	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Girl	0.91 (0.64-1.30)	1.05 (0.70-1.58)	0.99 (0.71-1.37)	1.08 (0.71-1.62)	1.25 (0.81-1.92)	1.44 (0.89-2.35)	1.34 (0.89-2.02)	1.63 (1.01-2.64)
Caregiver								
Parents	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Other family	0.64 (0.34-1.20)	0.63 (0.29-1.33)	0.37 (0.21-0.64)	0.47 (0.24-0.93)	0.51 (0.23-1.13)	0.64 (0.26-1.59)	0.47 (0.22-1.01)	0.76 (0.32-1.82)
Kindergaten	0.87 (0.46-1.65)	0.83 (0.39-1.75)	0.33 (0.19-0.59)	0.35 (0.17-0.71)	0.57 (0.25-1.28)	0.61 (0.25-1.50)	0.37 (0.17-0.80)	0.47 (0.20-1.13)
Baby-sitter/others	1.42 (0.67-3.00)	1.61 (0.67-3.87)	0.72 (0.37-1.42)	0.76 (0.33-1.76)	0.53 (0.21-1.39)	0.57 (0.20-1.65)	0.65 (0.27-1.59)	0.95 (0.35-2.61)
Siblings								
None	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Younger	0.53 (0.21-1.33)	0.58 (0.22-1.52)	1.25 (0.61-2.56)	1.32 (0.56-3.11)	1.15 (0.42-3.21)	1.26 (0.44-3.59)	1.52 (0.59-3.89)	1.94 (0.70-5.38)
Older	1.26 (0.85-1.85)	1.18 (0.74-1.52)	1.66 (1.15-2.40)	2.00 (1.24-3.20)	1.80 (1.11-2.94)	1.63 (0.93-2.87)	1.97 (1.24-3.14)	2.52 (1.44-4.41)

95% CI, 95% confidence interval; OR, *odds ratio.*

[a] Adjusted for maternal age and education, maternal body mass index pre-pregnancy, birth weight/gestational age, children caregivers and siblings.

[b] Reference class.

[c] Adjusted for maternal age, maternal body mass index pre-pregnancy, birth weight/gestational age, children caregivers and siblings.

Table 3. Multinomial associations of socioeconomic characteristics with consumption of cakes and salty snacks in 2-year-old children.

	Cakes				Salty snacks			
	<1/week vs. never OR (95%CI)		≥1/week vs. never OR (95%CI)		<1/week vs. never OR (95%CI)		≥1/week vs. never OR (95%CI)	
	Crude	Adjusted[a]	Crude	Adjusted[a]	Crude	Adjusted[a]	Crude	Adjusted[a]
Maternal age (years)								
<30	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
30-35	1.12 (0.73-1.71)	0.85 (0.50-1.44)	0.71 (0.45-1.13)	0.44 (0.24-0.79)	0.88 (0.60-1.31)	0.76 (0.47-1.23)	0.73 (0.44-1.21)	0.63 (0.34-1.17)
> 35	1.84 (1.07-3.14)	1.12 (0.58-2.18)	1.30 (0.73-2.31)	0.81 (0.39-1.66)	0.58 (0.37-0.91)	0.47 (0.27-0.82)	0.70 (0.40-1.23)	0.44 (0.21-0.92)
Maternal education (years)								
≤ 6	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
7-9	0.98 (0.54-1.79)	1.03 (0.52-2.01)	0.94 (0.50-1.77)	0.96 (0.47-1.96)	1.57 (0.94-2.64)	1.44 (0.80-2.60)	0.95 (0.62-1.76)	0.99 (0.49-2.00)
10-12	0.87 (0.50-1.52)	1.12 (0.59-2.14)	0.44 (0.24-0.82)	0.47 (0.23-0.98)	1.27 (0.78-2.06)	1.11 (0.63-1.96)	0.56 (0.31-1.03)	0.61 (0.30-1.25)
> 12	0.99 (0.56-1.74)	1.38 (0.70-2.72)	0.56 (0.30-1.04)	0.85 (0.41-1.80)	1.38 (0.85-2.24)	1.44 (0.80-2.58)	0.47 (0.25-0.88)	0.65 (0.30-1.38)
Maternal grandmother education (years)[c]								
≤ 5	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
> 5	0.99 (0.60-1.66)	1.26 (0.70-2.27)	1.15 (0.66-2.01)	1.47 (0.77-2.80)	1.19 (0.75-1.88)	1.06 (0.64-1.77)	1.14 (0.62-2.09)	1.24 (0.63-2.45)
Maternal grandfather education (years)[c]								
≤ 5	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
> 5	0.96 (0.59-1.55)	1.09 (0.64-1.86)	0.85 (0.50-1.46)	1.00 (0.55-1.83)	0.92 (0.60-1.41)	0.82 (0.51-1.32)	1.05 (0.61-1.84)	1.18 (0.63-2.18)
Maternal occupation								
Manual/unskilled	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Non manual/skilled	1.19 (0.71-2.00)	1.63 (0.90-2.93)	0.91 (0.52-1.59)	0.93 (0.49-1.75)	1.81 (1.15-2.84)	1.81 (1.08-3.03)	0.88 (0.51-1.52)	1.09 (0.58-2.05)
Superior/intermediate	1.16 (0.67-2.03)	1.77 (0.92-3.41)	0.58 (0.32-1.08)	0.82 (0.40-1.71)	1.58 (0.97-2.56)	1.73 (0.98-3.07)	0.61 (0.32-1.13)	0.89 (0.42-1.86)
Others	1.06 (0.48-2.37)	1.26 (0.52-3.05)	1.17 (0.51-2.69)	1.24 (0.50-3.10)	3.01 (1.36-6.64)	2.93 (1.24-6.93)	2.35 (0.96-5.76)	2.39 (0.88-6.51)

Household monthly income (euros)								
≤ 1000	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
1001- 1500	0.95 (0.59-1.55)	1.10 (0.64-1.89)	0.57 (0.33-0.98)	0.80 (0.43-1.48)	1.01 (0.66-1.55)	0.95 (0.58-1.54)	0.52 (0.29-0.91)	0.57 (0.30-1.10)
> 1500	1.23 (0.75-2.00)	1.55 (0.88-2.73)	0.72 (0.42-1.24)	1.13 (0.60-2.13)	1.12 (0.73-1.72)	1.23 (0.75-2.00)	0.53 (0.30-0.93)	0.73 (0.38-1.40)
Children Sex								
Boy	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Girl	1.02 (0.68-1.53)	0.92 (0.60-1.38)	0.97 (0.67-1.39)	0.99 (0.62-1.58)	1.15 (0.83-1.59)	1.22 (0.85-1.75)	1.26 (0.82-1.93)	1.48 (0.91-2.41)
Caregiver								
Parents	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Other family	0.83 (0.44-1.55)	0.89 (0.44-1.80)	0.72 (0.36-1.42)	0.88 (0.40-1.91)	0.81 (0.47-1.40)	0.79 (0.43-1.46)	0.53 (0.27-1.04)	0.71 (0.33-1.54)
Kindergaten	0.68 (0.36-1.27)	0.66 (0.33-1.34)	0.59 (0.30-1.17)	0.67 (0.31-1.46)	0.78 (0.45-1.37)	0.76 (0.41-1.41)	0.46 (0.23-0.91)	0.64 (0.29-1.41)
Baby-sitter/others	0.62 (0.30-1.28)	0.82 (0.36-1.90)	0.64 (0.29-1.41)	0.84 (0.34-2.09)	0.73 (0.38-1.40)	0.82 (0.39-1.71)	0.99 (0.46-2.13)	1.33 (0.56-3.17)
Siblings								
None	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]	1[b]
Younger	2.82 (0.95-8.39)	2.58 (0.86-7.74)	2.92 (0.92-9.28)	2.58 (0.79-8.46)	0.67 (0.32-1.39)	0.73 (0.35-1.53)	1.17 (0.46-2.95)	1.06 (0.39-2.86)
Older	1.51 (1.00-2.26)	1.54 (0.96-2.47)	1.62 (1.03-2.54)	1.75 (1.02-2.99)	1.09 (0.76-1.56)	1.35 (0.89-2.05)	1.74 (1.08-2.78)	1.78 (1.02-3.10)

95% CI, 95% confidence interval; OR, *odds ratio.*

[a] Adjusted for maternal age and education, maternal body mass index pre-pregnancy, birth weight/gestational age, children caregivers and siblings.

[b] Reference class.

[c] Adjusted for maternal age, maternal body mass index pre-pregnancy, birth weight/gestational age, children caregivers and siblings.

Table 4. Multinomial associations of socioeconomic characteristics with consumption of any high energy-dense food in 2-year-old children.

	High energy-dense food*			
	Weekly vs. monthly consumption		Daily vs. monthly consumption	
	Crude OR (95%CI)	Adjusted OR (95%CI)[a]	Crude OR (95%CI)	Adjusted OR (95%CI)[a]
Maternal age (years)				
< 30	1[b]	1[b]	1[b]	1[b]
30-35	0.39 (0.24-0.65)	0.34 (0.18-0.64)	0.25 (0.15-0.41)	0.20 (0.10-0.40)
> 35	0.52 (0.30-0.92)	0.40 (0.19-0.82)	0.28 (0.15-0.50)	0.16 (0.07-0.35)
Maternal education (years)				
≤ 6	1[b]	1[b]	1[b]	1[b]
7-9	1.43 (0.74-2.75)	1.37 (0.63-2.96)	0.89 (0.46-1.73)	0.78 (0.35-1.72)
10-12	1.07 (0.58-1.98)	0.93 (0.45-1.92)	0.67 (0.36-1.24)	0.52 (0.25-1.10)
> 12	0.50 (0.28-0.88)	0.52 (0.26-1.03)	0.16 (0.09-0.30)	0.19 (0.09-0.41)
Maternal grandmother education (years) [c]				
≤ 5	1[b]	1[b]	1[b]	1[b]
> 5	0.57 (0.36-0.91)	0.48 (0.28-0.82)	0.43 (0.25-0.73)	0.36 (0.19-0.68)
Maternal grandfather education (years)[c]				
≤ 5	1[b]	1[b]	1[b]	1[b]
> 5	0.57 (0.36-0.91)	0.56 (0.34-0.94)	0.46 (0.28-0.77)	0.52 (0.29-0.94)
Maternal occupation				
Manual/unskilled	1[b]	1[b]	1[b]	1[b]
Non manual/skilled	0.90 (0.52-1.58)	0.95 (0.50-1.83)	0.84 (0.47-1.51)	0.93 (0.47-1.85)
Superior/intermediate	0.47 (0.27-0.83)	0.57 (0.29-1.12)	0.26 (0.14-0.48)	0.41 (0.19-0.86)
Others	1.81 (0.67-4,88)	1.54 (0.50-4.69)	1.97 (0.68-5.15)	1.61 (0.51-5.09)
Household monthly income (euros)				
≤ 1000	1[b]	1[b]	1[b]	1[b]
1001- 1500	0.41 (0.23-0.73)	0.58 (0.31-1.10)	0.30 (0.17-0.55)	0.48 (0.24-0.94)
> 1500	0.32 (0.18-0.54)	0.43 (0.24-0.79)	0.13 (0.07-0.23)	0.21 (0.11-0.41)
Children Sex				
Boy	1[b]	1[b]	1[b]	1[b]
Girl	1.10 (0.77-1.59)	1.23 (0.81-1.88)	1.26 (0.85-1.86)	1.60 (0.99-2.57)
Caregiver				
Parents	1[b]	1[b]	1[b]	1[b]
Other family	0.58 (0.30-1.12)	0.83 (0.39-1.77)	0.51 (0.26-1.01)	0.94 (0.42-2.10)
Kindergaten	0.56 (0.29-1.09)	0.76 (0.36-1.62)	0.37 (0.18-0.74)	0.54 (0.24-1.23)
Baby-sitter/others	0.71 (0.32-1.56)	1.09 (0.44-2.71)	0.81 (0.36-1.82)	1.29 (0.50-3.38)
Siblings				
None	1[b]	1[b]	1[b]	1[b]
Younger	1.01 (0.44-2.32)	1.16 (0.48-2.80)	1.12 (0.46-2.73)	1.29 (0.47-3.57)
Older	1.30 (0.87-1.96)	1.43 (0.89-2.31)	1.58 (1.02-2.44)	1.92 (1.12-3.28)

95% CI, 95% confidence interval; OR, *odds ratio.*

*Includes soft drinks, salty snacks, cakes and sweets.

[a] Adjusted for maternal age and education, maternal body mass index pre-pregnancy, birth weight/ gestational age, children caregivers and siblings.

[b] Reference category.

[c] Adjusted for maternal age, maternal body mass index pre-pregnancy, birth weight/gestational age, children caregivers and siblings.

Paper II

Influence of high energy-dense food consumption at 2 years of age on diet quality at 4 years of age

Abstract

Background: The consumption of unhealthy food at early ages could have long-term unfavourable health effects, but could a higher consumption of unhealthy foods early in life predict a worst diet quality few years later?

Objective: To evaluate the association between the consumption of high energy-dense foods at 2 years of age with food consumption and diet quality at 4 years of age.

Methods: 705 children (48.7% girls), evaluated at 2 and 4 years of age within the Portuguese population-based birth cohort Generation XXI, were included in the present study. Data on demographic, socioeconomic conditions and lifestyles of both children and mothers were collected by face-to-face interviews. Children's body mass index (BMI) was obtained from weight and height measured by trained professionals. Based on food frequency questionnaires, 4 high energy-dense food groups were defined: soft drinks (sweetened carbonated drinks and other sweetened drinks), sweets (chocolate and candies), cakes (creamy and not creamy cakes and sweet pastry) and salty snacks (crisps, pizza and burger). Food items were categorized considering a median consumption at both ages. A healthy eating index was constructed to evaluate the adherence to the World Health Organization dietary recommendations for children (2006) at 4 years of age. Quartiles of consumption were obtained from food groups of interest, scoring from 1 to 4 (4 was assigned to the upper or lower quartile of healthy or unhealthy food consumption, respectively). Additionally, the food groups included in the index were evaluated individually using the median of consumption at 4 years of age as cut off point. The associations were evaluated through Poisson regression models [incidence ratio rate (IRR) and 95% confidence intervals (95%CI)], adjusted for maternal age and education level, caregiver, siblings and child's BMI.

Results: In multivariate analysis, a higher consumption of high energy-dense foods at 2 years of age was associated with a higher consumption of the same foods 2 years later. An inverse association was found between intake at 2 years of age, of soft drinks (IRR=0.74, 95%CI: 0.58-0.95), salty snacks (IRR=0.80, 95%CI: 0.65-1.00) and sweets (IRR=0.73, 95%CI: 0.58-0.91) and the consumption of fruit and vegetables at 4 years of age. No statistically significant association was found between high energy-dense food consumption at 2 years of age and consumption of the remaining food groups at 4 years of age (dairies, red meat & meat products and lean meat & fish). A weekly and a daily consumption of high energy-dense food at 2 years of age, versus a

monthly consumption, was associated with a lower score in the healthy eating index at 4 years of age (IRR=0.75, 95%CI: 0.58-0.96; IRR=0.56, 95%CI: 0.41-0.77, respectively).

Conclusion: Consumption of unhealthy foods in early ages seems to have a long-term adverse effect on children's diet quality, mainly related with a decrease consumption of fruit and vegetables.

Keywords: High energy-dense foods, diet quality, preschool children

Background

A high prevalence of consumption of high energy-dense foods among children has been described in developed countries (1-4). An increase in caloric contribution from sugar-sweetened beverages has been reported in US children, in the last decades (1). The per capita daily caloric contribution from sugar-sweetened beverages in children aged 2-5 years increased from 107 kcal/day in 1988-1994 to 124 kcal/day in 1999-2004 (1). The snacking has also increased in US children (3). Children 2 to 6 years old accounted for the highest amount of snacks per day and the largest increase from 1977 to 2006 (approximately 1.41 events more) (3). In Europe, the school-aged children's daily consumption of soft drinks ranges from 10% (Finland) and 40% (Bulgaria). Almost one third of the children eat sweets or chocolate on a daily basis (2). The percentage of British children aged 4-6 years consuming at least once a week foods like savoury snacks, potato chips and chocolate confectionery was 80% (5). In Portugal the daily frequency among school-aged children was of 21% for girls and 30% for boys of soft drinks and 20% for sweets (2, 6).

Several studies have highlighted the adverse effects of high energy-dense food consumption on both children's and adults' health, being the weight gain and risk of obesity the dietary related-disease more often reported (7, 8). Consumption of high energy-dense foods seems also to have an adverse effect on global dietary quality in children. A previous study (9), conducted among children and adolescents in a national household survey in United Stated, found that children who ate fast food, compared with those who did not, had a significantly higher intake of total energy, total fat, saturated fat, added sugars and sugar-sweetened beverages, and a significant lower intake of dietary fibre, milk, fruit and starchy vegetables. Previous research (10, 11) found an association between increasing intake of added sugars and decreasing intake of some nutrients, such as protein, fat, vitamin A and E and folate. Moreover, a higher consumption of sugar sweetened beverages was negatively associated with diet quality in children and adolescents (12, 13). Lower levels of diet quality scores has been linked with increase disease risk and all-cause mortality rates in adulthood (14). Most of this studies use a cross-sectional approach to study the association between consumption of unhealthy food on children's dietary quality (9-11, 13, 15, 16). However, the use of a longitudinal analysis among young preschool children has been less explored (12, 17, 18).

Our aim is to evaluate the prospective effect of unhealthy foods on food consumption. We will explore the influence of consumption of high energy-dense foods

at 2 years of age on consumption of specific food groups and dietary quality at 4 years of age.

Methods

Subjects

The present study is based on a prospective population-based birth cohort-Generation XXI, which has been described elsewhere (19, 20). Generation XXI has recruited newborns and respective mothers during 2005-2006 at five level III maternity units of Porto. A total of 8647 children and 8495 mothers were enrolled at baseline. When the children were 2 years of age a subsample of 855 children was re-evaluated. In 2009/2011, an average of 4-5 years after birth, all children and respective mothers were invited to attend the first follow-up of the entire cohort. During this evaluation period, participants were invited to an interview and physical examination, with 86% of children being re-evaluated at this age.

The sample included in the present analysis comprises data from the singleton children evaluated at 2 years of age (mean=25 months, SD=3.5) and at 4 years of age (mean=49 months, SD=7.2), resulting in a total of 708 children and respective mothers.

Data collection

The study sample was evaluated in both moments (2 and 4 years of age) by trained interviewers in face-to-face interviews. Data collection through structured questionnaires included parents' socio-demographic characteristics, child health status, behavioural characteristics and anthropometric measures according to standard procedures.

Dietary intake

Information on dietary intake at 2 and 4 years of age was based on food frequency questionnaires (FFQ) reported by parents and/or caregivers. At 2 years of age the FFQ asked about currently frequency of consumption of food items not usually consumed on a daily basis (e.g. crisps, cakes, burger). Six responses were possible, ranging from 'never' to 'every day'. At 4 years of age the FFQ queried frequency of intake, for 35 food items (e.g. skimmed milk, fish, fruit, vegetable soup, etc). For each food, parents or caregivers were asked how many times on average his/her child had consumed that food item during the previous 6 months. The nine frequency responses

ranged from ‘never’ to ‘4 times or more per day’. Daily consumption frequencies were calculated in both questionnaires.

Four similar high energy-dense groups were created at 2 and at 4 years of age: soft drinks (sweetened carbonated drinks and other sweetened drinks), salty snacks (crisps, pizza and burger), cakes (creamy cakes, not creamy cakes and sweet pastry) and sweets (chocolate and candies). The median consumption was used to create dichotomic variables: consumption lower than the median versus consumption higher or equal to the median. Tertiles of consumption of high energy-dense foods were also obtained at 2 years of age.

Healthy eating index

Based on dietary recommendations for children from the World Health Organization (WHO) (21) a healthy eating index was developed at 4 years of age, including only food data and not nutrients. This index comprises 7 food groups: fruit & vegetables (vegetable soup, raw and cooked vegetables and fruit), dairies (half skimmed, skimmed milk and yoghurts), red meat & meat products (pork, beef, veal, goat, processed meat and salty pastry), lean meat & fish (rabbit, poultry, egg and fish), soft drinks (sweetened carbonated drinks and other sweetened drinks), salty snacks and sweet snacks (cakes, sweet pastry, chocolate and candies). For each food group, quartiles of consumption were calculated and a score between 1 and 4 was assigned. Children in the lower quartile of consumption of more “healthy foods” such as fruit vegetables, lean meat & fish and dairies were assigned a score of 1, intermediate quartiles of consumption were scored 2 and 3 and the higher consumption was score as 4. To the other groups, a decreasing score was assigned according to increasing consumptions. The final index range from 7 to 25 and it was stratified by the median of 17. Overall a higher score represents a better diet at 4 years of age.

Co-variates

The following variables were collected in the follow-up evaluation at 4 years of age: years of maternal age and education (as continuous variables), child’s siblings (none, younger or older), child’s current caregiver (family/babysitter or kindergarten/school) and child’s sex. The weight and height of the child was measured by a team of experienced investigators, at 4 years of age. Weight was measured in light clothing and without shoes using a digital scale, and was recorded to the nearest 0.1 kg. Height was measured as the distance from the top of the head to the bottom of

the feet without shoes using a fixed stadiometer, measured to the nearest 0.1cm. Child's body mass index (BMI) was defined as weight in kg divided by height in meter squared. This continuous variable was then categorized using specific cut offs for sex and age from WHO (22) and re-categorized into underweight/normal (BMI≤-2SD) and overweight/obesity (BMI≥+2SD).

Ethics

The study protocols for both evaluation periods were approved by the Ethics Committee of Hospital de São João/ University of Porto Medical School and by the Portuguese Authority of Data Protection. Procedures were developed in order to guarantee data confidentiality and protection. Legal representatives of each participant received an explanation on the purposes and design of the study, and gave written informed consent at baseline and 2 and 4-year-old re-evaluation.

Statistical analysis

All analyses were conducted using SPSS 20.0 software (SPSS INC. 2011, Chicago, Illinois, USA). Mean (standard deviation) and frequency differences were compared through student's t-test and chi-square test, respectively.

Associations between consumption at 2 and 4 years of age were estimated by crude and adjusted incidence rate ratios (IRR) and respective 95% confidence intervals (95% CI), using Poisson regression. The models were adjusted for maternal age and education in years (continuous variables), presence of siblings (none, younger or older), current caregiver (family/babysitter or kindergarten/school) and child's BMI (underweight/normal or overweight/obesity). The total person-time at risk were calculated and the log of person-months (mean=24 months) was included as the offset variable. It was also assessed a potential interaction effect of levels of maternal education between the consumption of high energy-dense foods at 2 years of age and the healthy eating index at 4 years of age.

Results

Table 1 comprises comparison of eligible participants and remaining cohort evaluated at baseline. Mothers in the present study sample were slightly more educated [11.3 (4.87) years vs. 10.9 (4.24) years, $p<0.001$] and older [30.4 (5.02) years vs. 29.4 (5.64) years, $p<0.001$] than the remaining mothers evaluated at baseline. More

children in the study sample were being taken care of by family or babysitter (18.4% vs. 10.7%, p<0.001). No significant differences were found concerning child's sex and BMI, presence of older siblings and maternal age.

Figure 1 shows the proportion of children consuming each high energy-dense food groups at least once a week, at 2 and at 4 years of age. The majority of children at 4 years of age were consuming sweets (92.0%) and soft drinks (63.2%) at least once a week. Cakes and salty snacks were the less consumed weekly or daily, by 2-year-old children at both ages. Among those who are already consuming these foods at least once a week at 2 years of age, the percentage of consumption at 4 years of age was 97%, 87.8%, 72% and 63.8% of sweets, soft drinks, salty snacks and cakes, respectively.

Table 2 shows the crude and adjusted associations between consumption of high energy-dense foods at 2 and consumption at 4 years of age. Overall, a higher consumption at 2 years of age was significantly associated with a higher consumption of the same foods at 4 years of age. The strongest effect was found for increasing frequency of consumption (until 1.5 times per week and more than 1.5 times per week) of soft drinks (IRR=2.22, 95%CI: 1.59-3.09; IRR=3.33, 95%CI: 2.36-4.70, respectively).

Table 3 presents the quantification of associations between high energy-dense food consumption at 2 years of age and the remaining food groups included in the healthy eating index, at 4 years of age. After adjustment, a higher intake at 2 years of age of soft drinks (IRR=0.74, 95%CI: 0.58-0.95), salty snacks (IRR=0.80, 95%CI: 0.65-1.00) and sweets (IRR=0.73, 95%CI: 0.58-0.91) was inversely associated with fruit and vegetables intake at 4 years of age. No significant associations were found with dairy products, fatty meat & meat products and lean meat & fish. Increasing frequency of consumption of any high energy-dense food was associated with a lower intake of fruit and vegetables (IRR=0.77, 95%CI: 0.59-0.99; IRR=0.61, 95%CI: 0.44-0.83). A significant crude association was found between consumption of high energy-dense food and intake of fatty meat & meat products (IRR=1.50, 95%CI: 1.09-2.06), however after adjustment the association did not remain statistically significant.

After adjustment, a higher consumption of high energy-dense food at 2 years of age was associated with a lower score in the health eating index at 4 years of age, with the exception of cakes consumption. A weekly and daily consumption of any high energy-dense food was associated with a worse dietary quality, comparing to a smaller consumption (IRR=0.75, 95%CI: 0.58-0.96; IRR=0.56, 95%CI: 0.41-0.77, respectively) (table 4). The potential modifying effect of maternal education was tested using an interaction term in the final model and no significant interaction effect was observed.

Discussion

The present study shows an adverse impact of consumption of unhealthy food at 2 years of age on diet quality at 4 years of age.

Overall a high consumption of high energy-dense foods at 2 years was independently associated with a higher intake of these foods at 4 years of age. An increase in the consumption from 2 to 4 years of age was expectable; however it was important to understand that children consuming more unhealthy foods at 2 years were the same ones consuming more at 4 years of age.

In the present study the children consuming more soft drinks at 2 years of age had about 3 times more risk of consuming more soft drinks at 4 years of age, being the strongest founded association. This association raise concern as sweetened beverage are specially linked to childhood obesity due both to high glycemic index and a week compensatory response to beverages (23). On the other hand, fast food is characterized by large portion size, palatability, high saturated and trans fat, high energy density and high glycemic index and a low content of fiber (24). These several dietary factors may also increase energy intake, hence promoting a positive energy balance and increasing risk for obesity. Decreasing both portion size and energy density of foods could leave to sustained decreases in energy intake (25).

The snacking behaviour by children has been increased in the last two decades (3, 26). Children in United State aged 2-6 years of age are consuming almost 3 snacks per day, and more than 27% of children's daily energy intake is coming from snacks (3). Skipping breakfast has been described as increasing impulsive snacking on foods high in sugar and fat (27). WHO has described an average of less than 70% of school-aged children having breakfast every morning on school days which might contribute to an extensive consumption of high sugar and fat foods among these children (28). Our study is constituted by preschool children and 96% of the children had always breakfast, however only less than half (45%) had always breakfast at table accompanied by an adult (results not published).

The consumption of high energy-dense foods might have a diluting effect on nutrient intake and total diet quality if they displace nutrient-dense foods such milk or fruit (29, 30). In the present study the an early life increase consumption of soft drinks, salty snacks (including fast food) and sweets was associated to a lower later consumption of fruit and vegetables. Fruit and vegetables had low glycemic index (31) and high fibre content which per se may protect against excessive weight gain (32). Furthermore, a low consumption of fruits and vegetables has been linked with other

diseases such as cardiovascular diseases and diabetes (33-36). Previous studies (9, 29) conducted mostly among school aged children or adolescents found an inverse association between high energy-dense food, mainly soft drinks' intake, and consumption of dairies. In the present study the consumption of high energy-dense food at 2 years of age was not associated with the consumption of dairies at 4 years of age. This relationship found in previous studies could also be explained by the replace of milk and milk products by soft drinks. However, in our study this might not occur, as dairies are mainly consumed at breakfast and the prevalence of skipping breakfast was lower among these children. On the other hand, this replacement of dairy products by soft drinks probably occurred later in life and not in the studied earlier period of life.

The main result of this study is the association of a high consumption of unhealthy diet at early age and lower scores in a healthy eating index 2 years later, particular through a decrease in fruit and vegetable consumption. Decreasing diet quality scores were found to be consistently associated with higher rates of all-cause mortality and selected diseases rates or mortality (e.g. cardiovascular disease and cancer) in adulthood (14). Claims that these types of foods can be part of a healthful diet (37) might be discouraged.

The increase in energy intake promoted by consumption of high energy-dense food plus displacement of nutrient-dense foods may play also an important role in childhood obesity.

Strengths/Limitations

One strength of this study is the use of a prospective approach to evaluate the influence of unhealthy food habits early in life on diet, a few years later. It was also used a sample of children from a population-based cohort, with a few differences from the remaining cohort: more children being taken care of by family or babysitter and mothers slightly more educated and older. Since no modify effect was observed by levels of maternal education is not expect that this differences in maternal education has affected our results.

The assessment of accurate dietary intake data on children is a challenge in epidemiologic studies and the use of parents as proxy reporters of their children's food consumption is consensual. The dietary information reported by parents/caregivers at both ages, could be biased since they might not be always aware of all food eaten by their children when they are being taken care of by others. Although, at these early stages of life it is less probably to occur.

The construction of a healthy eating index is useful to summarize children's food consumption, and in overall a high score represented a better diet.

A social desirability bias regarding food intake could be present as dietary intake was reported in face-to-face interviews. Recorded consumption could reflect attitudes about what should be consumed as opposed to what was consumed. If a lower reported of "unhealthy" food and/or a higher report of "healthy" food than the reality had occurred, our associations could be even underestimated.

In conclusion the consumption of high energy-dense foods in early ages seems to have a long term adverse effect on children's diet quality, particularly affecting the consumption of fruit and vegetable.

As food and beverages might track from childhood to adulthood, the presents results suggest that consumption of unhealthy foods should be preferably limited in childhood in order to prevent lasting diluting effects on diet's quality.

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Table 1. Comparison between characteristics of eligible participants and the remaining cohort evaluated at baseline.

	Sample[a]	Remaining cohort[b]	*p*
Children	**n=705**	**n=7942**	
Children sex (boy/girl), %	51.3/48.7	50.9/49.1	0.822
Siblings, n (%)			
None	320 (45.5)	3008 (44.7)	
Younger	13 (1.8)	196 (2.9)	
Older	370 (52.6)	3523 (52.4)	0.264
Caregivers, n (%)*			
Family/ babysitter	127 (18.4)	670 (10.7)	
Kindergarten /school	562 (81.6)	5611 (89.3)	<0.001
Body Mass Index, n (%)*			
Underweight/normal	618 (90.1)	4469 (89.5)	
Overweight/obesity	68 (9.9)	524 (10.5)	0.640
Mothers	**n=705**	**n=7942**	
Maternal age (years), mean (SD)	30.4 (5.02)	29.4 (5.64)	<0.001
Maternal education (years), mean (SD)	11.2 (4.33)	10.4 (4.24)	<0.001

SD: standard deviation.
[a] children evaluated at 2 and 4 years of age.
[b] cohort evaluated at baseline.
*Characteristics evaluated in the follow-up at 4-5 years of age (n=6753).
Note: in each variable, the total may not add to705/7942 due to missing data.

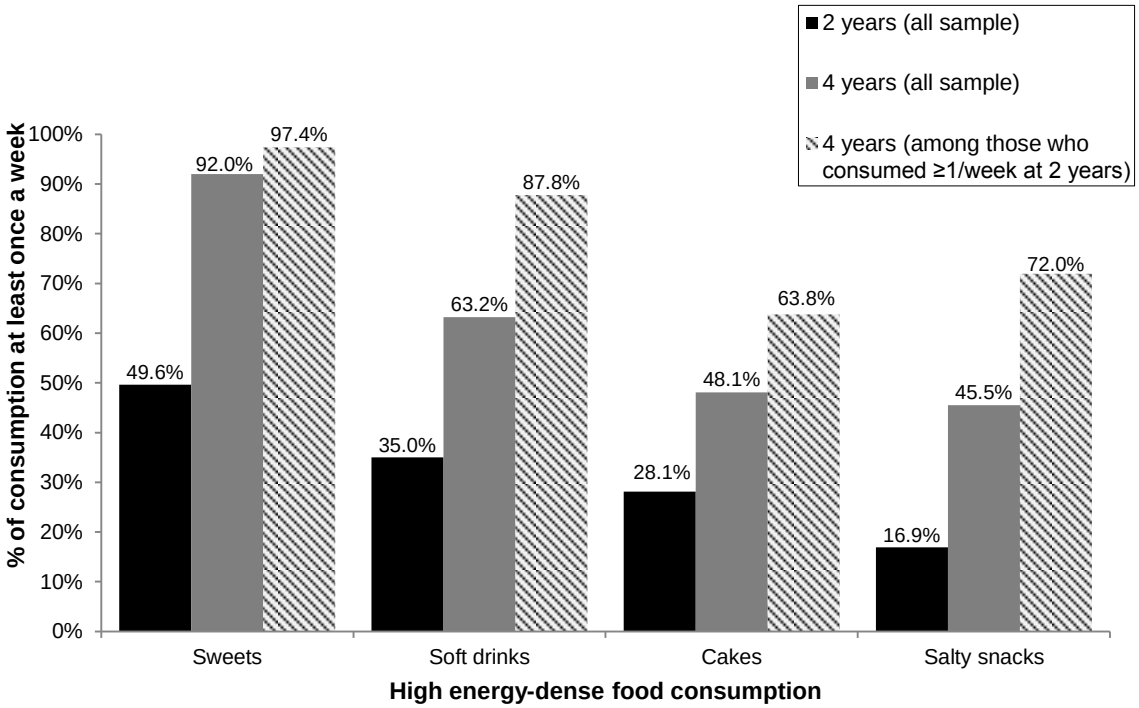

Figure 1. Proportion of children consuming high energy-dense foods at least once a week, at 2 and 4 years of age.

Table 2. Poisson associations between consumption of high energy-dense foods at 2 and consumption at 4 years of age.

	Consumption at 4y (≥ median vs. <median)[a] IRR (95% CI)	
	Crude	Adjusted)[b]
Soft drinks at 2y[d]		
1st tertile	1[c]	1[c]
2nd tertile	2.37 (1.73-3.25)	2.22 (1.59-3.09)
3rd tertile	3.64 (2.65-4.98)	3.33 (2.36-4.70)
Salty snacks at 2y[d]		
1st tertile	1[c]	1[c]
2nd tertile	1.55 (1.21-1.98)	1.53 (1.18-1.97)
3rd tertile	1.66 (1.34-2.07)	1.63 (1.30-2.04)
Cakes at 2y[d]		
1st tertile	1[c]	1[c]
2nd tertile	1.23 (0.91-1.66)	1.26 (0.93-1.71)
3rd tertile	1.61 (1.24-2.08)	1.60 (1.23-2.10)
Sweets at 2y[d]		
1st tertile	1[c]	1[c]
2nd tertile	1.45 (1.13-1.87)	1.44 (1.11-1.88)
3rd tertile	1.69 (1.32-2.18)	1.65 (1.27-2.16)

y, years; 95% CI, 95% confidence interval; IRR, incidence rate ratio.

[a] Median of consumption at 4 years of age: soft drinks, 1.5 times per week; salty snacks, 0.9 times per week; cakes, 1 times per week and sweets, 6 times per week.

[b] Adjusted for maternal age and education, child's siblings, caregiver and child's body mass index.

[c] Reference class.

[d] Tertiles of consumption at 2 years of age: soft drinks, 1st tertile, 0 times per week, 2nd tertile, 0-1.5 times per week, 3rd tertile, >1.5 times per week; salty snacks, 1st tertile, ≤0.1 times per week, 2nd tertile, 0.1-0.5 times per week, 3rd tertile, >0.5 times per week; cakes, 1st tertile, ≤0.1 times per week, 2nd tertile, 0.1-0.6 times per week, 3rd tertile, >0.6 times per week; sweets, 1st tertile, ≤0.5 times per week, 2nd tertile, 0.5-2.0 times per week, 3rd tertile, >2.0 per week.

Table 3. Poisson associations between consumption of high energy-dense foods at 2 years of age and different food groups' consumption at 4 years of age.

	Consumption at 4 years of age (≥ median vs. <median)[a]							
	Fruit & vegetables IRR (95% CI)		Dairies IRR (95% CI)		Fatty meat & meat products IRR (95% CI)		Lean meat & fish IRR (95% CI)	
	Crude	Adjusted[b]	Crude	Adjusted[b]	Crude	Adjusted[b]	Crude	Adjusted[b]
Soft drinks at 2y[d]								
< median	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]
≥ median	0.68 (0.54-0.85)	0.74 (0.58-0.95)	1.10 (0.92-1.34)	1.07 (0.87-1.30)	1.29 (1.04-1.60)	1.18 (0.94-1.49)	0.92 (0.76-1.13)	1.00 (0.81-1.25)
Salty snacks at 2y[d]								
< median	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]
≥ median	0.77 (0.63-0.95)	0.80 (0.65-1.00)	1.03 (0.85-1.25)	1.00 (0.83-1.21)	1.20 (0.97-1.49)	1.14 (0.91-1.43)	0.94 (0.78-1.15)	0.97(0.80-1.19)
Cakes at 2y [d]								
< median	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]
≥ median	0.84 (0.68-1.05)	0.89 (0.70-1.12)	1.06 (0.88-1.29)	1.05 (0.86-1.28)	1.16 (0.93-1.44)	1.08 (0.86-1.36)	0.84 (0.68-1.04)	0.87 (0.70-1.08)
Sweets at 2y[d]								
< median	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]
≥ median	0.67 (0.55-0.83)	0.73 (0.58-0.91)	1.06 (0.88-1.27)	1.05 (0.86-1.27)	1.13 (0.90-1.41)	1.14 (0.91-1.43)	1.00 (0.83-1.22)	1.09 (0.89-1.34)
High energy-dense foods at 2y[e]								
<1/per week	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]	1[c]
Weekly	0.73 (0.57-0.93)	0.77 (0.59-0.99)	1.11 (0.86-1.41)	1.07 (0.82-1.38)	1.17 (0.86-1.60)	1.09 (0.80-1.50)	0.85 (0.66-1.08)	0.90 (0.70-1.17)
Daily	0.53 (0.40-0.71)	0.61 (0.44-0.83)	1.13 (0.87-1.48)	1.09 (0.82-1.45)	1.50 (1.09-2.06)	1.31 (0.94-1.84)	0.86 (0.66-1.12)	0.97 (0.72-1.30)

y, years; 95% CI, 95% confidence interval; IRR, incidence rate ratio.

[a] Median of consumption: fruit & vegetable, 5 times per day; dairies. 3.5 times per day; fatty meat & meat products, 11.5 times per week; lean meat & fish, 1.3 times per

[b] Adjusted for maternal age and education, child's siblings, caregiver and child's body mass index.

[c] Reference class.

[d] Median of consumption: soft drinks, 0.5 times per week; salty snacks, 0.2 times per week; cakes, 0.5 times per week; sweets, 1.0 times per week.

[e] Includes soft drinks, salty snacks, cakes and sweets; sample size by categories of consumption: <1/per week (n=147), weekly (n=339) and daily (n=214).

Table 4. Poisson associations between consumption of high energy-dense foods at 2 years of age and the healthy eating index at 4 years of age.

	Consumption at 4y	
	Healthy Eating Index (≥ median vs. <median)[a] IRR (95% CI)	
	Crude	Adjusted[b]
Soft drinks at 2y[d]		
< median	1[c]	1[c]
≥ median	0.55 (0.44-0.69)	0.64 (0.50-0.83)
Salty snacks at 2y[d]		
< median	1[c]	1[c]
≥ median	0.65 (0.53-0.80)	0.70 (0.57-0.87)
Cakes at 2y[d]		
< median	1[c]	1[c]
≥ median	0.78 (0.62-0.97)	0.84 (0.66-1.06)
Sweets at 2y[d]		
< median	1[c]	1[c]
≥ median	0.62 (0.50-0.76)	0.73 (0.58-0.91)
High energy-dense foods at 2y[e]		
<1/per week	1[c]	1[c]
Weekly	0.67 (0.53-0.85)	0.75 (0.58-0.96)
Daily	0.44 (0.33-0.59)	0.56 (0.41-0.77)

y, years; 95% CI, 95% confidence interval; IRR, incidence rate ratio..

[a]Median = 17, ranging from 7 to 25.

[b] Adjusted for maternal age and education, child's siblings, caregiver and child's body mass index.

[c] Reference class.

[d] Median of consumption: soft drinks, 0.5 times per week; salty snacks, 0.2 times per week; cakes, 0.5 times per week; sweets, 1.0 times per week.

[e] Includes soft drinks, salty snacks, cakes and sweets. Sample size by categories of consumption: <1/per week (n=147), weekly (n=339) and daily (n=214).

GENERAL DISCUSSION AND CONCLUSIONS

In this thesis, determinants of consumption of high energy-dense foods, among preschool children were assessed, using both a cross-sectional and a prospective approach. Overall, the results suggest a high level of risk among the children with an unfavourable socioeconomic status, which in turn negatively influence dietary quality a few years later.

Half of the studied 2-year-old children had a weekly consumption of sweets (chocolate and candies) and 37.5% of children consumed soft drinks. At 4 years of age this proportion raised to 92% for sweets and 63% for soft drinks. Moreover, 32% of the 2-year-old children and 80% of the 4-year-old children were consuming any high energy-dense food on a daily basis. Although, these frequencies are globally lower than those described in other developed countries (99, 124, 125), the exponential increase of availability of high energy-dense foods in last decades, in Portugal, supports an expected increase in the next years.

It has been recognized that a higher consumption of high energy-dense foods can have adverse effects at short and long term on health of the children (52-54, 62, 73, 81, 82, 95). Thus, the assessment of determinants of consumption is crucial to identify high risk population groups. The findings of this thesis showed that the influence of socioeconomic environment starts at least during parents' infancy and could have a negative or positive effect on the food consumption of preschool children. Furthermore, the structure of the family, such as the presence of older sibling, can negatively influence the food consumption of the youngest.

The usefulness of a life-course perspective has been portrait in previously studies (126-129). The use of birth cohort studies has been demonstrated how adults' health is influenced by circumstances in the earlier phases of life (130-132). Taking a life course perspective has great potential and several challenges. Nowadays it is generally accepted that the risk of many non-communicable diseases is not just determined by risk factors in mid-adult life, but begins in childhood or adolescence, and likely even earlier, i.e. during fetal development (133). Time lags between exposure, disease initiation, and clinical recognition suggest that exposures early in life are involved in initiating disease processes prior to clinical manifestations (128). Our findings, through grandparents' education, support a life course influence of socioeconomic environment on consumption of high energy-dense foods by young children.

It was also showed the influence of a high consumption of high energy-dense food at 2 years of age on food consumption, 2 years later. The consumption of high energy-dense foods increases at 4 years of age and it was directly associated with the consumption at 2 years of age. An important result is the association with lower intakes of fruit and vegetables at 4 years of age and consequently with lower scores in the healthy eating index. These results raise special concern since diet quality scores are inversely related to health outcomes (134). Fruit and vegetables' intake was the main indicator of the healthy eating index. Most of previous studies studying these associations focused on older children or used a cross-sectional analysis.

Some limitations of this thesis should be discussed and consequently results should be interpreted with caution.

The children's dietary information was reported by parents or caregiver who might not be aware of all foods eaten by the child. For most epidemiologic purposes, long-term diet, rather than intake on specific day or small number of days, is the conceptually relevant exposure parameter (135). Prospective cohort studies with real time assessment of diet offer the best opportunity to gather valid and reliable information on nutrition (136). Previous research highlighted the difficulties in collecting accurate dietary intake data on children (137). Parents are often used as proxy reporters of their children's food consumption in research studies (138). This is greatly due to children at younger ages having lower literacy levels, limited cognitive abilities, and difficulties in estimating portion size (138). At approximately 12 years of age the child becomes an accurate self-reporter of his own dietary habits, although this varies by dietary assessment method (137). The dietary methods commonly used to assess the diets of preschool age children include respondent-based methods, such as dietary recalls, dietary records, and food frequency questionnaires (FFQ) (139).

Moreover, the questionnaires were answered though face-to-face interviews and hence subject to social desirability bias. This bias could have resulted in a lower report of unhealthy food (e.g. high energy-dense food) and/or over reporter of more healthy foods (e.g. fruit and vegetables). Consequently, the association described might be even stronger if the food consumption has been reported with more accuracy.

We use the information of a qualitative FFQ to evaluate children's food consumption and we assumed that 'frequency' was equal to 'quantity', which could underestimate the food consumption if the child usually eats more than one portion

each time. Nevertheless, in 2 and 4 year-old children this is less likely to occur comparing to older children. Furthermore, Willet (140) described that, for most food groups, frequency of consumption is more important in evaluating food habits of a group of individuals than portion sizes.

One strength of this study is the use of a sample of very young children, well characterized since birth within the framework of a prospective birth cohort. This allowed us to evaluate determinants of consumption in early ages and to assess the evolution of food habits throughout childhood. This approach has not been widely explored in previous studies. Even though we performed a cross sectional analysis at 2 years of age to evaluate the influence of socioeconomic determinants on high energy-dense food consumption, the majority of characteristics were evaluated in the context of a cohort and gathered at baseline, which allowed us to establish a temporal sequence.

Some significant differences were found between the study sample and the remaining cohort which could compromise the representativeness of our results. Our sample is constituted by children of mothers slightly older and more educated than the remaining cohort. However, the magnitude of difference (± 1 year) does not seem to be relevant. Additionally, the absence of a modify effect by levels of maternal education in the associations evaluated, allowed us not to expect that these differences in maternal education had affected our results. Moreover, at 4 years of age more children were being taken care by the family or babysitter. This could have improved the quality of dietary information reported because the parents might be more aware of the food the child eats.

The construction of a healthy eating index at 4 years of age was useful to summarize children's food consumption, and in overall a high score represented a better diet.

In conclusion, an unfavourable socioeconomic status was associated with a higher consumption of unhealthy foods at 2 years of age. This status has a long-term undesirable influence on preschool children's food consumption. The consumption of high energy-dense foods in early ages affects children's dietary quality, mainly though a decreasing in fruit and vegetables' intake. These findings support the influence of social and family structure on establishment of food habits in early ages and the tracking of the dietary habits through childhood.

As behaviours might track from childhood to adulthood, the present results suggest that consumption of unhealthy foods should be preferably limited in childhood in order to prevent lasting diluting effects on future diet's quality.

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