Nutrition, Metabolism & Cardiovascular Diseases (2015) **25**, 116–122

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

journal homepage: www.elsevier.com/locate/nmcd

Consumption of ultra-processed food products and its effects on children's lipid profiles: A longitudinal study

F. Rauber [a,*], P.D.B. Campagnolo [b], D.J. Hoffman [c], M.R. Vitolo [d]

[a] Graduate Program in Health Sciences, Universidade Federal de Ciencias da Saude de Porto Alegre, RS, Brazil
[b] Departament of Nutrition, Universidade do Vale do Rio dos Sinos, RS, Brazil
[c] Department of Nutritional Sciences, School of Environmental and Biological Sciences, Rutgers, The State University of New Jersey, NJ, USA
[d] Department of Nutrition, Universidade Federal de Ciencias da Saude de Porto Alegre, RS, Brazil

Received 2 April 2014; received in revised form 10 August 2014; accepted 11 August 2014
Available online 20 August 2014

KEYWORDS
Food processing and ultra-processed foods;
Risk factors;
Child nutrition;
Cohort studies

Abstract *Background and Aims:* Cardiovascular disease development is related to known risk factors (such as diet and blood lipids) that begin in childhood. Among dietary factors, the consumption of ultra-processing products has received attention. This study investigated whether children's consumption of processed and ultra-processing products at preschool age predicted an increase in lipid concentrations from preschool to school age.
Methods and Results: Cohort study conducted with 345 children of low socioeconomic status from São Leopoldo, Brazil, aged 3–4 years and 7–8 years. Blood tests were done to measure lipid profile. Dietary data were collected through 24-h recalls and the children's processed and ultra-processing product intake was assessed. Linear regression analysis was used to assess the relationship between processed and ultra-processed product intake at 3–4 years on changes in lipid concentrations from preschool to school age. The percentage of daily energy provided by processed and ultra-processed products was 42.6 ± 8.5 at preschool age and 49.2 ± 9.5 at school age, on average. In terms of energy intake, the main products consumed were breads, savoury snacks, cookies, candy and other sweets in both age groups. Ultra-processed product consumption at preschool age was a predictor of a higher increase in total cholesterol ($\beta = 0.430$; $P = 0.046$) and LDL cholesterol ($\beta = 0.369$; $P = 0.047$) from preschool to school age.
Conclusion: Our data suggest that early ultra-processed product consumption played a role in altering lipoprotein profiles in children from a low-income community in Brazil. These results are important to understanding the role of food processing and the early dietary determinants of cardiovascular disease.

Introduction

Cardiovascular disease remains the leading cause of premature death worldwide [1,2]. The development and progression of cardiovascular disease is related to a number of risk factors that begin in childhood, such as diet and specific blood lipid levels [3,4]. Dietary habits that are formed early are likely to track later in childhood and form the basis for adult eating patterns [5]. Evidence from the "Cardiovascular Risk in Young Finns" study showed

* Corresponding author. Graduate Program in Health Sciences, Universidade Federal de Ciencias da Saude de Porto Alegre, 245 Sarmento Leite, Anexo I, 2º andar, 90050-170, Porto Alegre, Brazil. Tel./fax: +55 51 33038798.
E-mail addresses: rauber.fernanda@gmail.com, rauber@ufcspa.edu.br (F. Rauber).

http://dx.doi.org/10.1016/j.numecd.2014.08.001
0939-4753/

substantial tracking of dietary patterns, reflecting food choices from childhood to adulthood [6]. In subsequent longitudinal analyses, such patterns were found to be associated with several cardiovascular risk factors [7,8].

Furthermore, it has been reported that elevated lipid concentrations track from childhood to adulthood, as lipid and lipoprotein results in childhood are predictive of future adult lipoprotein profiles [4]. There are a number of specific nutrient intake factors that are associated with cardiovascular disease, including high saturated and trans fat intake [9], low dietary fiber intake [10] and low polyunsaturated fat intake [11]. Among the various dietary factors that have been identified as contributors to the development of cardiovascular risk factors, the consumption of processed and ultra-processed products has received attention [12–14].

Processed products are foods that have been altered to add substances that substantially change their nature or use, while ultra-processed products are food products formulated mainly or entirely from processed ingredients, typically including little or no whole foods [12]. Evidence has shown that these products (particularly ultra-processed products) are more energy-dense and have more fat, sugar and sodium than fresh or minimally-processed foods and culinary ingredients (such as oils, sugar, and salt) [15,16]. Moreover, the sale and consumption of ultra-processed products is rapidly increasing throughout the world [13,17-20].

Therefore, there is reason to believe that consumption of processed and ultra-processed products may play a role in the development of chronic diseases [21,22]. Thus far, only a limited number of studies have addressed the relationship between food processing and cardiovascular disease risk. One study reported that processed and ultra-processed product consumption increased the risk for metabolic syndrome in adolescents [23]. A second study demonstrated a positive and independent association between the household availability of ultra-processed products and obesity in a national representative sample of the Brazilian population [24]. However, the association between processed and ultra-processed product consumption and lipid profiles in children has not been studied and is poorly understood.

Our objective was to assess whether children's consumption of processed and ultra-processed products at preschool age predicted an increase in lipid concentrations from preschool to school age. Given that processed and ultra-processed product consumption is associated with low diet quality in adults [15,16] and cardiovascular risk factors in youths [23], we hypothesized that the consumption of these products at preschool age would be a positive and significant predictor of an increase in blood lipid levels from preschool to school age.

Methods

Study population

This study used data from children who participated in a randomized trial of dietary counseling on breastfeeding and dietary practices during the first year of life [25]. Five hundred mother–child pairs were recruited between October 2001 and June 2002 in the maternity ward of a hospital that attends to low-income population, in São Leopoldo, Brazil, and the same children have been followed since. Inclusion criteria were full-term (>37 weeks) babies with a birth weight ≥2500 g. Exclusion criteria were HIV-positive mothers, congenital malformations, and children admitted to the intensive care unit. The study protocol was approved by the Ethics Committee of the Universidade Federal de Ciencias da Saude de Porto Alegre and informed consent of the mother was obtained at study entry.

Data collection

Fieldworkers conducted face-to-face structured interviews in home visits with the mothers at 6 months, 3–4 years, and 7–8 years following birth. Data were authenticated at monthly intervals by randomly calling 10% of the households and repeating several questions in the survey. Identification and data required for locating the family in the community were collected at the time of recruitment. Sex, birth length, and birth weight information was obtained from hospital records. Socioeconomic and family characteristics were assessed when the children reached an age of 6 months by face-to-face interviews with mothers. Anthropometric data was obtained at 7–8 years old using a digital scale (Techline, São Paulo, Brazil) to the nearest 0.1 kg and a stadiometer (SECA, Hamburg, Germany) to the nearest 0.1 cm. BMI-for-age z-scores (BMIz) were estimated based on the World Health Organization standards [26].

Dietary data

At 3–4 years (preschool age) and 7–8 years (school age) old, two 24-h dietary recalls for each child were collected on two non-consecutive days that were chosen randomly within two weeks to one month. For preschool children, the recall was provided by mothers or other caregivers; recalls of school age children were self-reported with assistance from mothers or other caregivers. If children spent time with multiple caregivers (e.g., during school hours), all or most of them were interviewed to record all items the children consumed during the previous day. To quantify food portion size, pictures were used to illustrate standard household measurements, such as teaspoons, tablespoons, and cups. A nutritional support program with a database of Brazilians foods (NutWin, version 1.5, Sao Paulo, Brazil) was used to quantify energy intake.

To determine the relationship between processed and ultra-processed product intake on lipid profiles, the consumption of these products by children was assessed using the food classification system proposed by Monteiro and colleagues [12] – recently named the "NOVA Classification System" by the authors of a systematic review [14]. The NOVA system gives primary importance to the nature, extent and purpose of food processing and is based on three groups: unprocessed and minimally processed foods, including all types of such food, of both plant and animal origin (Group 1); processed culinary ingredients designed to be combined with foods to make meals and dishes (Group 2); and processed and ultra-processed products (Group 3). Processed products are foods that have been altered to add substances such as salt, sugar or oil that substantially change their nature or use (e.g. canned vegetables, canned fish preserved in oil and cheese). Ultra-processed products are food products formulated mainly or entirely from processed ingredients, typically including little or no whole food (e.g. bread, chips, cookies, candy, chocolate, soft drinks, breakfast cereal and processed meat). They are very durable, edible, drinkable and palatable by themselves, and are made to be ready-to-consume or ready-to-heat. For the purposes of this study, only the third group (processed and ultra-processed products) was analyzed.

The usual dietary intake of energy and processed and ultra-processed products was estimated by the Multiple Source Method (MSM) https://msm.dife.de/ [27]. The MSM calculates dietary intake for individuals and then constructs the population distribution based on this data. This method was used to correct dietary data for intra- and inter-personal variability in each of the nine groups of processed and ultra-processed products (bread, savoury snacks and biscuits, sweets, soft drinks, cheese, processed meat, canned dishes, mayonnaise, dressing and sauces and others). A probability value of 0.5 (50%) was used to assign habitual consumer status, assuming that there is a certain percentage (50%) of real habitual consumers among the individuals who did not consume a food product during to the two dietary recall periods. Therefore, 50% of those who did not consume in the 24-h dietary recall period were randomly assigned habitual consumer status. An intake estimate was calculated for those who were selected in this manner (MSM, German Institute of Human Nutrition, Germany). After the MSM was applied, dietary data were analyzed for percentage of total energy from processed and ultra-processed products. No cases were excluded due to extreme over- or under-reported energy intake values.

Lipid profile

Venous blood samples were collected from the subjects' right arms after fasting overnight at age 3–4 and 7–8. Serum analyses were performed at the Cardiology Institute of Rio Grande do Sul laboratory by technicians who were blinded to the objectives of this study. Total cholesterol, high-density lipoprotein (HDL) and triglyceride concentrations were measured with an automatic analyzer (Cobas Integra, São Paulo, Brazil). Low-density lipoprotein (LDL) was calculated according to Friedewald's formula (all triglyceride concentrations were <400 mg/dL). Non-high-density lipoprotein (nHDL) was calculated by subtracting HDL-cholesterol from total cholesterol.

Statistical analysis

Variables were described using mean and standard deviation (normally distributed data) or median and interquartile range (non-normally distributed data), and percent frequency. Non-normally distributed variables were log-transformed (triglycerides at preschool and school age) before analysis and untransformed values were presented in tables to facilitate interpretation. Mean and standard deviation for the contribution of each processed or ultra-processed product group to the total energy intake were then calculated (as a percentage of total energy) for children strata corresponding to quartiles of the distribution of the contribution of processed and ultra-processed products to total energy intake. The outcomes were expressed as unit changes in lipid concentrations from preschool to school age (Δ lipid concentrations). Linear regression analysis was used to assess the effect of the consumption of processed and ultra-processed products at 3–4 years on Δ lipid concentrations. The model was adjusted for sex, group status in the early phase (intervention and control), birth weight, family income, maternal schooling, and BMIz score and total energy intake at age 7–8. Data were expressed as standardized regression coefficient β, 95%CI and P values. All statistical analyses were performed using SPSS 16.0 (SPSS Inc, Chicago, IL) and statistical significance was set at $p < 0.05$.

Results

Among the 500 children initially recruited at birth, 356 underwent assessment at age 3–4 and 315 underwent assessment at age 7–8. Loss to follow-up in this cohort was due to refusal to participate, change of address, child or maternal death and genetic disease. No differences were found between children who were lost to follow-up and those who remained at 7–8 years of age in terms of race, sex, birth weight, birth length, maternal age at child's birth, maternal education level, and annual family income. Complete dietary data were available for 345 preschool-age and 307 school-age children. Complete lipid data were available for 327 preschool-age and 307 school-age children. The children's baseline characteristics are shown in Table 1 and descriptive information on the children's lipid profiles is presented in Table 2.

The percentage of energy provided by consuming processed and ultra-processed products was 42.6 ± 8.5

Table 1 Characteristics of children at preschool and school age.[a]

	3–4 years (n = 346)	7–8 years (n = 307)
Boys, n (%)	194 (56.1)	171 (55.7)
Non-white, n (%)	156 (56.1)	142 (58.2)
Maternal age at child's birth (years), mean (SD)	25.7 (6.5)	25.7 (6.6)
Maternal schooling (years), mean (SD)	6.6 (2.7)	6.7 (2.5)
Annual family income (US$), mean (SD)	3314.4 (2340.4)	3391.3 (2415.1)

SD: standard deviation.
[a] Values may not equal total number of subjects in each group because of missing data.

Table 2 Lipid profile in preschool (3–4 years) and school age (7–8 years) children.

	3-4 years ($n = 327$)	7-8 years ($n = 305$)	Δ ($n = 277$)
Total cholesterol (mg/dL); mean (SD)	128.3 (25.7)	161.9 (27.0)	33.4 (1.4)
Triglycerides (mg/dL); median (IR)	54.0 (25.0)	64.0 (32.0)	7.0 (27.5)
LDL cholesterol (mg/dL); mean (SD)	71.2 (23.1)	100.2 (23.4)	28.4 (1.2)
nHDL cholesterol (mg/dL); mean (SD)	83.3 (23.8)	113.9 (24.4)	30.0 (1.2)
HDL cholesterol (mg/dL); mean (SD)	44.9 (10.4)	48.0 (10.9)	3.3 (0.5)

IR: interquartile range; SD: standard deviation; Δ: changes in lipid concentrations at 3–4 years and 7–8 years.

(643.4 ± 147.9 kcal) at preschool age and 49.2 ± 8.5 (767.7 ± 184.9 kcal) at school age, on average. In terms of energy intake, the main products consumed were breads, savoury snacks and cookies, sweets (i.e. candy, chocolate, ice cream), and other products like instant noodles, breakfast cereals, and sugary milk beverages in both age groups – all of them were ultra-processed product groups (Fig. 1). Taken together, these ultra-processed products provided 33.9% and 37.9% of the total energy intake at preschool and school age, respectively.

Table 3 shows the contribution of the processed and ultra-processed product groups to the children's total energy intake according to the quartiles of the amounts of processed and ultra-processed products in their diets. At 3–4 years, these values ranged from 32.3% of total energy in the 25% of children that consumed the least energy from processed and ultra-processed products to 53.2% in the 25% of children that consumed the most energy from processed and ultra-processed products. At 7–8 years, the values ranged from 36.9% of total energy in the 25% of children that consumed the least energy from processed and ultra-processed products to 61.0% in the 25% of children that consumed the most energy from processed and ultra-processed products.

Regarding associations between consumption at preschool age and lipid concentrations, we assessed the association between each of the five outcomes and the energy of processed products and ultra-processed products separately. The results showed that ultra-processed products were associated with lipid concentrations in the adjusted linear regression analyses, whereas processed products were not (Table 4). The consumption of ultra-processed products at preschool age was a significant predictor of an increase in total and LDL cholesterol concentrations from preschool to school age. In summary, for every 1% increase in energy intake from ultra-processed products, Δ total cholesterol increased by 0.430 mg/dL and Δ LDL cholesterol increased by 0.369 mg/dL after adjusting for sex, group status in the early phase, birth weight, family income, maternal schooling; and BMIz score and total energy intake at age 7–8.

Discussion

The prevalence of cardiovascular disease continues to increase throughout the world [1]. While there is consistent and substantial evidence that cardiovascular diseases are associated with specific dietary and activity patterns (such as high-fat, low-fiber diets and little or no physical activity), there is little if any research on how diet in childhood contributes to the development of such diseases [28]. To our knowledge, ours is the first study to examine the longitudinal relationship between the ultra-processed product consumption and lipid profiles in children in Brazil and throughout the world. Briefly, we found that the ultra-processed product consumption at preschool age was a significant predictor of increased total and LDL cholesterol concentrations during childhood. Thus, dietary patterns in childhood may very well mark the beginning of lipid profiles that predispose children to early

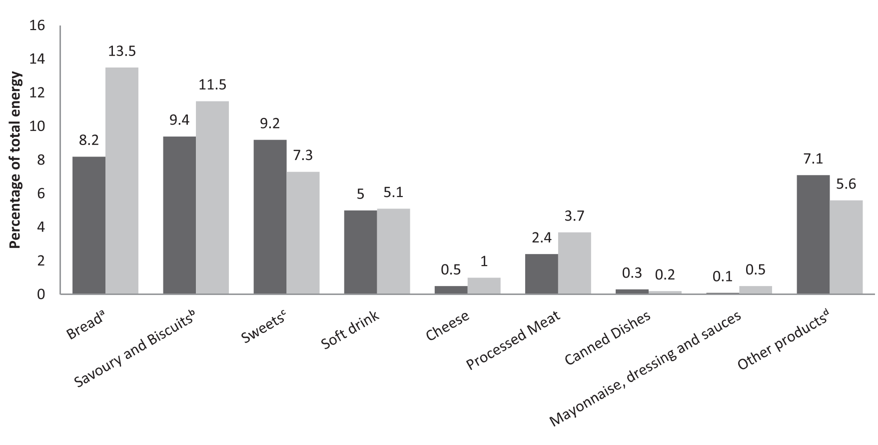

Figure 1 Contribution (%) of processed and ultra-processed products to the dietary intake of preschool (3–4 years) and school age (7–8 years) children. [a]Crackers, chips, cookies. [b]Candy, chocolate and ice cream. [c]Soda, sweetened juice. [d]Instant noodle, dehydrated soup, breakfast cereal, sugared milk beverages and sugared beverages.

Table 3 Contribution (%) of the processed and ultra-processed products groups to total energy intake by quartile of the contribution of total processed products intake in preschool (3–4 years) and school age (7–8 years) children.

	Quartiles of percentage of energy from processed and ultra-processed products			
	1	2	3	4
	mean ± *SD*			
At 3–4 years				
Processed products				
Cheese	0.4 ± 0.7	0.5 ± 0.8	0.5 ± 1.1	0.8 ± 1.2
Canned dished	0.3 ± 0.5	0.4 ± 0.6	0.2 ± 0.4	0.3 ± 0.4
Ultra-processed products				
Bread	7.0 ± 3.8	7.9 ± 4.2	8.4 ± 3.5	9.6 ± 4.2
Savoury and Biscuits[b]	7.0 ± 5.2	9.4 ± 4.0	9.5 ± 3.9	11.7 ± 3.5
Sweets[c]	6.1 ± 5.1	9.3 ± 4.4	9.8 ± 4.3	11.8 ± 3.6
Soft drinks[d]	4.4 ± 2.2	4.7 ± 2.3	5.2 ± 2.6	5.8 ± 3.0
Processed meat	1.3 ± 1.5	1.7 ± 1.7	2.7 ± 2.7	3.8 ± 3.4
Mayonnaise, dressing and sauces	0.07 ± 0.1	0.09 ± 0.2	0.1 ± 0.2	0.2 ± 0.4
Other[e]	5.4 ± 4.6	6.0 ± 4.7	8.2 ± 5.7	8.9 ± 6.2
All products[a]	32.3 ± 4.9	40.1 ± 1.2	44.9 ± 1.7	53.2 ± 4.7
At 7–8 years				
Processed products				
Cheese	0.5 ± 0.6	0.8 ± 0.8	0.8 ± 0.9	1.7 ± 1.8
Canned dished	0.1 ± 0.2	0.1 ± 0.2	0.2 ± 0.5	0.2 ± 0.3
Ultra-processed products				
Bread	11.2 ± 5.1	12.2 ± 5.3	13.8 ± 4.5	16.9 ± 6.3
Savoury and Biscuits[b]	8.0 ± 5.5	11.6 ± 5.4	12.3 ± 5.2	14.3 ± 5.0
Sweets[c]	5.6 ± 4.3	7.0 ± 4.3	7.5 ± 4.1	9.1 ± 4.4
Soft drinks[d]	3.8 ± 2.4	5.0 ± 2.3	6.0 ± 3.4	5.7 ± 2.7
Processed meat	3.1 ± 2.4	3.3 ± 2.1	4.0 ± 2.2	4.5 ± 2.0
Mayonnaise, dressing and sauces	0.2 ± 0.7	0.2 ± 0.6	0.5 ± 1.1	0.9 ± 1.5
Other[e]	4.0 ± 3.2	5.0 ± 4.0	6.2 ± 3.8	7.2 ± 5.0
All products[a]	36.9 ± 5.2	45.7 ± 1.9	51.8 ± 1.8	61.0 ± 5.0

[a] Expressed as percentage of total energy intake.
[b] Crackers, chips, cookies.
[c] Candy, chocolate and ice cream.
[d] Soda, sweetened juice.
[e] Instant noodle, dehydrated soup, breakfast cereal, sugared milk beverages and sugared beverages.

Table 4 Linear Regression of processed products and ultra-processed products consumption at preschool age on changes in lipid concentrations at preschool (3–4 years) and school age (7–8 years).

	B	95%CI	*P*
Processed products intake[a]			
Δ Total cholesterol	1.457	−2.068–4.98	0.416
Δ LDL cholesterol	1.508	−1.529–4.544	0.328
Δ nHDL cholesterol	1.397	−1.780–4.573	0.387
Δ Triglycerides	−0.875	−4.962–3.213	0.673
Δ HDL cholesterol	0.060	−1.203–1.322	0.926
Ultra−processed products intake[a]			
Δ Total cholesterol	0.430	0.008–0.853	0.046
Δ LDL cholesterol	0.369	0.005–0.733	0.047
Δ nHDL cholesterol	0.319	−0.059–0.697	0.098
Δ Triglycerides	−0.465	−0.955–0.025	0.063
Δ HDL cholesterol	0.125	−0.026–0.277	0.105

Δ: changes in lipid concentrations at 3–4 years and 7–8 years (mg/dL).
[a] Expressed as percentage of total energy intake. Adjusted to sex, group, birth weight, family income, maternal schooling, and BMI-for-age z-scores and total energy intake at 7–8 years.

atherosclerotic changes associated with cardiovascular disease development [4].

The consumption of processed and ultra-processed products is an important factor to study as this accounted for approximately 50% of the total energy consumed by the children, almost double the average of 27% found in the overall Brazilian population [18]. Specifically, the ultra-processed products like bread, chips, cookies, candy and other sweets, and sweetened beverages contributed the most to the percentage of energy coming from processed and ultra-processed products, corroborating previous studies [16,18]. Such products are nutritionally unbalanced because they are usually energy-dense; contain large amounts of total fat, saturated fat, trans fat, free sugars and sodium; have high glycaemic loads; and contain little or no fibre, micronutrients or other protective bioactive compounds that are naturally present in foods [15,16]. In addition, ultra-processed products are highly palatable (which makes them quasi-addictive) and can lead to the physiological disruption of hunger and satiety signals, thus inducing overeating [29]. They are fast and convenient to consume anywhere (ready-to-eat), attractive and even glamorous due to sophisticated marketing strategies that specifically target children and adolescents [30]. All these factors explain excessive ultra-processed product consumption by children. Thus, unless this overconsumption is curtailed, other interventions focusing on increasing fruit and vegetable consumption will have limited impact on controlling obesity and diet-related diseases, since evidence has shown that food preferences are formed early in life and predict food consumption patterns throughout life [31].

Another important finding is that a 10% increase in the consumption of ultra-processed products at preschool age increased the change in total and LDL cholesterol from preschool to school age by up to 3 mg/dL, even when adjusting for energy intake and BMI-for-age z-score. Ultra-processed products are thought to cause adverse health effects through several mechanisms. The convenience and speed associated with eating these products [15] favor consumption behaviors such as snacking (instead of eating regular meals based on vegetables, grains and meat) and eating while watching television, which are known to harm the mechanisms that regulate energy balance and therefore lead to overconsumption and subsequent obesity over time [32,33]. In addition, excessive consumption of energy-dense foods that are high in sugar and trans fats is associated with increased lipogenesis [34], the secretion of very low-density lipoproteins [35], reduced oxidation and greater fatty acid accumulation in tissues and blood [36]. Such changes are associated with atheromatous plaque formation on blood vessel walls as well as its clinical consequences, such as myocardial infarction, stroke and peripheral vascular disease [4]. Our results suggest that the dysmetabolic effects of ultra-processed products may even start in childhood, placing the pediatric population at potential risk for cardiovascular and metabolic disease. In order to combat this process, a national policy is needed to promote, support, and protect traditional food systems and healthy dietary patterns, including restrictions on the advertising and marketing of ultra-processed products and creating environments conducive to healthy eating [13,17], especially for children.

Although we did not find an association between ultra-processed product consumption at preschool age and changes in triglyceride and HDL cholesterol levels during childhood, we point out that other factors (such as physical activity) may be stronger predictors of changes in lipid levels. Moreover, evidence has shown that food has a stronger effect on total and LDL cholesterol levels in children than other dyslipidemia markers [37]. The absence of association between processed products and lipid levels is probably due to the lower share of these products in children's diets (0.8% of total energy at preschool age and 1.2% of total energy at school age), which did not cause an effect. Also, our findings are consistent with a recent study conducted in a national representative sample of the Brazilian population that showed that ultra-processed products were associated with obesity, whereas processed products were not [24].

There are some specific limitations of this study that warrant discussion. The first is the number of participants lost to follow-up from birth to age 8. Our losses, which are mainly due to families moving to an unknown address, are similar to those of studies involving the follow-up of people living in low-income urban areas. However, selection bias is unlikely to be a major problem, considering the similarity in baseline characteristics between those lost and those not lost. Second, the study included a sample of children of low socioeconomic status and this could limit the ability to generalize the results to other strata. However, the consumption of ultra-processed products in Brazil rises with income [15,18]. Therefore the observed relationship could be even more important for middle and upper socioeconomic groups. Third, the children's dietary data were reported by the mothers and children (at age 7–8) and are subject to reporting errors. However, dietary measurements were performed by trained fieldworkers using the multiple-pass method to facilitate dietary recall and reduce error. Fourth, the use of two 24-h dietary recalls is not ideal scientifically. However, it was not practically possible to include more days. Therefore, the dietary intake data has been corrected for intra- and inter-personal variability using the MSM method [27] to partially counteract reporting error. Despite these limitations, this study has a number of strengths that reinforce our results. Most importantly, because we used a longitudinal design, it is possible to assess cause–effect relationships between variables. In addition, the statistical analyses controlled for several confounding variables, including socioeconomic, anthropometric and dietary factors. Finally, studying pre-pubertal children limited the influence of hormonal differences between boys and girls that may confound the reported results.

Although cardiovascular disease becomes symptomatic only in adulthood, the detection and prevention of cardiovascular disease risk factors should begin during childhood, when changes in lifestyle, including dietary habits [11], can reduce disease incidence and severity [4]. Our results add new information about the relationship between the early consumption of ultra-processed products and lipid profiles in children and highlight the need for a comprehensive assessment of the effect of ultra-processed products on other cardiovascular risk factors such as obesity, hypertension and diabetes. These results, if confirmed in other populations, will be extremely important for understanding the etiology of cardiovascular diseases and for formulating public health strategies aimed at preventing these diseases and reducing consumption of ultra-processed products early in life.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This study was supported by the Brazil CNPq (National Funding for Research) and Capes Foundation, Ministry of Education (FR doctoral fellowship, proc. no. 9853-11-1). The contributors had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

[1] Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Borden WB, et al. Executive summary: heart disease and stroke statistics—2013 update: a report from the American Heart Association. Circulation 2013 Jan 1;127(1):143–52. http://dx.doi.org/10.1161/CIR.0b013e318282ab8f.
[2] Pagidipati NJ, Gaziano TA. Estimating deaths from cardiovascular disease: a review of global methodologies of mortality measurement. Circulation 2013 Feb 12;127(6):749–56. http://dx.doi.org/10.1161/CIRCULATIONAHA.112.128413.
[3] Morrison JA, Glueck CJ, Woo JG, Wang P. Risk factors for cardiovascular disease and type 2 diabetes retained from childhood to adulthood predict adult outcomes: the Princeton LRC follow-up study. Int J Pediatr Endocrinol 2012 Apr 16;2012(1):6. http://dx.doi.org/10.1186/1687-9856-2012-6.
[4] Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents; national heart, lung, and blood institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. Pediatrics 2011 Dec;128(Suppl. 5):S213–56. http://dx.doi.org/10.1542/peds.2009-2107C.
[5] Nicklaus S, Remy E. Early origins of overeating: tracking between early food habits and later eating patterns. Curr Obes Reports 2013;2(2):179–84. http://dx.doi.org/10.1007/s13679-013-0055-x.
[6] Mikkila V, Rasanen L, Raitakari OT, Pietinen P, Viikari J. Longitudinal changes in diet from childhood into adulthood with respect to risk of cardiovascular diseases: the cardiovascular risk in young finns study. Eur J Clin Nutr 2004 Jul;58(7):1038–45. http://dx.doi.org/10.1038/sj.ejcn.1601929.

[7] Mikkila V, Rasanen L, Raitakari OT, Pietinen P, Viikari J. Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in young finns study. Br J Nutr 2005 Jun;93(6):923–31. http://dx.doi.org/10.1079/BJN20051418.
[8] Mikkila V, Rasanen L, Laaksonen MM, Juonala M, Viikari J, Pietinen P, et al. Long-term dietary patterns and carotid artery intima media thickness: the cardiovascular risk in young finns study. Br J Nutr 2009 Nov;102(10):1507–12. http://dx.doi.org/10.1017/S000711450999064X.
[9] Kelishadi R, Gouya MM, Adeli K, Ardalan G, Gheiratmand R, Majdzadeh R, et al. Factors associated with the metabolic syndrome in a national sample of youths: CASPIAN study. Nutr Metab Cardiovasc Dis 2008 Sep;18(7):461–70. http://dx.doi.org/10.1016/j.numecd.2007.02.014.
[10] Zhang Z, Xu G, Liu D, Zhu W, Fan X, Liu X. Dietary fiber consumption and risk of stroke. Eur J Epidemiol 2013 Feb;28(2):119–30. http://dx.doi.org/10.1007/s10654-013-9783-1.
[11] Hoppu U, Isolauri E, Koskinen P, Laitinen K. Diet and blood lipids in 1–4 year-old children. Nutr Metab Cardiovasc Dis 2013 Oct;23(10):980–6. http://dx.doi.org/10.1016/j.numecd.2012.10.007.
[12] Monteiro CA, Cannon G, Levy RB, Claro R, Moubarac J-C. The food system. Ultra-processing. The big issue for nutrition, disease, health, well-being. World Nutr December 2012;3(12):527–69. Obtainable at, www.wphna.org.
[13] Moodie R, Stuckler D, Monteiro C, Sheron N, Neal B, Thamarangsi T, et al. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. Lancet 2013 Feb 23;381(9867):670–9. http://dx.doi.org/10.1016/S0140-6736(12)62089-.
[14] Moubarac JC, Parra DC, Cannon G, Monteiro CA. Food classification systems based on food processing: significance and implications for policies and actions: a systematic literature review and assessment. Curr Obes Rep 2014 Jun;3(2):256–72. http://dx.doi.org/10.1007/s13679-014-0092-0.
[15] Monteiro CA, Levy RB, Claro RM, de Castro IR, Cannon G. Increasing consumption of ultra-processed foods and likely impact on human health: evidence from Brazil. Public Health Nutr 2011 Jan;14(1):5–13. http://dx.doi.org/10.1017/S1368980010003241.
[16] Moubarac JC, Martins AP, Claro RM, Levy RB, Cannon G, Monteiro CA. Consumption of ultra-processed foods and likely impact on human health. Evidence from Canada. Public Health Nutr 2013 Dec;16(12):2240–8. http://dx.doi.org/10.1017/S1368980012005009.
[17] Stuckler D, McKee M, Ebrahim S, Basu S. Manufacturing epidemics: the role of global producers in increased consumption of unhealthy commodities including processed foods, alcohol, and tobacco. PLoS Med 2012;9(6):e1001235. http://dx.doi.org/10.1371/journal.pmed.1001235.
[18] Martins AP, Levy RB, Claro RM, Moubarac JC, Monteiro CA. Increased contribution of ultra-processed food products in the Brazilian diet (1987-2009). Rev Saude Publica 2013 Aug;47(4):656–65. http://dx.doi.org/10.1590/S0034-8910.2013047004968.
[19] Moubarac J-C, Batal M, Martins AP, Claro R, Levy R, Cannon G, et al. Processed and ultra-processed food products: consumption trends in Canada from 1938 to 2011. Can J Diet Pract Res 2014;75(1):15–21. http://dx.doi.org/10.3148/75.1.2014.15. Spring.
[20] Monteiro CAM, Moubarac J-C, Cannon G, Ng S, Popkin B. Ultra-processed products are becoming dominant in the global food system. Obes Rev 2013;2013(Suppl. 2):21–8. http://dx.doi.org/10.1111/obr.12107.
[21] Ludwig DS. Technology, diet, and the burden of chronic disease. JAMA 2011 Apr 6;305(13):1352–3. http://dx.doi.org/10.1001/jama.2011.380.
[22] Vandevijvere S, Monteiro C, Krebs-Smith SM, Lee A, Swinburn B, Kelly B, et al. Monitoring and benchmarking population diet quality globally: a step-wise approach. Obes Rev 2013 Oct;14(Suppl. 1):135–49. http://dx.doi.org/10.1111/obr.12082.
[23] Tavares LF, Fonseca SC, Garcia Rosa ML, Yokoo EM. Relationship between ultra-processed foods and metabolic syndrome in adolescents from a Brazilian family doctor program. Public Health Nutr 2012 Jan;15(1):82–7. http://dx.doi.org/10.1017/S1368980011001571.
[24] Canella DS, Levy RB, Martins AP, Claro RM, Moubarac JC, Baraldi LG, et al. Ultra-processed food products and obesity in brazilian households (2008-2009). PLoS One 2014 Mar 25;9(3):e92752. http://dx.doi.org/10.1371/journal.pone.0092752. eCollection 2014.
[25] Vitolo MR, Bortolini GA, Feldens CA, Drachler Mde L. Impacts of the 10 steps to healthy feeding in infants: a randomized field trial. Cad Saude Publica 2005 Sep-Oct;21(5):1448–57 [Article in Portuguese].
[26] de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 2007 Sep;85(9):660–7. http://dx.doi.org/10.2471/BLT.07.043497.
[27] Harttig U, Haubrock J, Knuppel S, Boeing H. The MSM program: web-based statistics package for estimating usual dietary intake using the multiple source method. Eur J Clin Nutr 2011 Jul;65(Suppl. 1):S87–91. http://dx.doi.org/10.1038/ejcn.2011.92.
[28] Daniels SR, Pratt CA, Hayman LL. Reduction of risk for cardiovascular disease in children and adolescents. Circulation 2011 Oct 11;124(15):1673–86. http://dx.doi.org/10.1161/CIRCULATIONAHA.110.016170.
[29] Garber AK, Lustig RH. Is fast food addictive? Curr Drug Abuse Rev 2011 Sep;4(3):146–62. http://dx.doi.org/10.2174/1874473711104030146.
[30] Mehta K, Phillips C, Ward P, Coveney J, Handsley E, Carter P. Marketing foods to children through product packaging: prolific, unhealthy and misleading. Public Health Nutr 2012 Sep;15(9):1763–70. http://dx.doi.org/10.1017/S1368980012001231.
[31] Mennella JA, Trabulsi JC. Complementary foods and flavor experiences: setting the foundation. Ann Nutr Metab 2012;60(Suppl. 2):40–50. http://dx.doi.org/10.1159/000335337.
[32] de Graaf C. Effects of snacks on energy intake: an evolutionary perspective. Appetite 2006 Jul;47(1):18–23. http://dx.doi.org/10.1016/j.appet.2006.02.007.
[33] Lissner L, Lanfer A, Gwozdz W, Olafsdottir S, Eiben G, Moreno LA, et al. Television habits in relation to overweight, diet and taste preferences in European children: the IDEFICS study. Eur J Epidemiol 2012 Sep;27(9):705–15. http://dx.doi.org/10.1007/s10654-012-9718-2.
[34] Parks EJ, Skokan LE, Timlin MT, Dingfelder CS. Dietary sugars stimulate fatty acid synthesis in adults. J Nutr 2008 Jun;138(6):1039–46.
[35] Chong MF, Fielding BA, Frayn KN. Mechanisms for the acute effect of fructose on postprandial lipemia. Am J Clin Nutr 2007 Jun;85(6):1511–20.
[36] Kennedy A, Martinez K, Chuang CC, LaPoint K, McIntosh M. Saturated fatty acid-mediated inflammation and insulin resistance in adipose. J Nutr 2009 Jan;139(1):1–4. http://dx.doi.org/10.3945/jn.108.098269.
[37] Ho M, Garnett SP, Baur L, Burrows T, Stewart L, Neve M, et al. Effectiveness of lifestyle interventions in child obesity: systematic review with meta-analysis. Pediatrics 2012 Dec;130(6):e1647–71. http://dx.doi.org/10.1542/peds.2012-1176.