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Does early fruit juice introduction influence anthropometric outcomes and food consumption at preschool age?

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Abstract *The aim of this study was to evaluate the impact of fruit juice consumption before 6 months of age on Body Mass Index-for-age (BMI-for-age) and food consumption in preschoolers. We conducted a longitudinal study with mothers and their children (n=103) at 6 months and 3-6 years. Weight and height were measured and converted into BMI-for-age z-scores. Food consumption was analyzed using the Food Frequency Questionnaire for Children. Groups were compared using the chi-squared and Student's t-tests. No differences in anthropometric measurements were found at preschool age between children who had been given fruit juice before 6 months and those who had not. Consumption of artificial juice (≥once/day) and sandwich cookies at preschool age was higher in children with early introduction of fruit juice (≤150 days of life) (63.8% versus 35.7%; p=0.028 and 21.3% versus 14.3%; p=0.001, respectively). The prevalence of the consumption of soda (1 to 4 times/week) and chocolate milk (at least once/day) was higher in children who had been given artificial juice before 6 months (69.2% versus 27.4%; p=0.014 and 38.5% versus 69.4%; p=0.027, respectively). It can be concluded that the consumption of sweet foods and sugary beverages was higher in children with early introduction of fruit juice.*

Key words *Juices, Nutritional status, Sugar-sweetened beverages, Food consumption*

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Introduction

Adequate dietary intake and breastfeeding (BF) have been associated with reduced infant morbidity and mortality and lower occurrence of anemia, diarrhea, respiratory problems, and tooth decay. These factors have also been shown to promote better cognitive, motor, and socioemotional development, increase learning capacity and productivity in adulthood, and prevent obesity and chronic non-communicable diseases[1,2]. In healthy infants, breast milk provides all the child's nutritional needs in the first months of life. The introduction of drinks or foods in the first 6 months is not recommended and may be harmful to the child's health[3].

In Brazil, the prevalence of exclusive breastfeeding (EBF) has yet to reach the desired level. However, preliminary data from the National Child Diet and Nutrition Study (ENANI-2019) show that there was an important increase in EBF prevalence among infants aged under 6 months between 1986 (2.9%) and 2020 (45.7%)[4]. In addition, the II Survey of Prevalence of Breastfeeding in Brazilian Capitals and the Federal District, undertaken in 2008, reported high prevalence of the consumption of fruit juices (natural or industrialized) by breastfed infants from the third month of life (18.2% among infants aged 3-4 months and 37% in those aged 4-6 months)[5].

Given the high prevalence of natural or artificial fruit juice consumption, it is important to investigate future adverse child health outcomes. A recent systematic review and meta-analysis commissioned by the World Health Organization (WHO) investigated evidence of the effects of unhealthy food and beverage consumption in children. The findings indicate that consumption of sugar-sweetened beverages in children aged under 10 may increase BMI/BMI z-score, percentage of body fat, or risk of overweight/obesity (low certainty of evidence). In contrast, it was shown that 100% fruit juice consumption makes little or no difference to increased BMI, percentage of body fat, or the risk of overweight/obesity. Only two of the 10 studies that analyzed natural fruit juice consumption and BMI-for-age analyzed consumption in children under 2[6].

Another review of the literature on this topic compared the metabolic effects of the consumption of different beverages by adults. The findings show that despite having similar sugar content, it remains unclear whether fruit juices and sugar-sweetened beverages lead to the same metabolic consequences[7].

In addition to the impact on nutritional status, repeated exposure to specific flavors during infancy influences food preferences later in life and therefore the consumption of sweet foods and artificial sweeteners by infants promotes flavor learning[8]. Previous studies indicate that the consumption of fruit juices and sugar-sweetened beverages during infancy (before 1 year of age) is associated with the consumption of these drinks in later years. However, longitudinal studies confirming the association between juice and sugar-sweetened beverage consumption in early childhood and dietary intake in later years are scarce and there is a lack of evidence of the association between the early introduction of juices and sugar-sweetened beverages and anthropometric parameters[9,10].

Longitudinal cohort studies of the influence of the early introduction of juices and sugar-sweetened beverages on future health parameters are therefore essential to determine real impacts and generate evidence to inform policies to control the consumption of these drinks among children.

Considering the change in the recommendation regarding the consumption of fruit juices brought by the latest edition of Brazil's dietary guidelines for children under two (parents should avoid giving fruit juice of any kind, natural or artificial, to children before 1 year of age)[11,12], the lack of research into consumption in children under 1, and the increase in prevalence of childhood obesity, the present study investigated the impact of the introduction of fruit juices in infants before 6 months on anthropometric parameters and the consumption of sweet foods and sugar-sweetened beverages in preschoolers.

Methods

We conducted a prospective study nested within a larger project titled Impact of perinatal environmental variations in the first 6 months of life (IVAPSA), undertaken in two stages. The original study protocol, sample calculation, and preliminary results are described by previous studies[13,14]. Figure 1 presents the sample flowchart.

In the first stage, a sample of 400 mother-child pairs was selected in the period 2011 to 2016. The sample was selected from three public hospitals in Porto Alegre-RS: *Hospital de Clínicas de Porto Alegre* (HCPA), *Hospital Conceição*, and *Hospital Fêmina*. Interviews were conducted immediately after birth before discharge and at 7, 15, 30, 90, and 180 days of life. This study uses

the information collected in the interviews conducted immediately after birth and at 180 days.

Porto Alegre has a Human Development Index (HDI) of 0.805 and 93% of households have adequate sanitation. According to the latest census (2010), the population of children aged 0-4 years was 78,626, accounting for 5.57% of the overall population (1,409,351). In 2020, the city's infant mortality rate was 7.78 per 1,000 live births[15].

The sample was divided into five different groups of perinatal environments based on the mothers' clinical conditions during pregnancy: 1) diabetes; 2) systemic arterial hypertension; 3) smoking; 4) intrauterine growth restriction (IUGR), where newborns were small for gestational age (SGA), based on Alexander *et al.* curve[16]; and 5) control group. HIV-positive *postpartum* women, newborn twins, infants with a chronic or congenital disease requiring hospital admission, and those weighing under 500 grams were excluded from the study sample.

Sociodemographic data (maternal age, education level, and race/color and family income, pre-pregnancy BMI, and child sex) were obtained using a questionnaire administered 48 hours after delivery and from the participant's medical records. Pre-pregnancy BMI was calculated based on pre-pregnancy weight and height, obtained from the mother's medical records. Pre-pregnancy BMI was divided into the following categories: low weight: <18.5 kg/m²; normal weight: between 18.5 and 24.9 kg/m²; overweight: between 25 and 29.9 kg/m², and obesity: ≥30 kg/m²[17].

The interviews at 6 months of life were conducted in the HCPA's Clinical Research Center (CPC). Information on fruit juice consumption was obtained using a structured questionnaire containing the question "Does your baby drink or has he/she ever drunk fruit juice?". If the answer was yes, the following questions were asked: "When did you introduce fruit juice?"; "How much juice does your baby drink per day?"; "What type of fruit juice does your baby drink (natural, concentrated, diluted, artificial)?", "Did someone recommend that you give fruit juice to your baby?". Natural fruit juice was defined as the juice extracted from fresh fruit without adding sugar; concentrated fruit juice was defined as natural juice from which part of the water has been extracted; diluted fruit juice was defined as juice obtained by diluting natural fruit juice; and artificial fruit juices included powdered juices, nectars, or fruit drinks. The mother was also asked whether the baby was being breastfed. The infant's weight was calculated as the weight of the mother holding the baby without a nappy and as little clothing as possible minus the mother's weight. Weight was measured using a Plenna® scale with an accuracy of 50 grams. The infant's length was measured in the supine position using a Sanny® professional stadiometer.

The second stage of the study was undertaken between 2017 and 2019. The sample consisted of the mothers and respective children (aged 3-6 years) who participated in the interview 6 months after birth. The mothers answered a questionnaire designed to obtain general information about the mother and child and socioeconomic characteristics. The infant's weight and height were measured twice. Dietary intake was assessed using the Food Frequency Questionnaire for Children (*Questionário de Frequência Alimentar Infantil* - QFAI) developed by Collucci *et al.*[18] to determine usual dietary intake among children aged 2-5 years. The questionnaire consists of 57 food items with seven possible answers for each item on a scale from "never" to "at least twice a day". For sample distribution purposes, the answers were categorized into three groups: "≤3 times/month", "1 to 4 times/month", and "≥once a day".

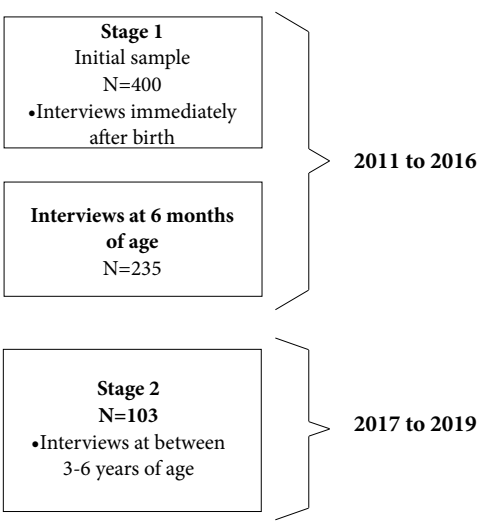

Figure 1. IVAPSA cohort sampling flowchart. Porto Alegre-RS, Brazil, 2011-2019.

Source: Authors.

The infant's energy intake was assessed using a 24-hour dietary recall. Values were calculated using Dietbox®. Energy intake was used as the descriptive variable due to the association between positive energy balance and weight gain[19]. It was therefore important to investigate whether there was a difference in calorie intake between the different juice consumption groups. Daily screen time was assessed using the Children's Physical Activity Questionnaire[20] and was classified into three categories: doesn't watch TV/videos or play computer games; up to an hour a day, and more than an hour a day.

BMI-for-age z-scores (BMI-for-age) were calculated using Anthro® (children under 5) and Anthro Plus® (children over 5), adopting the WHO growth curves as a reference standard[21,22].

To determine the association between fruit juice consumption before 6 months and anthropometric parameters, the children were divided into two groups: fruit juice introduced before six months and fruit juice not introduced before six months, considering both natural and artificial juices. To assess the association between introduction of fruit juice before 6 months in infants and pre-school dietary intake, the children who were given juice were divided into three categories: age when introduced (≤150 days versus >150 days), amount of juice introduced (≥60ml versus <60ml), and type of juice introduced (artificial versus non-artificial). The cut-offs for the groups age when introduced and amount of juice introduced were set based on the median values (150 days and 60 ml, respectively). The following QFAI food items were selected for the analyses: artificial fruit juice, soda, fermented milk, fromage frais, sandwich cookies, chocolate milk, cake, chocolate, and added sugars. These items were chosen because it is hypothesized that the consumption of fruit juices before the first year of life may lead to a sweet taste preference, thus influencing the consumption of sugary foods in later years.

The non-parametric continuous variables were analyzed using medians and 25^{th}-75^{th} percentile range and the categorical variables were assessed using absolute numbers and percentages. The groups that had been given juice before 6 months and those who had not were compared using the chi-squared test for the categorical variables (maternal education level, maternal race, pre-pregnancy BMI, number of children, child sex, breastfeeding, maternal clinical condition during pregnancy, screen time, child nutritional status, and preschool food frequency) and the Mann-Whitney test for the non-parametric continuous variables (maternal age, family income, preschooler energy intake, and BMI z-score). The Student's t-test was used to compare means and the variation of the BMI-for-age z-score. Multinomial logistic regression was used to predict the probability of differences in anthropometric outcomes between the different fruit consumption groups using the odds ratio. Two models were created for the adjusted analysis: (1) adjusted maternal race/skin color, maternal age, maternal education level, parity, and breastfeeding at 6 months for the association between fruit juice consumption before 6 months and nutritional status at 6 months; and (2) adjusted maternal race/skin color, maternal age, maternal education level, parity, and breastfeeding at 6 months, screen time, and daily energy intake for the association between fruit juice consumption before 6 months and nutritional status in preschoolers. The adjusted model variables were defined using a directed acyclic graph (DAG) created using DAGitty® (version 3.0, Johannes Textor). The data were analyzed using SPSS® version 18.0 (SPSS Inc., Chicago, IL, US). Sample power was calculated using PSSHealth® (Power and Sample Size for Health Researchers) and was estimated to be less than 80%.

All participants signed an informed consent form. The study protocol for the first stage was approved by the HCPA's and *Grupo Hospitalar Conceição*'s research ethics committees, the latter representing the *Conceição* and *Fêmina* hospitals (reference numbers 11-027 and 11-0097, respectively). The study protocol for the second stage was approved by the HCPA's research ethics committee (reference number 17-0107, CAAE: 65190217500005327).

Results

A total of 103 mother-child pairs participated in this study, resulting in a 43.8% loss in relation to the sample interviewed at 6 months of life (n=235). A comparison of the characteristics of the pairs who participated in the second stage and the losses showed a significant difference between the groups for the variables number of children and breastfeeding at 6 months: the prevalence of multiparity was higher in the women who did not participate in stage 2 (p=0.013), while the prevalence of breastfeeding was greater among the children who participated in both stages (p=0.011).

The median age of the women who participated in both stages (percentile 25; 75) was 28 (21; 33) years. Most of the sample had between 9 and 11 years of education (n=59; 57.3%), were white (n=60; 58.3%), and belonged to the control group (n=46; 44.7%). Approximately 25% (n=25) of the women were obese based on pre-pregnancy BMI. Around 77% (n=80) of the children were being breastfed at 6 months of life. The prevalence of breastfeeding among children who had been given juice before 6 months of age was 73.3% (n=55), compared to 89.3% (n=25) in those who had not. The difference between the groups was not statistically significant (p=0.143).

Median energy intake (percentile 25; 75) among the preschoolers was 2,037 (1,662; 2,537) kcal. Total screen time per day was over one hour in the overwhelming majority of preschoolers (n=86; 83.5%). No significant difference in sociodemographic characteristics was found between the groups who had been given fruit juice before 6 months and those who had not (p>0.05) (Table 1).

The median age (percentile 25; 75) of the infants who had been given juice before 6 months (n=75) was 150 (120; 180) days. The median amount (percentile 25; 75) of juice introduced was 60 ml (30; 100). The most commonly mentioned persons who recommended the introduction of juices (n=36; 48%) were health professionals, followed by mother's own decision (n=29; 38.7%), and other (n=10; 13.3%). Seventy-two (96%) of the children who had been given juice before 6 months of age were given natural juices, 13 (17.3%) were given artificial juices, four (5.3%) diluted fruit juice, and two (2.7%) concentrated fruit juice. The sum of the values is not 100% as the same child may have been given more than one type of juice (data not presented).

Table 2 shows the nutritional status of the children at 6 months and at preschool age. Six percent (n=6) of the children at 6 months were overweight or obese, compared to 26.2% (n=27) of the preschoolers. No statistically significant difference in nutritional status was found between children who had been given juice before 6 months and those who had not. The variation in BMI-for-age z-score between 6 months of life and preschool age is shown in Figure 2. No statistically significant difference was found between the group who had been given juice before 6 months and those who had not for the following parameters: BMI-for-age at 6 months (p=0.379); BMI-for-age at preschool age (p=0.282); and variation in BMI-for-age z-score between the two periods (p=0.824).

Likewise, the results of the crude regression analysis showed no significant differences between the groups for at risk of overweight or obese at 6 months of life (p=0.532), thinness or pronounced thinness at 6 months (p=0.562), overweight or obese at preschool age (p=0.468), and thinness at preschool age (p=0.651). Similarly, the results of the adjusted model 1 (maternal race/skin color, age, education, parity, and breastfeeding at 6 months) showed no significant difference between the groups at risk of overweight or obese at 6 months (p=0.700) and thinness or pronounced thinness at 6 months (p=0.356). The results of the adjusted model 2 (maternal race/skin color, age, education, parity, breastfeeding at 6 months, preschooler screen time, and daily energy intake) showed that there was no significant association between fruit juice consumption before 6 months and at risk of overweight or obese at preschool age (p=0.325) and thinness at preschool age (p=0.688) (data not presented).

Table 3 shows the frequency of consumption of different foods and beverages in the preschoolers grouped according to the age at which fruit juice was introduced (≤150 and >150 days) and the type of juice introduced. The table shows the foods and beverages that showed a significant difference in consumption: artificial fruit juice (p=0.028) and sandwich cookies (p=0.001) between the groups categorized according to age of fruit juice introduction; and soda (p=0.014) and chocolate milk (p=0.027) between the groups categorized according to the type of juice introduced.

Discussion

The findings showed that the introduction of fruit juice before 6 months of life was associated with the consumption of sugar-sweetened beverages and sweet foods at preschool age, indicating that exposure to specific flavors during infancy may influence dietary intake and predict future food preferences.

Despite consistent evidence of the health impacts of artificial fruit juice consumption in older children, adolescents, and adults, the effects of consumption in infants remain poorly understood, especially in the first year of life[6]. Despite the recommendation to the contrary, our study shows high prevalence of the introduction of natural and artificial juices in infants before 6 months of age.

Likewise, the prevalence of breastfeeding was 16% lower in children who had been given

juice before 6 months than in those who had not (73.3% versus 89.3%); however, this difference was not statistically significant. These findings reinforce the importance of current recommendations advising that the introduction of fruit juices before one year of age should be avoided as it can result in reduced breast milk consumption and, consequently, protein, lipid, vitamin, and mineral intake[23]. In addition, breastfeeding plays an important role in acceptance of foods due to the transmission of a variety of flavors through breast milk, thus promoting acceptance of novel foods[24]. Finally, the median age the children who were given juice before 6 months of age was 150 days, demonstrating early fruit juice introduction in the study sample.

Table 1. General and sociodemographic characteristics categorized by fruit juice introduction before 6 months; IVAPSA cohort. Porto Alegre-RS, Brazil, 2011-2019.

	Introduction before 6 months (n=75)	Not introduced before 6 months (n=28)	Total (n=103)	P-value
Maternal age (years)	27 [21; 32] §	28 [21; 36] §	28 [21; 33] §	0.188 Ψ
Maternal education level (years), n (%)			0.268 ¥	0.268 ¥
0-8	19 (25.3%)	11 (39.3%)	30 (29.1%)	
9-11	44 (58.7%)	15 (53.6%)	59 (57.3%)	
>11	12 (16.0%)	2 (7.1%)	14 (13.6%)	
Family income (reais)[a]	2,000 [1,200; 3,000] §	1,800 [1,175; 2,625] §	1,950 [1,200; 3,000] §	0.656 Ψ
Maternal race/skin color, n (%)			0.175 ¥	0.175 ¥
White	44 (58.7%)	16 (57.1%)	60 (58.3%)	
Black	20 (26.7%)	4 (14.3%)	24 (23.3%)	
Other[b]	11 (14.6%)	8 (28.6%)	19 (18.4%)	
Pre-pregnancy BMI (kg/m²)[c], n (%)			0.961 ¥	0.961 ¥
Low weight	2 (2.8%)	1 (3.6%)	3 (3.0%)	
Normal weight	32 (44.4%)	13 (46.4%)	45 (45.0%)	
Overweight	19 (26.4%)	8 (28.6%)	27 (27.0%)	
Obesity	19 (26.4%)	6 (21.4%)	25 (25.0%)	
Nº children, n (%)			0.628 ¥	0.628 ¥
Primiparous	38 (50.7%)	12 (42.9%)	50 (48.5%)	
Multiparous	37 (49.3%)	16 (57.1%)	53 (51.5%)	
Child sex, n (%)			0.388 ¥	0.388 ¥
Female	42 (56.0%)	19 (67.9%)	61 (59.2%)	
Male	33 (44.0%)	9 (32.1%)	42 (40.8%)	
Breastfeeding, n (%)			0.143 ¥	0.143 ¥
Yes	55 (73.3%)	25 (89.3%)	80 (77.7%)	
Clinical condition during pregnancy, n (%)			0.780 ¥	0.780 ¥
Diabetes	12 (16.0%)	6 (21.4%)	18 (17.5%)	
Hypertension	10 (13.3%)	2 (7.1%)	12 (11.6%)	
Smoking	10 (13.3%)	5 (17.9%)	15 (14.6%)	
RCIU	10 (13.3%)	2 (7.1%)	12 (11.6%)	
Control	33 (44.0%)	13 (46.4%)	46 (44.7%)	
Preschooler energy intake (kcal)	2,057 [1,741; 2,537] §	1,957 [1,469; 2,567] §	2,037 [1,662; 2,537] §	0.514 Ψ
Preschooler screen time: >1 hour/day, n (%)	61 (81.3%)	25 (89.3%)	86 (83.5%)	0.504 ¥

IVAPSA=Impact of perinatal environmental variations in the first 6 months of life; BMI=body mass index. § Median [25th and 75th percentile]; [a] n=90 due to missing data; [b] Yellow and brown; [c] n=100 due to missing data; ¥ Chi-squared test; Ψ Mann-Whitney test.

Source: Authors.

Table 2. Classification of nutritional status at 6 months and preschool age and fruit juice introduction before 6 months; IVAPSA cohort. Porto Alegre-RS, Brazil, 2011-2019.

Infant nutritional status	Juice introduction before 6 months (n=75)	Juice not introduced before 6 months (n=28)	Total (n=103)	P-value
At 6 monthsa, n (%)			0.907 ¥	0.907 ¥
Thinness	8 (10.7)	2 (7.1)	10 (9.7)	
Normal weight + risk of overweight	62 (82.7)	25 (89.3)	87 (84.5)	
Overweight/obese	5 (6.6)	1 (3.6)	6 (5.8)	
At preschool age[a], n (%)			0.843 ¥	0.843 ¥
Thinness	4 (5.3)	1 (3.6)	5 (4.9)	
Normal weight + risk of overweight	50 (66.7)	21 (75.0)	71 (68.9)	
Overweight/obese	21 (28.0)	6 (21.4)	27 (26.2)	

IVAPSA=Impact of perinatal environmental variations in the first 6 months of life. [a] Nutritional status based on BMI-for-age; ¥ Chi-squared test.

Source: Authors.

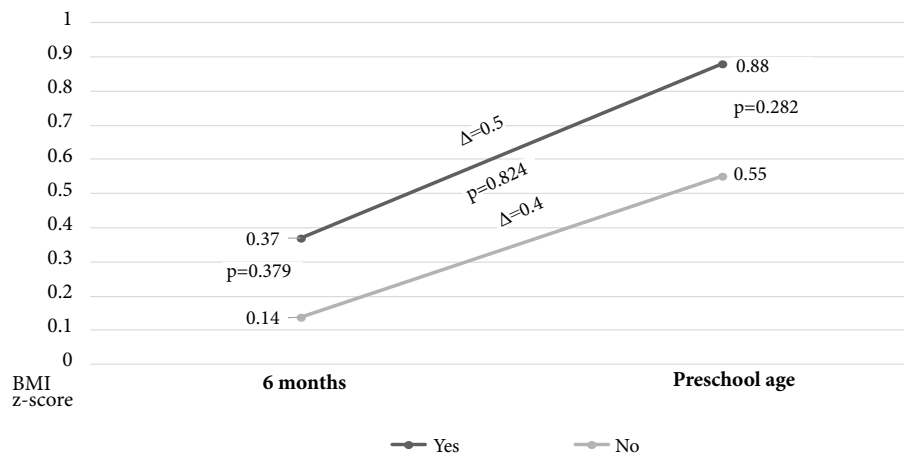

Figure 2. Variation in mean BMI z-score categorized by juice consumption before six months.

Note: Test used: Student's t-test.

Source: Authors.

The most commonly mentioned persons who recommended the introduction of fruit juice were health professionals. Considering that health workers are often a point of reference for families, these professionals must be constantly updated on specific guidance to avoid early fruit juice introduction. The findings of a qualitative study using focus groups of parents of overweight preschoolers showed that the participants suggested that pediatricians used concrete demonstrations such as showing the amount of sugar in fruit juice[25], demonstrating the importance of explaining the reason for not introducing juices before 1 year of age.

The latest edition of Brazil's dietary guidelines for children under 2, launched in 2019, recommends that the introduction of fruit juices before 1 year of age should be avoided. The guidelines also recommend that parents should avoid introducing juices between 1-3 years of

Table 3. Frequency of food consumption in preschoolers categorized by age at which fruit juice was introduced and type of fruit juice introduced; IVAPSA cohort. Porto Alegre-RS, Brazil, 2011-2019.

Foods	Frequency of consumption	Category		P-value
		Juice introduction ≤150 days (n=47)	Juice introduction >150 days (n=28)	
Artificial fruit juice, n (%)	≥once a day	30 (63.8%)	10 (35.7%)	0.028 ¥
	1 to 4 times/month	11 (23.4%)	8 (28.6%)	
	≤3 time/month	6 (12.8%)	10 (35.7%)	
Sandwich cookies, n (%)	≥once a day	10 (21.3%)	4 (14.3%)	0.001 ¥
	1 to 4 times/month	25 (53.2%)	5 (17.8%)	
	≤3 time/month	12 (25.5%)	19 (67.9%)	
		Artificial fruit juice not introduced before 6 months (n=62)	Artificial fruit juice introduced before 6 months (n=13)	
Soda, n (%)	≥once a day	7 (11.3%)	1 (7.7%)	0.014 ¥
	1 to 4 times/month	17 (27.4%)	9 (69.2%)	
	≤3 times/month	38 (61.3%)	3 (23.1%)	
Chocolate milk, n (%)	≥once a day	43 (69.4%)	5 (38.5%)	0.027 ¥
	1 to 4 times/month	8 (12.9%)	1 (7.7%)	
	≤3 time/month	11 (17.7%)	7 (53.8%)	

IVAPSA=Impact of perinatal environmental variations in the first 6 months of life; ¥ Chi-squared test.

Source: Authors.

age and, if juices are introduced, to give around 120ml of natural juices without added sugar per day[12]. It is important to highlight that stating an approximate amount rather than setting a maximum limit provides leeway for error, resulting in overconsumption of juice. In addition to the above, the consumption of sugar, which is often contained in industrialized juices, is not recommended before 2 years of age[12].

Few longitudinal studies have assessed the impact of introducing sugar-sweetened beverages before 1 year of age on nutritional status in later years. In a systematic review undertaken in 2019 to assess the relationship between types and amounts of foods and beverages during the complementary feeding period and growth outcomes, the authors suggested that there was a positive association between juice intake (natural and artificial) and infant weight-for-length and child BMI-for-age z-scores. However, the results are from observational studies in which there was variation in types of fruit juice and child age[26]. In a study with 1,189 children, Pan *et al.*[27] compared the prevalence of obesity at 6 years of age and consumption of sugar-sweetened beverages during the first year of life. The authors found that obesity prevalence at 6 years among children who consumed sugar-sweetened beverages during infancy was twice as high as that among non-consumers (17.0% vs 8.6%).

It is known that juices can make a considerable contribution to daily energy intake, which is directly related to weight gain. However, the present study did not observe an association between fruit juice introduction in infants under 6 months and anthropometric parameters in preschoolers. There was no statistically significant difference between the prevalence of overweight and obesity and in variation in BMI-for-age z-score between the two groups (early fruit juice introduction versus non-introduction) at both 6 months and preschool age. In contrast, the overall sample showed an increase in the prevalence of overweight and obesity between the first and second stages of the study (5.8% versus 26.2%).

The variables natural fruit juice consumption and artificial juice consumption were combined for analysis purposes since, despite containing vitamins and phytonutrients, the predominant ingredients in both natural and artificial juices are water and sugar (natural or added). In addition, the types of predominant sugars contained in these drinks are similar: monosaccharides (glucose and fructose) and disaccharides (sucrose). However, it remains unclear whether natural fruit juices and sugar-sweetened bever-

ages lead to the same metabolic consequences[7]. Furthermore, parents tend to believe that juices in general, especially natural juices, are healthy and that they, therefore, do not need to limit consumption[25].

Although our findings do not show a statistically significant association between overall juice consumption (natural and artificial) and anthropometric parameters, it is important to highlight that artificial fruit juice consumption, found in 17.3% of children, can be potentially harmful due to the high content of food colorings, artificial sweeteners, and added sugar. In addition, children have an innate preference for sweet foods and are in the process of developing dietary habits. Sugar consumption should therefore be avoided, especially during the first two years of life.

The findings show that early fruit juice introduction (≤150 days of life) was associated with increased consumption of artificial fruit juice at preschool age, corroborating the results of previous studies that demonstrated an association between the consumption of sugar-sweetened beverages before 1 year of age and consumption in later years[9,10]. In addition, early fruit juice introduction was also associated with increased consumption of sandwich cookies at preschool age: while there was no difference between the two groups (≤150 days versus >150 days) in the frequency category ≥once a day, prevalence in the category 1 to 4 times a week was higher in children who had been given juice before 6 months. In addition, children who consumed artificial fruit juice before 6 months showed a higher prevalence of soda consumption (1 to 4 times a week) at preschool age (69.2%) than those who had been given other types of juices (natural, diluted or concentrated) (27.4%).

Sensorial experiences in early life can shape preferences and predilection for certain flavors in later years. The early introduction of sugar contained in juice in infants may have influenced food preferences among preschoolers (consumption of artificial fruit juices, sodas, and sandwich cookies)[8]. In contrast, it is curious to note that the consumption of artificial fruit juice before 6 months was associated with lower consumption of chocolate drinks at preschool age.

Evidence shows that screen time (time spent using watching TV or looking at a cellphone, computer, tablet or other electronic devices) is associated with consumption of sugar-sweetened beverages in young children[28]. One of the reasons is that exposure to TV advertising and social media can lead to increased consumption of these beverages, despite the restrictions imposed by regulatory agencies. In the present study, 83.5% of preschoolers spent more than an hour a day looking at a screen, which exceeds the time recommended by the WHO for children aged 3-4 years (no more than an hour a day), indicating that these children may be highly exposed to sugar-sweetened beverage advertising[29].

Another factor that may contribute to the consumption of sugar-sweetened beverages is taxes on purchases. A meta-analysis evaluating the impact of increased taxes on sugar-sweetened beverages around the world showed that a 10% increase in taxes was associated with an average decline in beverage purchases and dietary intake of 10.0%. The authors recommend larger taxes to promote a greater decline in sugar-sweetened beverage consumption[30].

The present study has some limitations that may explain why the findings do not show an association between entre early fruit juice introduction and anthropometric parameters in preschoolers: the small study sample due to the high number of losses in the follow-up stage and the lack of certain confounding factors that may influence nutritional status, such as physical activity and habitual dietary intake. However, loss at follow-up is a common problem faced by longitudinal studies[31]. Furthermore, considering the length of time between the study and follow-up and difficulty in maintaining contact with the study participants, especially those from more socially vulnerable groups, the total number of cases analyzed may be considered reasonable and expected. Study strengths include: the longitudinal study design; the inclusion of infants at complementary feeding age, given that few studies have evaluated the impact of the introduction of fruit juices and sugar-sweetened beverages before 1 year of age; and the high quality of anthropometric measurements, given that weight and height were measured twice by trained researchers, minimizing potential bias.

Our findings show that the introduction of fruit juices to infants before 6 months does not influence anthropometric parameters at preschool age. However, the results show that early fruit juice introduction in infants before 6 months is associated with increased consumption of artificial fruit juice, sandwich cookies, and soda at preschool age. Further research is necessary to determine whether early introduction of natural and artificial juices can have long-term health consequences.

These findings reinforce the need for continuous training and updates for health professionals regarding the introduction of foods and beverages during infancy and its influence on future dietary habits. In addition, public policies are needed to reduce the consumption of sugar-sweetened beverages among children of all ages, including increased taxes on purchases, healthy eating and drinking campaigns, banning sales in schools, restrictions on child advertising, and the introduction of warning labels on sugary drinks to promote the development of healthy eating habits and protect the health of children.

Collaborations

PC Becker, RO Neves and JR Bernardi: conceptualization, literature review, research and survey design, data collection, data analysis, validation, and writing. RO Neves and JR Bernardi: critical review. MZ Goldani and CH Silva: conceptualization, writing and review. All authors have read and agreed to the published version of the manuscript.

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