Influence of fruit juice consumption before two years of age on the development of childhood obesity

Influência do consumo de suco de frutas antes dos dois anos de idade no desenvolvimento da obesidade infantil

Influencia del consumo de jugos de frutas antes de los dos años de edad en el desarrollo de la obesidad infantil

Abstract

Objectives: to describe the main data published in the literature, between the years 1990 and 2023, to better understand the influence of the consumption of fruit juices under two years of age on the development of childhood obesity. Methodology: the present study is a literature review where 55 articles on the subject were selected from the MEDLINE and Scielo databases from august 2020 to july 2023 and critically analyzed according to the relationship between the consumption of fruit juices in children under two years of age and obesity in adults. Result: studies have shown that the grinding step of the fruit for juice production removes fibers from its composition, negatively affecting gastrointestinal dynamics. In addition, fructose (i.e., found primarily in fruits) has a complex metabolism and accumulates adipose tissue if no associated fiber is consumed. It is also suggested that the balanced intake of juices throughout the first years of life prevents the accumulation of body fat in childhood and youth. Conclusion: excessive consumption of fruit juices should be avoided under two years of age, since their intake can contribute to the development of obesity and lead to important consequences from childhood to adulthood.

Keywords: Child; Fruit juice; Obesity; Carbohydrate metabolism.

Resumo

Objetivos: descrever os principais dados publicados na literatura, entre os anos de 1990 e 2023, para melhor compreender a influência do consumo de sucos de frutas menores de dois anos no desenvolvimento da obesidade infantil. Metodologia: o presente estudo é uma revisão de literatura onde 55 artigos sobre o tema foram selecionados das bases de dados MEDLINE e Scielo, no período de agosto de 2020 a julho de 2023, e analisados criticamente segundo a relação entre o consumo de sucos de frutas em crianças menores de dois anos e obesidade em adultos. Resultado: os estudos demonstraram que a etapa de moagem da fruta para produção de suco remove fibras de sua composição, afetando negativamente a dinâmica gastrointestinal. Além disso, a frutose (ou seja, encontrada principalmente em frutas) tem um metabolismo complexo e acumula tecido adiposo se nenhuma fibra associada for consumida. Sugere-se também que a ingestão balanceada de sucos ao longo dos primeiros anos de vida previne o acúmulo de gordura corporal na infância e juventude. Conclusão: o consumo excessivo de sucos de frutas deve ser evitado em menores de dois anos de idade, uma vez que sua ingestão pode contribuir para o desenvolvimento da obesidade e levar a consequências importantes desde a infância até a idade adulta.

Palavras-chave: Criança; Suco de fruta; Obesidade; Metabolismo dos carboidratos.

Resumen

Objetivos: describir los principales datos publicados en la literatura, entre los años 1990 y 2023, para comprender mejor la influencia del consumo de jugos de frutas menores de dos años en el desarrollo de la obesidad infantil. Metodología: el presente estudio es una revisión de la literatura donde se seleccionaron 55 artículos sobre el tema de las bases de datos MEDLINE y Scielo de agosto de 2020 a julio 2023 y se analizaron críticamente de acuerdo con la
relación entre el consumo de jugos de frutas en niños menores de dos años y la obesidad en adultos. Resultado: los estudios han demostrado que la etapa de molienda de la fruta para la producción de jugo elimina las fibras de su composición, afectando negativamente la dinámica gastrointestinal. Además, la fructosa (es decir, que se encuentra principalmente en las frutas) tiene un metabolismo complejo y acumula tejido adiposo si no se consume fibra asociada. También se sugiere que la ingesta equilibrada de jugos durante los primeros años de vida evita la acumulación de grasa corporal en la infancia y la juventud. Conclusión: el consumo excesivo de jugos de frutas debe evitarse antes de los dos años de edad, ya que su ingesta puede contribuir al desarrollo de la obesidad y llevar a consecuencias importantes desde la infancia hasta la edad adulta.

**Palabras clave:** Niño; Jugo de frutas; Obesidad; Metabolismo de los hidratos de carbono.

1. Introduction

Obesity is a public health problem and it is a global epidemic that contributes substantially to morbidity and mortality and the consequences of the increase in its incidence and prevalence alert health organs (Silva et al., 2021). This epidemic, however, has an alarming impact on developed and developing countries, increasing the chance of the emergence of diseases that can lead to death, such as diabetes, cardiovascular disease and up to 13 types of cancer, according to the National Cancer Institute (“Posicionamento do Instituto Nacional de Câncer José Alencar Gomes da Silva acerca do Sobrepeso e Obesidade,” 2019). It is also concerning that a high body mass index (BMI) in childhood can lead to obesity in later life. However, childhood obesity depends on several factors, including the process of introducing food in solid form and subsequent food intake over the years (Andrade et al., 2016).

While there is preeminent research on this topic, controversies are still seen, and decision-taken actions towards better recommendation standards regarding juice consumption in childhood are lacking. Several studies indicate that excessive consumption could lead to increased risk of childhood obesity (Dennison et al., 1997), while some evidence show that this association is not true (Crowe-White et al., 2016). Thus, this review aims to describe the main discoveries found in the literature about this field between the years 1990 and 2020 to better understand the relationship between childhood obesity and the consumption of natural fruit juice before two years of age.

2. Methodology

The present study is a bibliographic review of the narrative type. After defining the objective of better understanding the influence of the consumption of fruit juices under two years of age on the development of childhood obesity, the search in the literature began and, despite the large number of articles available in the literature, it is important to search for articles that provide the necessary subsidies to the central idea of the study (Pereira, 2018). Thus, 55 articles related to the theme addressed were selected, regardless of the type of scientific study, critically analyzed after observation of the similarities and differences and explained by the authors of the study (Pereira, 2018) and used in the composition of this review. For the aforementioned selection, the MEDLINE and Scielo databases were consulted, from August 2020 to July 2023. The keywords used to search for the articles were: child, fruit juice, obesity and carbohydrate metabolism. The keywords guided, but did not delimit the searches. The terms listed in Portuguese were used for research in Brazilian journals. Relevant references and articles of paramount importance in the context of the review were also analyzed, regardless of the date of publication. There was no maximum time for the inclusion of the review were also analyzed, regardless of the date of publication. There was no maximum time for the inclusion of the review.
Table 1 - Publishing time range and quantity of articles revised.

<table>
<thead>
<tr>
<th>Time range</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>1990 - 1995</td>
<td>2</td>
</tr>
<tr>
<td>1996 - 2000</td>
<td>7</td>
</tr>
<tr>
<td>2001 - 2005</td>
<td>6</td>
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<tr>
<td>2011 - 2015</td>
<td>16</td>
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<tr>
<td>2016 - 2020</td>
<td>21</td>
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<td>2021-2023</td>
<td>3</td>
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</tbody>
</table>

Source: Authors.

Table 1 shows the growth in the number of important studies on the subject over the years, that is, selecting old articles on this topic is more difficult when compared to finding them in the most recent literature, which demonstrates the current ascendancy of research on fruit juice consumption by young children, in addition to the growing concern about childhood obesity and the factors related to it.

Table 2 - Summary points of ten notable articles revised.

<table>
<thead>
<tr>
<th>First author</th>
<th>Summary points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallfrisch (1990)</td>
<td>The increased consumption of fructose among the general population and people with metabolic disorders has consequences due to its absorption and metabolism.</td>
</tr>
<tr>
<td>Perman (1996)</td>
<td>Absorption of fructose and sorbitol present in fruit juice has consequences in children.</td>
</tr>
<tr>
<td>Dennison et. al (1997)</td>
<td>Fruit juice consumption $\geq 12$ fl. oz/day during childhood is associated with short stature and obesity.</td>
</tr>
<tr>
<td>Kolotkin et al. (2001)</td>
<td>Obesity is a condition not caused solely by a single factor. Instead, obesity is multifactorial, including genetic, metabolic, sociobehavioral and cultural factors.</td>
</tr>
<tr>
<td>De Mello et. al (2004)</td>
<td>Childhood obesity is increasing, has serious metabolic consequences and several are the challenges to avoid it.</td>
</tr>
<tr>
<td>Barreiros et. al (2005)</td>
<td>Early diagnosis of inborn errors of metabolism and the consumption of an adequate amount of this sugar in the diet are important to avoid side effects.</td>
</tr>
<tr>
<td>Lacerda et. al (2014)</td>
<td>Obesity and overweight are public health problems caused by the sum of poor eating habits, inactive lifestyles, lack of information and awareness of family members, genetic predisposition and socioeconomic factors.</td>
</tr>
<tr>
<td>Andrade et. al (2016)</td>
<td>The first 1,000 days of life are an opportunity to influence the epigenetic programming of obesity factors and avoid future diseases.</td>
</tr>
<tr>
<td>Heyman et. al. (2017)</td>
<td>Fruit juice has no benefits for children under 1 year; it is necessary to give preference for the whole fruit; consuming fruit juice excessively can cause malnutrition or other health problems.</td>
</tr>
</tbody>
</table>

Source: Authors.

Table 2 presents a summary with the main points about the main articles used in the narrative review. Thus, it is clear how researchers demonstrate the importance of understanding fructose metabolism, the consequences of excess sugar consumption and childhood and adult obesity, the benefits of a quality food introduction and the harms of offering fruit juice to children. However, it is evident that this availability of articles influences the recommendations on this theme by health professionals who follow the literature.
3. Results and Discussion

3.1 Childhood obesity overview

Obesity is listed as a disease in the Group of Chronic Non-Communicable Diseases (Pinheiro et al., 2004) and is multifactorial, including genetic, metabolic, sociobehavioral and cultural factors (Kolotkin et al., 2001). It is known that chronic-degenerative diseases are directly associated with excess fat levels in the abdominal or trunk region, excess visceral fat and total amount of fat (de Mello et al., 2004), being a public health problem that increases morbidity and mortality worldwide (de Mello et al., 2004). In addition, obesity has been increasing markedly and has presented several complications for the affected population, both in childhood and adulthood (de Mello et al., 2004; Hasnain et al., 2014).

There are different ways to assume that an individual is actually obese. The World Health Organization (WHO) uses the BMI criterion, which considers the height and weight of the individual. In the case of children, it is necessary to analyze them according to their ages. Thus, two forms of classification according to BMI by the WHO were created, one for children from 0 to 5 years old and another for children from 5 to 13 years old. Despite the existence of other tables and other age groups, the weight/age table for children aged 0 to 5 years classifies children as obese only if they are above p97 or have a z score of +3 (Camarinha et al., 2016).

In Brazil, recent data state that 1 in 10 children up to 9 years and 11 months of age are obese, being 10% in girls and 13% in boys, according to the criteria determined by the WHO (Castro et al., 2019). In addition, in Japan, in 10 years, the mean BMI by age increased by 0.32 kg/m² in boys and 0.24 kg/m² in girls and, as a consequence, the prevalence of obesity increased from 6.1% in boys and 7.1% in girls to 11.1% and 10.2%, respectively (Matsushita et al., 2004). In the United States, childhood obesity is also increasing, with 25% of the child population overweight and 11% obese (Lacerda et al., 2014). The explanation would be the change in eating habits and/or lifestyle changes over the years, including early weaning, the introduction of formulated and processed foods, prolonged screen time, reducing energy expenditure from outdoor activities, among others (Lacerda et al., 2014).

Childhood obesity is closely linked to comorbidities in adulthood, such as obesity, hypertension and cardiovascular diseases – three aspects that correlate with mortality today. Thus, preventing childhood obesity effectively reduces chronic-degenerative diseases (de Mello et al., 2004).

3.2 Fruit juice consumption in childhood

Recommendations of juice intake

WHO recommends that breastfeeding be exclusive in the first six months of life, without water, tea, or juice, since breast milk has the nutrients responsible for immunomodulation, protection against allergies and infections, neurological maturation, and infant digestion. Breastfeeding should be stimulated until 24 months or more (Manual de Orientação - Departamento de Nutrologia, 2012).

Traditionally, fruit juice intake was on pediatricians’ recommendations as an additional source of water and vitamin C to children (Heyman et al., 2017). However, both industrialized and artificial juices contain a large amount of dyes, sugars and monosodium glutamate, a highly harmful component to the central nervous system (Ferreira, 2015). Since children under two years of age have cognitive immaturity, this consumption can generate mental disorders such as hyperactivity, developmental and attention deficit, autism and depression, in addition to other metabolic disorders such as obesity and diabetes (Ferreira, 2015). Therefore, some aspects such as the age and the amount of natural fruit juice ingested by the child are also relevant.

The Brazilian Society of Endocrinology and Metabolism, in its guide to feeding children up to two years of age, highlights the importance of the consumption of fruit juice rich in vitamin C (from 50 to 100 mL per day) for children who have already undergone food introduction, when it is not possible to eat meat, favoring the absorption of inorganic iron (Dez...
Excessive natural or industrialized fruit juice intake in childhood

In childhood, there is an innate preference for sweet taste, but offering sweet foods to children increases the chance of rejection of natural foods (Giesta et al., 2019; Louzada et al., 2015; Tandoi et al., 2017). In addition, food introduction is essential for the formation of eating habits (Marques et al., 2013).

The consumption of ultra-processed products already in the first six months of age is typical in Brazil (Saldiva et al., 2014). In addition, a study with North American children from the last trimester of pregnancy to the 6th year of life showed a 92% chance of the child will be obese in the future when the introduction of sugary fruit juice occurs before 6 months of life (Pan et al., 2014). Juices produced by the industry go through several stages and take many ingredients, such as salt, fats, oils, food additives and sugar (Ministério da Saúde, 2019), being sources of sodium, preservatives and food additives (de Alcântara & de Almeida, 2020). Regarding the consumption of overall (i.e., other than juice) ultra-processed products, there was an important growth between 2000 and 2013, being 43% worldwide (114% in Asia and the Pacific, 73% in Eastern Europe and 48% in Latin America) at all ages (Bortolini et al., 2019).

Some industrialized juices also lack fiber, an important component for intestinal health (Ferris et al., 2017), increase satiety (Wojcicki & Heyman, 2012), improve cholesterol profile and decrease low-density lipoproteins (LDL) (Brown et al., 1999), in addition to improving glycemic control in patients with diabetes mellitus (Riccardi & Rivellese, 2000) and helping to reduce body weight (Birketvedt et al., 2005). The consumption of at least 30 g/day added to the variety of fiber sources can be significant (Bermaud & Rodrigues, 2013).

Of note, when the juice is indicated to supply some individual need of a child older than six months, it is suggested offered it in a glass to prevent also dental caries, which is another problem caused by the consumption of juice (König & Navia, 1995), avoiding prolonged exposure of teeth to sugars (Heyman et al., 2017).

3.3 Fructose metabolism increases lipids production

Fructose is a monosaccharide obtained by the ingestion of fruits or glucose and may be involved in the development of childhood obesity associated with the ingestion of fruit juices, since its metabolism results in increased blood lipids (Barreiros et al., 2005; Campbell et al., 2014).

Its absorption may be by a transport that does not depend on glucose, but has less influence, or by a glucose-dependent pathway, which has greater influence (Perman, 1996; Shi et al., 1997). Thus, absorption is potentiated when ingested together with glucose. After the absorption of fructose in the intestine, it is taken to the liver, leaving the enterocyte through the
basolateral membrane and reaching the blood of the portal vein, ending its transport in the liver (that is, responsible for its metabolism) (Buchs et al., 1998).

Studies show a higher production of triglycerides in the human body associated with fructose intake compared to more complex carbohydrates such as glucose (Hallfrisch, 1990). In addition, excessive fructose consumption can lead to metabolic syndrome, since there is an association with ectopic fat accumulation, especially in the liver (Lim et al., 2019; Mirtschink et al., 2018; Santos et al., 2019; Stahl et al., 2019; Stanhope et al., 2018).

Fructose is widely used to sweeten industrialized beverages and fruit juices, because it is more soluble in aqueous solutions and about 1.5 times sweeter than sucrose (Gaino & Silva, 2011). Each gram of fructose offers 16kJ of energy (Barreiros et al., 2005) compared to glucose which offers 14kJ of energy per gram (Spolidoro, 2000).

3.4 1000-day theory

The 270 days of gestation and the 730 days of the first two years of life add up to 1000 days of great relevance for the development of the child, which include adequate feeding of the pregnant woman, exclusive breastfeeding of the newborn up to 6 months and subsequent introduction of balanced feeding (Andrade et al., 2016).

In addition, the beginning of life is an essential period for development, including eating, sleeping, the first exertive physical activities of the human body (Taylor et al., 2016) and even the development and increase in the size of fat cells (Hauner et al., 2013). Soon after birth, body fat that represents about 14% of total weight grows to 20% in 1 year (Hauner et al., 2012).

Thus, knowing that there is a relationship between food introduction (AI) and childhood obesity, some factors should be taken into account, such as the fact that, in addition to the fact that AI should not precede 4 months or extend after 6, it should not be based on hypercaloric foods, but rather low energy density, such as fruits and vegetables. Salt, sugar, fruit juices, sugary drinks, sweets, soft drinks, pasta and industrialized should not be offered (Lellis & Coelho, 2023). However, the reality is different, as shown by a cross-sectional Brazilian study that observed that more than a third of children aged 12 to 23 months (1,216 children out of a total of 4,863 studied) consume artificial juices (Flores et al., 2021).

The theory of epigenetics and the concepts of neurobiology show that a phenotype is formed with changes in gene expression and can even be transmitted to future generations (Noro & Gon, 2015). Thus, the first 1000 days of life are an opportunity to generate an excellent metabolic scheme and avoid future damage such as obesity and chronic diseases (Andrade et al., 2016), since fat deposition in babies is associated with excessive weight gain in adulthood (Rudolph et al., 2017).

4. Conclusion

Although the topic is challenging and not yet fully understood, several studies between 1990 and 2023 have shed light on the relationship between fruit juice consumption by individuals under two years of age and overweight or obesity in adulthood. It was found that exclusive breastfeeding in the first 6 months of life, the phase in which adipose tissue cells develop, is essential to avoid overweight or obesity in adulthood. In addition, even small amounts of fruit juice taken by children under 2 years of age play a role in childhood and adult obesity. The unfavorable effects of fruit juice on children affect both developed and underdeveloped countries, also relying on cultural aspects of child nutrition. Thus, more research is needed for applicability to the clinical scenario, allowing the establishment of standards and integrated information to health professionals, aiming to provide the correct and necessary guidance to parents and caregivers, so that the children they assist have the opportunity to develop a healthy metabolic profile and a better body composition in adult life. In addition, future research should aim at the creation of nutrition protocols applicable to daycare centers and schools, seeking to reduce the consumption of sugary drinks and fruit juice by children under 2 years of age in their living scenarios.
Conflict of interest

Authors declare no conflict of interest.

Author contributions

Study concept and methodology design: CGS, JVFF; data curation: CGS, JVFF and DPMD; drafting of the manuscript: CGS, JVFF and DPMD; critical revision of the manuscript: CGS, JVFF and DPMD; and study supervision: DPMD.

References


