

Energy density and the nutritional quality of diets based on their sugar content

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Abstract

Sugar content in foods cannot be distinguished from added sugar, although it is true that this added sugar brings mainly energy and no other essential nutrients. On the other hand, in the context of diet, sugar helps make it more varied and palatable allowing including foods that may otherwise not be would consume, thus indirectly contributing to the intake of other nutrients.

Having interest in knowing the possible relationship between a high intake of sugars and the decrease in micronutrients intake, we noted that the nutrient density of the diet might be influenced by factors such as the high presence of sugar added to food. It seems that this nutritional dilution produced by adding sugar to food is, in general, not very significant and, often, offset by the fortification in micronutrients that we usually can find in many sugary products. After a detailed analysis of the published studies on the subject, it has been found that there is no a clear evidence of the hypothetical micronutrient dilution that would occur by adding sugar to the diet.

On the other hand, given that the addition of sugar to the diet doesn't seem to report any remarkable advantages from the point of view of the intake of micronutrients; It seems reasonable to promote a moderate consumption of foods and sugary drinks, so in that way, they become an important extra energy source.

It should also be borne in mind that the addition of sugar to the diet does not seem remarkable report any advantage in terms of intake of micronutrients. For this reason, it seems logical that the consumption of sugary food and sweet drinks will be moderate given the ease of consumption and the likelihood of their becoming a major source of energy.

Finally, it is concluded on the need for further research on the mechanisms underlying that, up to now showed no, possible displacement of micro-nutrients and other food components of the diet that could occur in cases of consumption of foods with a high sugar content, as well as their impact from a clinical point of view.

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LA DENSIDAD ENERGÉTICA Y LA CALIDAD NUTRICIONAL DE LA DIETA EN FUNCIÓN DE SU CONTENIDO EN AZÚCARES

Resumen

El azúcar contenido de forma natural en los alimentos no se puede distinguir del añadido, aunque lo cierto es que este azúcar de adición aporta fundamentalmente energía y no otros nutrientes esenciales. Por otro lado, en el contexto de la dieta, el azúcar contribuye a hacerla más variada y apetecible permitiendo incluir alimentos que quizá de otra manera no se consumirían, contribuyendo pues indirectamente a la ingesta de otros nutrientes.

Habiendo interés en conocer la posible relación entre una elevada ingesta de azúcares y la disminución de la de micronutrientes, se ha observado que la densidad nutritiva de la dieta podría estar influida por factores como la presencia elevada de azúcar añadido en los alimentos. Parece ser que esta dilución nutricional producida al añadir azúcar a los alimentos es, en general, poco significativa y, a menudo, contrarrestada por la fortificación en micronutrientes que frecuentemente encontramos en numerosos productos azucarados.

Tras el análisis en detalle de los estudios publicados al respecto, se ha comprobado que no existe una evidencia clara de la hipotética dilución de micronutrientes que se produciría al añadir azúcares a la dieta.

Por otra parte, dado que la adición de azúcar a la dieta no parece reportar ninguna ventaja destacable desde el punto de vista de la ingesta de micronutrientes; parece razonable que se promueva un consumo moderado de alimentos y bebidas azucaradas, para de ese modo, evitar que se conviertan en una importante fuente energética extra.

Finalmente, se concluye sobre la necesidad de profundizar en la investigación acerca de los mecanismos subyacentes a ese, hasta ahora no demostrado, posible desplazamiento de micronutrientes y otros alimentos componentes de la dieta que podría ocurrir en casos de consumo de alimentos con un elevado contenido en azúcares, así como su repercusión desde un punto de vista clínico.

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Palabras clave: *Micronutrientes. Densidad energética. Dilución de nutrientes.*

Abbreviations

NT: Nutrition transition.

NMES: Non milk extrinsic sugars.

DRI: Dietary reference intakes.

EBRB: Energy balance-related behaviours.

DOiT: Dutch Obesity Intervention in teenagers.

FAO: Food and Agriculture Organisation of the United Nations.

Introduction

There is growing concern about the relationship between high sugar consumption and the possible decrease in macronutrient intake in the populations of developed and developing countries. However, the fact is that so far studies have not reached a clear conclusion on this matter.

The concern about a possible connection between sugar and public health is old, as confirmed by the various guidelines that have been issued on the dietary intake of added sugars and tooth decay¹, however the guidelines on limiting added sugars with the aim of preventing the dilution of micronutrient intake are unclear and often controversial.

If we consider what is really important for public health it is lifestyle, and within this, overall diet; we accept that, although sugar intake is important, it continues to be just one part of an individual's overall diet.

Which is precisely why countries that are concerned about excessive sugar consumption have undergone,

over the last few decades, huge lifestyle changes in their populations, especially when it comes to food. This change is known as nutrition transition (NT) and consists of a number of eating habit and lifestyle changes, associated with certain improvements in socioeconomic and health conditions (demographic and epidemiological transition) which far from leading to an improvement in health, seem to have a positive relationship with increases in excess weight and obesity rates, as well as certain chronic illnesses, such as cardiovascular disease and type II diabetes mellitus.

NT is broadly characterised by a reduction in consuming foods that are high in complex carbohydrates and fibre (bread, cereals, pasta, pulses, potatoes) in favour of those that contain sugar, dairy products and other products of animal origin. As a result, in these populations there has been an overall increase in total energy intake, animal protein and fats.

Since NT is worldwide phenomenon², Of the Western countries, Spain is a good example for illustrating its impact, as the social and economic changes in our country during the 20th century were very rapid (Fig. 1) and especially from the 1970s onwards³.

According to Popkin y Gordon-Larsen⁴, different regions or countries of the world would be (depending on their level of cultural and technological development) in one of the three final stages proposed by the authors in an attempt to summarise the characteristics that define the progression of NT. According to this proposal, Spain would currently be in phase⁴ of the process which is summarised in figure 2.

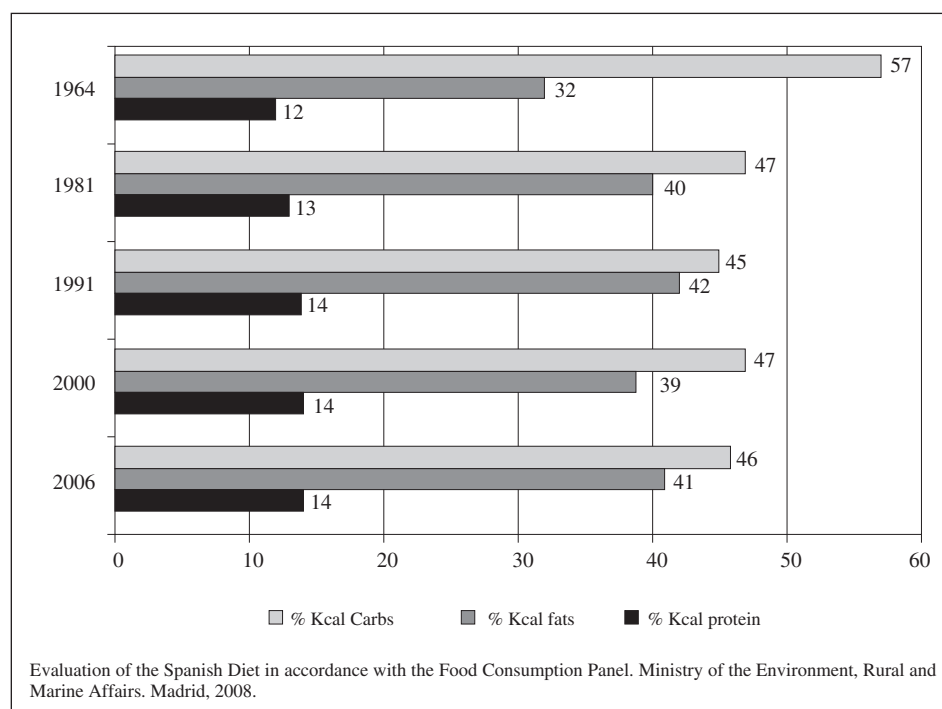


Fig. 1.—The evolution of calorie profiles in Spain (1964-2006). % of total energy from the immediate principles.

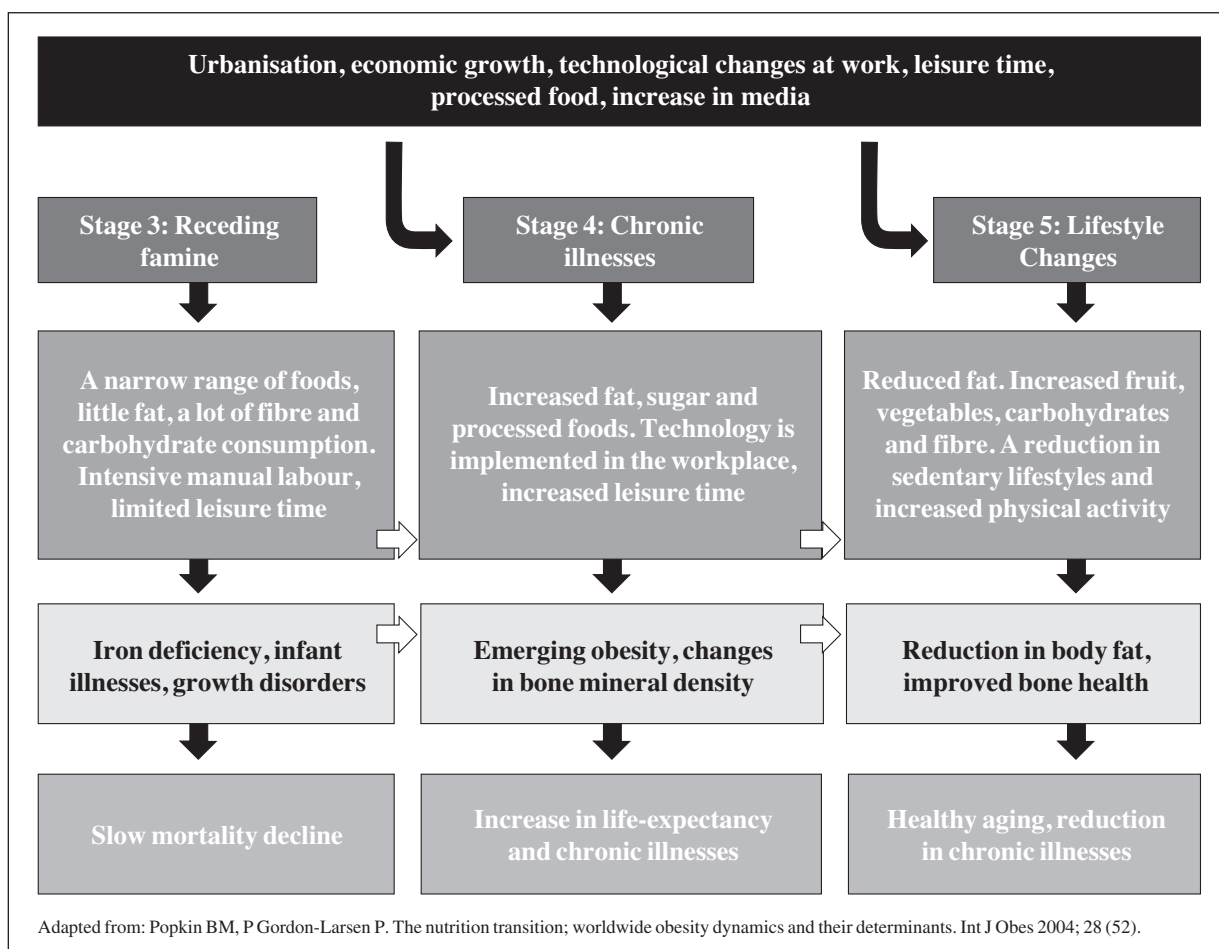


Fig. 2.—Stages of nutrition transition.

Definitions

Any review of the evidence on micronutrient dilution should refer to the inconsistencies that exist in scientific literature⁵ and that mainly stem from a variation in the definition of the term ‘sugar’ (as this term can include total sugars, added sugars or free sugars). This inaccurate categorisation could substantially affect the analysis of the relationship between sugar intake and micronutrients.

Sugar is an all-pervasive ingredient in the food industry and is also consumed as an ingredient that is naturally present in many foods. One of the main concerns is, precisely, to specify what is meant by ‘sugar consumption’. So, in the USA added sugars are defined as those sugars, sweeteners and syrups that are consumed as such or even used as ingredients in processed or prepared foods, therefore excluding sugars naturally found in honey and fruit.

In the UK, the term NMES is preferred (non milk extrinsic sugars), a category which includes all sugars that are not naturally found in milk or dairy products and which is effectively synonymous those that are usually called ‘free sugars’.

Sugar intake recommendations

In the USA, in the year 2000, when drafting the corresponding *Dietary Guidelines* it was recommended that the population choose foods and drinks that, on the whole, help moderate the population’s sugar intake.

The 1990 World Health Organisation guidelines, reiterated by the Committee of Experts on diet, nutrition and the prevention of chronic diseases, recommended that the consumption of free sugars should not exceed 10% of the total energy intake¹. However, the American Institute of Medicine concluded, in the 2002 dietary reference intake (DRI) edition, that there is insufficient evidence to enable the maximum intake of added sugars to be selected, as we don’t know the exact adverse effects on health associated with ‘excessive’ consumption. On the other hand, it has also been suggested in these DRI that the maximum intake from added sugars should be 25% of the total daily energy, given the growing concern about inadequate micronutrient intake but without being ‘interpreted as a recommendation for consumption’.

In short, from the overall data on dietary intake it could be concluded that, overall, it's possible that a proportion of the population consumes larger amounts of sugar than are recommended, which is reflected in the results of some of the reviewed studies, that place this consumption at about 15-17% of the total caloric value based on the population group studied.

Weaknesses

Without a doubt, sugar content which is naturally found in food, such as fruit, cannot be distinguished analytically from added sugar. Nutrient density, i.e. the intake of nutrients in relation to energy intake, is commonly used as an indicator for the quality of a diet. In spite of the fact that for certain populations it is imperative to achieve high nutrient density, as in young or sick people who for different reasons restrict their eating, we can't extend this recommendation to the whole population.

The nutritional consequences of added sugar consumption. The problem of nutrient density and dilution

The diet's nutrient density can be influenced by various factors, one of which is sugar added to foods. So, diets that include high intakes of added sugar are often characterised by an increase in total energy value, whilst decreasing nutrient density.

This has been noted in the case of adults and, above all, in young people. Studies carried out in South African, on an adult female population, have shown a reduction in nutrient intake as added sugar intake increases and the Lyhne study showed a general trend towards a reduction in nutrient density when the percentage of energy obtained from added sugars increased. This negative association is a lot narrower than those mentioned in previous studies.

All these results are in line with Gibson's results on British adults' diets, who observed that an increase in the energy percentage obtained from added sugars, increased total energy intake and slightly decreased micronutrient intake. The only micronutrient whose levels were not affected in this way was vitamin C.

It seems that this nutrition dilution which is produced by adding sugar to food is, in general, not very significant and is frequently offset by micronutrient fortification, which is often found in many sugary products. In this way, the possible negative association with added sugars and nutrient density can be offset through the fortification of foods. In fact, in the case of children and adolescents, fortified foods (for example, certain drinks, dairy products, cereals, etc.) contribute substantially to the total

intake of vitamins and minerals, at least in Germany and the USA.

In this respect, it is a good idea to take the World Sugar Research Organisation's declaration of principles into consideration⁵, whose report 'Sugar and micronutrient dilution' (issued in January 2012) states that 'It is often assumed that a diet high in sugars reduces the intake of essential nutrients (or micronutrient dilution). However, this is often a simplified view of a rather more complicated problem and for which there is insufficient scientific evidence. Additionally, a reduction in sugar intake may be unpredictable and have undesirable consequences for public health. For example, certain foods would be avoided that, even though they contain sugar, would be fortified or high in micronutrients per se.'

Energy consumption and obesity

Recent studies show a significant increase in daily energy intake in relation to increases in sugary drink consumption by children, adolescents and adults. However, the evidence regarding the positive association between the consumption of sugary drinks and obesity is inconsistent. This would seem logical as both excess weight and obesity are very complex situations, from a metabolic point of view, to be able to pinpoint the blame for their development on a single food or group of foods. As a result, the issue is open to debate as it is possible to find studies that highlight the likely relationship between sugary drink consumption and the risks of excess weight and obesity, meanwhile other authors show evidence to the contrary.

If we refer to this positive relationship, it should be taken into account that the development of obesity in the USA ran parallel to an increase in the consumption of added fructose, as a result of the introduction of high fructose corn syrup as a sweetener in drinks. Evidence on the causal relationship between high fructose intakes and metabolic disorders is quite clear and a recent study on American adults confirmed the link between fructose consumption and dyslipidaemia⁶. In this regard, high consumption of sugary drinks increases the risk of developing type 2 diabetes, as demonstrated by the Health Professional Follow-up Study⁷, an effect which also produces an increase in the risk of coronary heart disease according to the Nurse's Health Study (when more than two units of these drinks are consumed per day, the risk is 35% higher than in those subjects who did not consume them or who consumed them in very small quantities), an effect that could even be measured by an increase in different inflammatory markers.

We note here the recent Aeberli study⁸ which shows how adverse effects of cardiovascular risk markers occur (LDL, fasting blood glucose and C-reactive

protein or CRP) even following the consumption of low or moderate amounts of sugary drinks. This effect appears quickly and can be measured in healthy young men after 3 weeks of consumption, which gives these results special significance when it comes to providing dietary advice to young consumers.

The fact is that sugary drinks consumed with foods have doubled in recent years. In a well-known trial, it was found that increasing the size of sugary drinks involved a parallel increase in the energy consumed from solid foods. In this way, by increasing the size of sugary drinks, the energy consumed from foods ultimately increased by 10% in women and 26% in men.

Between 1970 and 2005, the sugars and sweeteners available for consumption in the USA increased on average by 76 calories a day, from 25 teaspoons (around 400 calories) to 29.8 teaspoons (476 calories), which corresponds to an increase of 19%. Bray et al pointed out that added sugar consumption increased from 235 calories per day per person in 1977 to 318 calories/day per person in 1994, drawing particular attention to the fact that high fructose syrups increased from 80 to 132 kcal per day per person during the same period.

A NAHNES study found that the average intake was 22.2 teaspoons of sugar per day (355 kcal) and between the ages of 14 and 18 is when the highest consumption occurs, equivalent to 34.3 teaspoons per day (549).

Added sugar intake in children's and adolescents' diets, according to the Donald study, represent between 10 and 13% of total daily energy and is similar to the values found in studies carried out in Germany (from 12 to 14% of total energy) and in Denmark (14% of energy). Sugar intake in Great Britain provides around 17% of daily energy and in the USA 16% of the energy for children between the ages of 2 and 5 years old, and 20% for young people between the ages of 12 and 19 years old. All the studies agree that sugar consumption is higher than the traditionally recommended limit (10% of total energy) in these countries.

Therefore, these results show a weak but general trend towards a reduction in the nutrient density of vitamins and minerals when there is an increase in calories from added sugars, as many authors have concluded. This effect is magnified when micronutrients are not fortified, which supports the hypothesis that fortified foods may behave like masking factors for the possible dilution of nutrients.

Minerals

As far as mineral intake is concerned, the results of the different studies published are inconsistent when it comes to the impact of a diet rich in added sugars on calcium, iron and magnesium intake. If we refer to iron intake, in most studies there is a correlation between

calcium levels and high sugar diets which is only seen in women. So, both low sugar and high sugar diets are associated with lower iron levels. Nevertheless, Gibson et al.⁹ did not find any association between sugar intake and iron status in aging adult populations, or the serum ferritin levels in men and women.

As far as zinc is concerned, the results are somewhat more consistent since numerous studies observed an inverse association between added sugar intake and zinc, in adults and it would seem also in children.

Vitamins

The results are inconsistent when it comes to the amounts of vitamins A, B₁, B₂, B₆, folates, vitamin C and vitamin E consumed, in the context of a high sugar diet. In the case of vitamin C and vitamin B₂, some authors indicate a positive association. However, it is important to bear in mind that the average intakes of these vitamins (A, B₁, B₂, B₆) in the general population normally exceeds the recommended amounts.

So, in the case of vitamin E, in the UK data that refers to intake in adults is indicative of higher than recommended intakes, although this data has not been confirmed by other researchers. On the other hand, when it comes to folate the overall folate intake is low, both in women and children, and independently from sugar intake. This could explain, at least in part, the gender differences that exist when reviewing what happens to folate when there is high added sugar consumption. In this case, there are more studies that show a clear connection between sugar consumption in women and a lower folate intake. For the same reason, this correlation does not occur in men⁹.

Given the proliferation of studies that used different methodologies, it is difficult to find conclusive data when it comes to the infant population, where, at any rate, there is an inverse association between added sugar intake and vitamin B₁. This reduction in consumption could reach 3% in children who obtain less than 8% of their daily calories from added sugars and is the same amount even if they consume more than 16%. Furthermore, in another study they found that children who consumed higher amounts of sugars were not even able to meet their daily recommended intakes of vitamin B₁.

As we have already observed in the case of iron, it seems there is a non-linear relationship between added sugar and vitamin intake. For example, women who eat added sugars in moderation consume more vitamin E than those who eat a lot or, on the contrary, very little sugar. In certain cases, there has been an increase in vitamin C intake. This is probably because the sugar consumed came from the addition of fruit juices. In short, it seems clear that there is no association between plasma vitamin C status and the addition of sugars to the diet.

Threats

Sugars added to foods as a percentage of energy intake tend to increase with age amongst young people; the opposite occurs when it comes to micronutrient intake, with lower intakes of some of them such as folates, vitamin C and calcium.

To clarify this data a little, as numerous as they are contradictory, maybe Gibson's statement is illustrative as it confirms that 'in the same vein, in England, it has been proven that⁹ a diet moderately high in added sugars (around 15% of total energy) does not appear to affect micronutrient intake, energy intake (and not its origin) is, in fact, the main determinant for the adequate intake of micronutrients.'

Although it is not the purpose of this chapter, the Intermap study included data related to blood pressure, sugar and sugary drink consumption in the UK and USA, in a sample of 2,696 people between the ages of 40 and 59 years old. Sugary drinks were directly linked to blood pressure¹⁰.

Strengths

It would be advisable to promote healthy eating to the population; a diet that incorporates moderate amounts of sugar in foods and specific situations. In this way, in order to develop measures that prevent unhealthy weight gain, changes should be made to the 'energy balance-related behaviours' (EBRB). So, consuming large quantities of sugary drinks, spending time watching TV or in front of the computer are behaviours that are associated with an increased risk of obesity.

In this sense, school is considered the ideal place to put measures in place that reduce the incidence and prevalence of childhood and adolescent obesity, as they offer the possibility of continuous, intensive contact with young people or children from all socio-economic and even ethnic backgrounds. However, the inadequate preventative measures that have so far been developed in this field, have sparked a debate, in various countries and on different occasions, over what would be the best and most effective strategies to deal with this.

The Dutch Obesity Intervention in Teenagers (DOiT) was a randomised study, developed in schools, which proved to be effective in reducing the consumption of sugary drinks among adolescents. It showed that interventions that try to reduce sugary drink consumption can be effective without changing the consumption of other drinks.

Of course, including the family and home environment in these strategies would increase their effectiveness in preventing obesity^{11,12}. Nevertheless, the mechanism and effect of parental involvement in obesity prevention programmes is still not clear.

As the effects of habits established at home show, we can mention the Harris study¹³, which found that when children ate breakfast containing high sugar products, it increased, in a similar way, total daily sugar intake and also reduced the overall nutritional quality of their breakfast.

On the other hand, it should be noted that the risk of obesity can be very different for different population groups, so strategies are needed that allow for the individual nature of each of these groups. In fact, the pupils' gender is one of elements which is regularly considered and there seems to be a correlation in that the measures are more effective in girls than boys, probably because in early adolescence girls and boys respond differently to different intervention strategies. This variable can be embedded in a very complex framework whatever the starting weight or socioeconomic background of the young people may be, for example, there hasn't even been sufficient evidence of consistent energy intake moderators related to different lifestyles.

In the Bjelland study¹⁴, which lasted eight months, it was confirmed that, amongst young people, gender was a result-related variable, in so far as it affected the response to educational interventions in such a way that the preventative measures seemed to work better for girls than for boys.

Finally, when it comes to the various opportunities to improve the diet and health of the population, it is of interest to mention Thornley's work¹⁵. It examined the possible association between asthma and the per capita sugar consumption of six and seven year old children. For this study, clinical data was collected on asthma between 1999 and 2004 in 53 countries and the sugar consumption per capita was obtained from the FAO's food balance sheets. Once the results had been analysed, a connection was observed between the severity of asthma symptoms and the per capita consumption of added sugars (in kilos per annum). In other words, a moderate ecological association was found between sugar consumption during the perinatal period and the subsequent risk of severe asthma symptoms in 6 or 7 year old children.

Opportunities

The link between diet and health opens up new prospects in areas which have certainly not had much emphasis placed on them in recent years. This occurs with the low consumption of sugary drinks and added sugars, which are associated significantly with a reduction in blood pressure. So, consuming moderate and adequate amounts of sugary soft drinks and added sugar could be a significant strategy for reducing blood pressure¹⁶. Nevertheless, the way in which high consumption of sugary drinks may be connected to the risk of hypertension is unclear. In fact, although this

link between high sugary soft drink consumption and increased blood pressure has previously been observed in tests animals, this has certainly not yet been proven in humans (which would be necessary where there is a 3 mmHG reduction in systolic pressure that could reduce the death rate from myocardial infarction by around 8% and from coronary heart disease by 5%).

Ultimately, as one might expect, a healthy and balanced diet contains natural sources of sugar, since monosaccharides, such as fructose, or disaccharides, like sucrose or lactose, are components of fruit, vegetables, dairy products and many cereals. Sugars, naturally found in foods or added to them, obviously emit a very pleasant flavour which allows certain foods and meals to be enjoyed. Furthermore, when sugar is added to certain nutrient-rich foods, such as milk, yoghurt or cereals, the quality of diets followed by children and adolescents may even improve, something that has also been observed in the case of flavoured milks which also have no negative effects on body mass index.

Conclusions

The general conclusion, obtained from the detailed analysis of studies published, is that there is no clear evidence that micronutrient dilution occurs when sugar is added to the diet. Adding sugar to the diet doesn't seem to have any remarkable advantages, in terms of micronutrient intake, either.

Sugar added to drinks can be a major source of energy, whose intake, due to its ease of consumption should be monitored.

Sugar, as an ingredient added to food and drinks, can satisfy the tastes of a significant proportion of the population, satisfying their appetite and allowing access to many foods that, without sugar, maybe more difficult to consume, and thus indirectly contributing to an increase in the consumption of other micronutrients.

It is therefore necessary to continue research into how certain foods, that have a high sugar content, could adversely affect micronutrient intake or even to what extent they can end up displacing other foods in the diet.

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