The relationship between sucrose consumption and cancer; a review of the evidence

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Abstract

Objectives: The aim of this review is to summarize the evidence available about the association between sugar consumption, especially sucrose, and the risk of different types of cancer.

Methods: A systematic review was conducted of key reports, systematic reviews, meta-analysis as well as big prospective studies published after 2007 January 1 thru 2012 December 31 about the association between sugar consumption, especially sucrose, and the risk of cancer.

Results: Evidence of the association of the intake of mono- and disaccharides with different types of cancer is insufficient or there is evidence of lack of association. There is only possible evidence of a positive relation between the intake of monosaccharides (fructose and glucose) and pancreatic cancer. Evidence about the association between monosaccharides' intake and obesity is insufficient, as well as between the intake of sucrose or added sugars and the risk of obesity in adults and children. There is possible evidence of a positive association between glycemic index (GI) and colorectal cancer and that there is no association between GI and the risk of endometrial cancer, breast cancer and pancreas cancer.

Conclusion: More research is needed. Cohort studies are especially required and randomized intervention trials would be desirable, although these are difficult in this field.

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RELACIÓN ENTRE EL CONSUMO DE SACAROSA Y CÁNCER; UNA REVISIÓN DE LA EVIDENCIA

Resumen

Objetivos: El objetivo de esta revisión es resumir la evidencia disponible sobre la asociación entre el consumo de azúcar, principalmente sacarosa, y el riesgo de cáncer de distinta localización.

Métodos: Se ha realizado una revisión de los principales informes publicados, las revisiones sistemáticas, metanálisis, así como grandes estudios epidemiológicos prospectivos publicados con fecha posterior al 1 de enero de 2007 hasta 31 de diciembre de 2012 sobre la asociación entre el consumo de azúcar, principalmente sacarosa, y el riesgo de cáncer.

Resultados: La evidencia de asociación entre la ingesta de mono y disacáridos con los distintos tipos de cáncer es insuficiente o existe evidencia de no asociación. Sólo existe evidencia posible de una relación positiva entre la ingesta de monosacáridos (fructosa y glucosa) y el riesgo de cáncer de páncreas. La evidencia sobre la asociación entre la ingesta de monosacáridos y el riesgo de obesidad es insuficiente, lo mismo que en relación con la ingesta de sacarosa o azúcar añadido y el riesgo de obesidad en adultos o en niños. Existe evidencia posible de una asociación positiva entre el índice glucémico (IG) y cáncer colorrectal y de que no hay asociación entre el IG y el riesgo de cáncer de endometrio, mama y páncreas.

Conclusiones: Es necesario seguir investigando. Son especialmente necesarios estudios de cohortes y serían deseables estudios aleatorizados de intervención, aunque son difíciles en este ámbito.

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Abbreviations

GL: Glycaemic Load. CI: Confidence Interval.
GI: Glycaemic Index.
IGF: Insulin like Growth Factor.
BMI: Body Mass Index.
EPIC: European Prospective Investigation into Cancer and Nutrition.

OR: Oestrogen Receptor.

PR: Progestagen Receptor.

RR: Relative Risk.


Introduction

Sugars form part of food, and they are used as sweeteners, and as preservatives and volume forming agents in some cases. They also contribute to improving the palatability of starches, fats and other ingredients. Sugars and syrups elaborated from sugar cane, beet and corn are used in many foods and processed drinks.

Up until the 16th century when sugar cane was first cultivated in large harvests, foods with added sugar were considered a luxury. Consumption of sugar beet, sugar cane and syrups greatly increased in industrialised countries in the 19th and 20th centuries, and it continues to grow all over the world, especially in poor countries. In many countries in the last few decades, sugar consumption represents a considerable part of energy intake.

Reports on sub nutrition often recommend a considerable amount of sugars and fats to their energetic density, which allows for a rapid weight gain, and because of the innate preference for sweet flavours, which favours energetic intake. On the other hand, reports on prevention of chronic illnesses usually recommend moderate consumption of sugars, among other reasons because there is evidence that sugars are the cause of tooth decay, although a combination of amount and frequency of sugar, exposure to fluoride and the stickiness of the food are better indicators of the risk of tooth decay than the amount of sugar consumed alone.

Intake of sugars, in the amounts usually consumed in industrialised nations, has become associated with obesity, and therefore, indirectly associated with illnesses related to obesity, although the evidence available in this sense is not sufficient. There are hypotheses stating that diets with high glycaemic response levels, and consequently hyperinsulinemia, may be implicated in the aetiology (study of cause or origin) of some types of cancer.

When we talk about sugars, we mean all sugars contained within a diet, which are mainly extrinsic, but we do not mean sucrose (commonly known as sugar) alone. The term “extrinsic sugars” also includes maltose, lactose, glucose and fructose contained within food and drink, including juices and milk, as well as honey and syrups, fructose-rich syrups, refined sugars used in the processing, preparation and cooking of foods, and at the table. Intrinsic foods are those that are present in natural form in foods such as fruit or in milk.

Sucrose is refined from sugar beet and sugar cane. Maltose and glucose are mostly refined from corn. The rich syrup in fructose includes a mix of glucose and fructose, usually in equal amounts, and currently it is used a lot in the production of foods and drinks, especially in the USA.

Sugars are simple carbohydrates that provide 3.75 kcal per gram. They are simple molecules like glucose, fructose, and galactose (monosaccharides) and two joined up molecules (disaccharides), like sucrose (fructose and glucose); lactose (glucose and galactose); or maltose (two molecules of glucose). The body metabolises the different sugars at different speeds. For example, fructose is absorbed and metabolised slower than glucose or sucrose. It is also somewhat sweeter than glucose or sucrose, and therefore, it can be substituted in lesser total amounts. Chemical sweeteners without calories produce a sweet flavour, but they are not sugars.

There are no dietary requirements for sugars. The World Health Organisation recommends that average sugar consumption should be less than 10 per cent of total energy intake.

The objective of this review is to summarise the available evidence about the links between sugar consumption, especially sucrose, and the risk of cancer of different parts of the body.

Methods

There has been a review of the main published reports, systematic reviews, metaanalyses and recent large-scale prospective epidemiological studies of the relationship between sugar consumption, especially sucrose, and the risk of cancer. The systematic review carried out by the World Cancer Research Foundation (WCRF) in collaboration with the American Institute for Cancer Research (AICR) was taken as a reference, and the report published in 2007 was based on it. This review brought together studies published up to December 2006. We have centred our strategy on searches for systematic reviews and meta-analyses published after the 1st of January 2007 until the 31st of December 2012. The bibliographic search was done on PubMed using the following key words in the search execution: "dietary carbohydrates/ adverse effects"[Mesh Terms] OR "dietary sucrose/ adverse effects"[Mesh Terms] OR "glycaemic index"[MeSH Terms] AND “humans” [MeSH Terms] and “neoplasms”[MeSH Terms]). This method produced 226 publications, of which 110 had a publication after the 1st of January 2007. Special attention was given to meta-analyses and systematic reviews. 9 meta-analyses were identified along with 21 additional systematic reviews. The identification of studies was completed with the manual search and review of the bibliographical lists and preselected works, after an
initial screening, following the PRISMA document. Only the studies carried out on human beings have been included, which analyse the relationship between consumption of total sugars, added sugars, monosaccharides, disaccharides, glycaemic index and the appearance of cancer. Secondary cancer prevention studies have not been included. After the exclusion of duplicates and work that did not meet the requirements for inclusion, there are 61 publications in this review (Fig. 1).

Weaknesses

One of the main difficulties when researching the relationship between sugar consumption and health is that it becomes very complicated to measure and evaluate the overall effect of sugars as possible modifiers of the risk of any illness, including cancer, in part due to inconsistency in terms of classifications of sugars. Sometimes “sugar” is identified as sucrose, traditionally the main sugar in the human diet, and some studies research packaged sugar used domestically in families. However, in general, this type of sugar represents a relatively small proportion of all the types of sugar consumed, which is decreasing. Other studies include sugars contained in their natural form, in fruit and milk. Therefore, we need to study the methodology used in each study meticulously, in order to evaluate the results referred to. These methodological limitations complicate analysis of the evidence. It is very difficult to compare studies that use such different classifications for sugar.

Another possible inaccuracy in the studies could be the underestimation of real sugar intake, because added sugars are usually perceived as unhealthy foods, and therefore, studies of consumption based on information provided by participants might underestimate their consumption.

High sugar consumption is not an isolated feature of diet, but it usually forms part of consumption patterns that often go alongside low consumption of fruits, vegetables and legumes (green vegetables), in which carbohydrates could be indicative of a poor quality.
in vitro (test tube) studies and in animals, for cancer.

Hyperinsulinemia (high levels of insulin in the blood) is usually found in instances of tolerance of adulterated glucose, which has been linked to a greater risk of cancer. It has been found that insulin acts as a catalyst for glucose, which has been linked to a greater risk of cancer.

IGF-1 have been observed in gastric (stomach) cancer cell lines of different types of cancer. High levels of IGF-1 have been observed in gastric (stomach) cancer patients when compared to healthy individuals.

Dietary demand for insulin is determined by the type of carbohydrates consumed, and by the combination of type and amount of carbohydrates. The glycaemic index (GI) and the glycaemic load (GL) are indicative of the absorption rate of carbohydrates in the diet and therefore they are measures of the demand for insulin, which in turn may be linked to IGF. The least favourable situation would be when foods with a high GI are consumed in large amounts (e.g. high quantities of refined cereals). However, other factors come into play in the secretion of insulin such as protein intake, and the addition of fats to a source of carbohydrates which may increase the insulin reaction without increasing glycaemia.

We currently have clearer evidence that excess weight and obesity increase the risk of certain types of cancer. In recent decades, excess weight and obesity rates in adults and children have increased considerably in most countries. There is evidence that foods and diets of high energy level content, especially highly processed foods and sweetened beverages, increase the risk of excess weight and obesity.

On the other hand, in most populations, people who live in urban industrialised areas participate in levels of physical activity that are below levels that the human body is adapted to. The increase in sedentary time and low levels of physical activity encourage excess weight.

Nutritional interventions add ethical, economic and logistical complications that make it difficult to carry out controlled experiments. Furthermore, unfeasibly long periods of exposure are usually necessary. For this reason, literary evidence in the field of nutrition is usually based mainly on long-term observational studies, and these lead recommendations classified as level C, and sometimes level B, in which there are some quality studies with minimal risk of bias. When nutrients that require less exposure time, it is also possible to achieve A level evidence.

Threats

Reports by experts, such as the one by the FAO/OMS committee published in 2003 and others, did not consider that high sugar consumption was linked to cancer. The WCRF report, based on studies published up to 2006, concluded that there is limited evidence to suggest that sugar is a cause of bowel cancer. This was also the conclusion of a review produced by a committee of experts for the FAO on the role of carbohydrates in human health from 2007.

In the systematic review produced by Ruxton et al., which combines publications from between 1995 and 2006, 18 studies that analyse links between cancer risk and consumption of sucrose, sugar and foods that contain sugar were identified. The authors concluded that in spite of including studies that were more recent than previous reviews, the findings were still in line with previous reviews, with inconsistent evidence regarding the role of sugar intake in cancer development.

A review on which the production of Food Guides in Germany was based, using studies published up to December 2009 and metanalyses published up to 2010, concluded that the evidence was insufficient in some cases, but it also pointed to evidence of a possible link between intake of monosaccharides and the risk of pancreatic cancer.

The review of evidence that backs up the Australian Dietary Guidelines published in December 2011 includes studies published up to April 2009. The authors concluded that sucrose consumption was not linked to a greater risk of cancer, with C level evidence available.

GI and GL have been linked to bowel, breast, ovarian and uterine (lining of the uterus) cancers, and this suggests the hypothesis of a greater risk of gastric (stomach) cancer with high ingestion of carbohydrates.

Stomach Cancer

The hypothesis of a greater risk of stomach cancer with a high intake of carbohydrates has been suggested. High GIs and GLs can come as a result of high intake of refined carbohydrates, which usually comes accompanied with a low intake of vitamins, minerals, anti-oxidants and fibre, as well as a low consumption of legumes (green vegetables), fruit, vegetables and wholegrain cereals, food groups that have been inversely linked to the risk of stomach cancer. In some studies no links between GI and risk of stomach cancer have been found, which may suggest that it is not just the type but also the amount of carbohydrates that could be linked to the carcinogenesis of this form of cancer.

In the systematic review by the WCRF, no prospective or intervention studies were identified on the links between monosaccharides, disaccharides or sweetened beverages and the development of stomach cancer. Subsequently, there have been some panel studies and...
investigations into this link, although the evidence is not sufficient\textsuperscript{8}.

\textit{Uterine cancer (cancer of the lining of the uterus)}

Uterine cancer is linked to obesity, diabetes and polycystic ovary syndrome, all of which are linked to hyperinsulinemia (high levels of insulin in the blood). Diets with a high glycaemic index (e.g. with a high content of foods rich in refined carbohydrates and low in legumes (green vegetables), fruits, vegetables and wholegrain cereals) are characterised by a rapid absorption of their carbohydrate component in the consequent increase in glucose and insulin levels.

Carbohydrates have been directly linked to the risk of uterine cancer, mainly with refined carbohydrates\textsuperscript{9,10}, while foods with a wholegrain cereal base seem to play a protective role. In some studies a stronger link has been observed in women who are overweight, but it also seems that diets with a high GI tend to increase the risk of uterine cancer in women with a low body mass index (BMI). Although oestrogen is the main factor in the risk of uterine cancer, insulin can alter hormonal balance. Insulin has been seen to act as a cancer-inducing agent in test tube (in vitro) and in animal studies. It also has an affinity with receptors of IGF, which means IGF levels increase. It has been observed that IGF-1 stimulates mitogenesis (triggering of mitosis – process of encouraging a cell to commence cell division), in cell lines of uterine cancer. Another possible mechanism due to which a high glycaemic index may contribute to a risk of uterine cancer could be an increase in oxidative stress.

In the systematic review by the WCRF, a panel study is described which researched the links between sugar intake and uterine cancer, although this study was not related to risk in any way\textsuperscript{2}. Subsequently, two group studies have been identified that do not provide evidence of links with risk\textsuperscript{11-13}. The NIH-AARP Diet and Health Study cohorts found non-significant links that implied greater risk with fructose and sucrose intake\textsuperscript{11}.

\textit{Pancreatic cancer}

In the systematic review by the WCRF form 2007, we are informed of a panel study that researched the relationship between fructose intake and pancreatic cancer. In this study there was no major significant risk from intake of fructose\textsuperscript{2}. Three more recent studies in the USA focused on this relationship and did not find a greater risk of pancreatic cancer with higher fructose intakes. In one of them, the NIH-AARP study, it was found that there was a greater risk from a high intake of glucose. On the other hand, in the study of Diet and Health in the Low Countries, intake of monosaccharides and disaccharides was not linked to pancreatic cancer\textsuperscript{2}.

The WCRF review looked at three panel studies on sucrose intake and none of these mentioned a link with pancreatic cancer\textsuperscript{2}. In studies published afterwards it was not seen that the amount of sugar consumed was a risk factor for pancreatic cancer. Nor did it mention a link with consumption of sweets or jams, or with the GI\textsuperscript{8}.

In one meta-analysis that carried out research into links between sweetened beverages consumption and pancreatic cancer, the analysis of 6 panel studies did not find evidence of change in risk of pancreatic cancer in participants who consumed sweetened beverages in comparison with those who did not (RR = 1.05; IC 95% 0.94; 1.17)\textsuperscript{12}. A study carried out in Sweden and another in China that analysed several categories found a positive link of risk between sweetened beverage intake and pancreatic cancer.

Meta-analysis of panel studies\textsuperscript{13} and another of group studies and cases and controls\textsuperscript{14} did not find links between GI, GL and the risk of pancreatic cancer. A later meta-analysis, which included a great number of studies and approximately 3000 cases, with therefore greater statistical power, found that only a few specific types of carbohydrates could increase the risk of pancreatic cancer. A link was found between insulin load and fructose intake, but not with the total intake of carbohydrates\textsuperscript{15}.

The results of a meta-analysis published in 2012 do not support links between diets with a high glycaemic index, glycaemic load, total carbohydrate or sucrose intake and risk of pancreatic cancer. A greater risk was observed with fructose intake, although more studies are necessary to confirm and back up this finding, taking into account possible confounding factors\textsuperscript{16}.

The data analysis of the Nurses Study and the Study of Health Professionals in the USA attempted to show that diets rich in foods that increase postprandial (after eating) insulin concentration do not increase overall risk of pancreatic cancer. However, in people with a BMI of less than 27, low physical activity and a greater presence of insulin are linked to a greater risk of pancreatic cancer, although not significant\textsuperscript{16}.

Table I summarises the most relevant details of the most recent evidence of the relationship between sugar and risk of pancreatic cancer. There is some possible evidence of a positive link between monosaccharides intake and pancreatic cancer. There is also convincing evidence of causal links between body adiposity and pancreatic cancer; the evidence is probable with regards to abdominal fat.

\textit{Breast cancer}

In the WCRF’s systematic review of 2007, three panel studies on lactose, sucrose or fructose are described. No link was found between sucrose, lactose
Table I

Table: Relationship between sugar intake, glycaemic index, glycaemic load and pancreatic cancer 2006

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study description</th>
<th>Glycaemic Index</th>
<th>Glycaemic Load</th>
<th>Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n sex RR (IC 95%)</td>
<td>RR (IC 95%)</td>
<td>RR (IC 95%)</td>
<td></td>
</tr>
<tr>
<td>Panel studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larsson et al., 2006</td>
<td>77,797 M, F</td>
<td>1.69 (0.99-2.89)</td>
<td>1.28 (0.95-1.73)</td>
<td>1.08 (0.81-1.45)</td>
</tr>
<tr>
<td>Nöthlings et al., 2007</td>
<td>162,150 M, F</td>
<td>1.10 (0.80-1.52)</td>
<td>1.23 (0.91-1.65)</td>
<td>1.35 (1.02-1.80)</td>
</tr>
<tr>
<td>Patel et al., 2007</td>
<td>124,907 M, F</td>
<td>0.92 (0.68-1.24)</td>
<td>1.01 (0.75-1.37)</td>
<td></td>
</tr>
<tr>
<td>Bao et al., 2008</td>
<td>487,922 M, F</td>
<td>0.85 (0.68-1.06)</td>
<td>1.12 (0.91-1.39)</td>
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<td>Heinen et al., 2008</td>
<td>120,852 M, F</td>
<td>0.87 (0.59-1.29)</td>
<td>0.85 (0.58-1.24)</td>
<td>0.78 (0.52-1.16)</td>
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<tr>
<td>Jiao et al., 2009</td>
<td>482,362 M, F</td>
<td>1.09 (0.90-1.32)</td>
<td>0.95 (0.74-1.22)</td>
<td>1.10 (0.88-1.38)</td>
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<td>Meinhold et al., 2010</td>
<td>109,175 M, F</td>
<td>1.08 (0.78-1.49)</td>
<td>1.45 (1.05-2.00)</td>
<td>1.37 (0.99-1.89)</td>
</tr>
<tr>
<td>Tasesvka et al., 2012</td>
<td>255,696 M, F</td>
<td>0.98 (0.69-1.39)</td>
<td>1.02 (0.75-1.38)</td>
<td>0.96 (0.71-1.29)</td>
</tr>
</tbody>
</table>
| M: Male; F: Female; RR: Relative Risk; IC: Interval of confidence; a Total sugars; b added sugar; c sucrose; d total fructose; e glucose.

References:
or fructose intake and breast cancer2. The Danish branch also investigated this link in the EPIC study, but no link was found in this case either. No panel studies were found on links with the consumption of sweetened beverages.

The meta-analysis carried out by Ruxton et al in 20107 looked at four studies on breast cancer, and three of these mentioned some level of links between risk and different estimators of sugar intake, although in a somewhat inconsistent way. Other authors found links with some sweet foods, but not with others. In a preceding systematic review a significant link was found between breast cancer and a high intake of cakes and biscuits, although they pointed out that apart from sugar, these foods also contain high quantities of fats, which may be a confounding factor. A systematic review of panel studies did not find a link with the GI or GL.

In the Women’s Health Initiative cohort, no link was observed between GI, GL, or carbohydrate intake and breast cancer, although a possible relationship is suggested between GL and carcinoma in situ (the early stages of cancer).

In the EPIC study, it was observed that a diet with high GL and carbohydrate intake is positively linked with a greater risk of breast cancer types that are receptors of negative oestrogen (OR-) and OR-/ receptors of progesterone (PR-) in postmenopausal women18. An Italian panel study mentioned this link in premenopausal women.

Diets that are rich in carbohydrates, especially those with high GI or GL, increase postprandial (after eating) concentrations of glucose and insulin. This metabolic change, as with diabetes, has been linked to lesser chances of survival in breast cancer19,20.

The second WCRF-AICR report concluded that it seems probable that body fat may reduce the risk of breast cancer before the menopause, but there is insufficient evidence for a link to be established between intake of sucrose and other sugars, as well as sweetened foods and beverages, with premenopausal breast cancer. In postmenopausal women, however, there is convincing evidence that adds substance to the link between body adiposity and a greater risk of breast cancer, and it is likely that abdominal body fat gain (adiposity) and weight gain at adult age also implies a greater risk2. There is not enough evidence either for linking breast cancer with sucrose intake, foods and soft drinks, or the glycaemic index (Fig. 2).

**Colorectal cancer**

The 2007 WCRF review looked at a panel study and 7 case-control studies researching the relationship
between consumption of sugars as food and bowel cancer. Seven panel studies and 16 case-control studies on the relationship with sugars as nutrients, defined as sucrose or fructose. In the first group, looking at sugars as foods, the study panel stated that there was no link between adding sugar to cereals and cancer of the colon and rectum. In the case control studies a greater risk was observed with greater sugar consumption, statistically significant in two of them. However, the establishment of “sugar” as a food varied from one study to the next. The available evidence on the links between sucrose and bowel cancer is difficult to interpret; in any case there is limited evidence that suggests sugar might be a cause of bowel cancer.

Of the four panel studies on fructose intake, a positive link was found in one, and two on lactose intake did not find any links with risk. None of the three panel studies on disaccharide intake showed significant positive links with risk.

In subsequent panel studies that have not been included in this review such as the NIH-AARP Diet and Health Study21 no links were found between sugar intake and cancer of the colon and rectum. A meta-analysis of case-control studies and panel studies published in 2008 suggested a direct overall link between GI, GL and bowel cancer22. The analysis of 13 panel studies that formed part of the Pooling Project did not find any links between sweetened beverage consumption and bowel cancer.

According to the WCRF report, there is convincing evidence that body fat gain and abdominal fat gain increase the risk of bowel cancer. There is limited evidence to suggest that foods containing sugar increase the risk, and there is inconclusive limited evidence of the links with sucrose consumption or total carbohydrates. Subsequent reviews concluded that the evidence suggests a link with sugar, but the energy intake and the glycemic load could be confounding factors.

Meta-analyses published in 201221,22 concluded that there is no consistent evidence, although they did observe a modest excess risk in case-control studies in which added sugars, GI and GL are linked to a greater risk of cancer of the colon, in spite of the effects on energy intake, obesity or diabetes, linked to greater risk of cancer of the colon.

Table II summarises the most relevant and current information from 2007 onwards on the relationship between sugar intake and bowel cancer.

Around 60 panel studies and 86 case-control studies have researched the link between body fat gain and bowel cancer, using the BMI as a gauge in most cases. The majority of panel studies showed a greater risk of cancer with greater body fat gain. The meta-analyses in panel studies demonstrated an increased risk of 15% for each 5 kg/m². Layered according to the location of the tumour, the magnitude of the increased risk is even greater for colon cancer than for rectum cancer.

There is a lot of consistent epidemiological evidence with a clear “dose and response” relationship, and plausible mechanical evidence. The evidence for greater body fat gain as a cause of bowel cancer is convincing. The risk of cancer is modified not just by obesity, but also by excess weight, and even by levels of body fat gain that could be considered to be within normal healthy weight limits.

Regarding obesity and excess weight, evidence for high consumption of drinks with added sugars, including sucrose and syrups rich in fructose, being linked to weight gain, excess weight and obesity is consistent, according to the WCRF report. This report classifies as probable evidence that high consumption of these products causes weight increase and obesity. However, other subsequently published meta-analyses state that the evidence of the importance of monosaccharides in obesity is not sufficient, as is the evidence for the importance of sucrose or added sugar respectively to the risk of obesity in adults.

Panel studies and intervention studies show a greater risk of obesity in adults who consume sweetened beverages, with the level of evidence showing this to be probable. The conclusions of two out of four meta-analyses state that a greater consumption of sweetened beverages in children and teenagers is linked to a greater risk of obesity, whilst in another meta-analysis, no link was found. Subsequent panel studies confirm this greater risk. The most recent panel study concludes that the greatest risk of obesity is limited to individuals who already have a high BMI or excess weight, and the level of evidence is classed as possible.

**Ovarian cancer and prostate cancer**

In some panel studies it has been suggested that consumption in diets with high GL could be linked to a greater risk of ovarian cancer, although the evidence is limited and inconclusive.

The results of a case-control study in Australia suggested that diets with a high glycaemic load could increase the risk of ovarian cancer, especially in women who are overweight or obese. Panel studies have not found links between carbohydrate intake, GI or GL and the risk of prostate cancer.

**Strengths**

In recent years, the number of studies investigating links between sugar consumption and chronic illnesses like cancer has increased. Systematic reviews of the literature and meta-analyses have also been carried out attempting to answer this question. One of the most detailed critical reviews of the available evidence was carried out by the WCRF-AICR, which published its first report in 1997, and the second one in November.
### Table II

**Relationship between sugar intake, glycaemic index and glycaemic load, and bowel cancer.**

**Summary of relevant evidence published since 2008**

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Description studies</th>
<th>Glycaemic index</th>
<th>Glycaemic load</th>
<th>Sugar</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>n</td>
<td>sex</td>
<td>RR (IC 95%)</td>
</tr>
<tr>
<td><strong>Panel studies</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Weijenberg et al., 2008</td>
<td>120,852 M, F</td>
<td></td>
<td></td>
<td>0.81 (0.61-1.08)</td>
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<tr>
<td>Howarth et al., 2008</td>
<td>85,898 M</td>
<td></td>
<td></td>
<td>1.15 (0.89-1.48)</td>
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<tr>
<td>Kabat el al., 2008</td>
<td>158,800 F</td>
<td></td>
<td></td>
<td>1.11 (0.82-1.49)</td>
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<tr>
<td>George et al., 2009</td>
<td>262,642 M, F</td>
<td></td>
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<td>1.16 (0.98-1.37)</td>
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<tr>
<td>Li et al., 2011</td>
<td>73,061 F</td>
<td></td>
<td></td>
<td>1.09 (0.81-1.46)</td>
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<td>Tasesvka et al., 2012</td>
<td>179,990 F</td>
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<td></td>
<td>1.06 (0.87-1.29)</td>
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<td><strong>Meta-analysis</strong></td>
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<tr>
<td>Gnardella et al., 2008</td>
<td>12,790 Panles and case controls</td>
<td></td>
<td></td>
<td>1.18 (1.05-1.34)</td>
</tr>
<tr>
<td>Barclay et al., 2008</td>
<td>349,982 Panles, until December 2007</td>
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<td></td>
<td>1.10 (1.00-1.21)</td>
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<td>Mulholland et al., 2009</td>
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<td>Bosetti et al., 2009</td>
<td>10,000 Case-control studies until 2007</td>
<td></td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>Galeone et al., 2012</td>
<td>994,154 Panles and case controls until 2012</td>
<td></td>
<td></td>
<td>1.17 (1.00-1.36)</td>
</tr>
<tr>
<td>Aune et al., 2012</td>
<td>994,154 Panles, cases and controls until Oct. 2011</td>
<td></td>
<td></td>
<td>1.07 (0.99-1.16)</td>
</tr>
</tbody>
</table>

M: Men; W: Women; RR: Relative Risk; CI: Confidence interval

- Total sugars
- Added sugar
- Sucrose
- Total fructose

**References:**

2007. This second report based its conclusions and recommendations on the analysis of evidence published up until the end of 2005, and then completed, subsequently, with studies published in 2006.

Since then, new evidence has been published, and other work groups have carried out systematic reviews and meta-analyses analysing the links between sugar consumption and some types of cancer.

The evidence is getting better all the time, and it is getting better in terms of quality. Systematic reviews have also improved, including evaluations of the quality of the methodologies used in the studies, and better control over confounding factors. The relationship between sugar intake and the risk of cancer is usually adjusted to the total energy intake, in such a way that sugars are valued as a proportion of total energy in a diet.

The most recent reviews are usually based on previous meta-analyses and systematic reviews, as well as on original publications that were not covered in existing reviews. Until now, the most recent meta-analyses on this topic cover publications up until October 2011, and they investigate the links between carbohydrate intake, GI, and GL and pancreatic cancer, or with bowel cancer.

However, there are still many areas that still need to be researched. Meta-analyses and panel studies are required.

Opportunities

Evidence for links between monosaccharide and disaccharide intake and the various forms of cancer is insufficient or there is evidence against links. There is only possible evidence for a positive relationship between monosaccharide intake and the risk of pancreatic cancer.

Although the evidence is insufficient, it has been suggested that added sugars, GI and GL could be linked to cancer of the colon, in spite of the effects on energy intake, obesity or diabetes. It has also been suggested in some panel-studies that consumption in diets with a high GL could be associated with a greater risk of ovarian cancer, and there is convincing evidence that abdominal fat gain increase the risk of bowel cancer and postmenopausal breast cancer.

High consumption of sweetened beverages increases the risk of obesity, with strong evidence for adults, and possible evidence for children.

There is evidence for the practice of physical activity as protection against cancer, and it helps to avoid excess weight and therefore cancers related to obesity have increased considerably since the 1990s.

When researching the links between carbohydrate intake and the appearance of chronic illness, one must take into account that the overall risk is determined by the interaction of lots of different food components, so the importance of isolated components must not be overestimated.

Recommendations

More research is required. Panel studies are particularly important, and ideally randomised intervention studies are useful, although they are difficult to organise in this area.

Based on the evidence available, it would be ideal to keep body weight at a healthy level. Living an active life, avoiding sedentarism, practising regular physical exercise of moderate intensity, limiting consumption of food and drinks with high energetic density that favour weight gain, consuming a good amount of green foods with a full presence of fruit and vegetables, as with as regular consumption of wholegrain cereals are some measures that could help to maintain body weight.

Conclusions

Evidence in relation to intake of monosaccharides and the risk of cancer of the oesophagus, bowel cancer and breast cancer is insufficient. There is some possible evidence of links with a greater risk between monosaccharide intake and pancreatic cancer.

Regarding intake of disaccharides, the link to the risk of cancer of the oesophagus and uterine cancer is also insufficient. There is evidence that there is possibly no link between disaccharide intake and a risk of bowel cancer, breast cancer and pancreatic cancer.

There is also evidence that there is possibly no link between consumption of sweetened beverages and risk of bowel cancer and breast cancer.

Evidence of a link between GL and the risk of cancer of the oesophagus and stomach is insufficient. There is possible evidence for a positive link between GI and bowel cancer. There is evidence that there is possibly no link between GI and the risk of uterine cancer, breast cancer and pancreatic cancer.

The evidence of links between GL and the risk of cancer of the oesophagus is insufficient. In relation to uterine cancer, there is possible evidence of a positive risk with the GL. There is possible evidence that GL is not linked to risk of bowel cancer and pancreatic cancer. It is considered probable that there is no link between GL and breast cancer.

References


2. World Cancer Research Fund/American Institute for Cancer Research. Food, Nutrition, Physical Activity, and the Preven-


