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Review Article

Consumption of Sugar Sweetened Beverages (SSBs) and Breast Cancer: A Narrative Review

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Abstract

Sugar sweetened beverages (SSBs) have become a cause of concern because of their growing consumption levels across age groups and associated chronic diseases such as diabetes mellitus, cardiovascular diseases and cancers. The aim of this review was to provide a detailed profile of the SSBs trends and associated health risk, with special focus on its role in breast cancer development. A review of current literature has depicted increased intakes of SSBs across the globe with servings ranging from 3 to 11 per day in different countries, while children, adolescents and young adults report the highest intake levels. These increased intakes further contribute to different metabolic diseases via increased body adiposity, blood glucose and insulin levels, and increased post-menopausal estrogen levels, all of which contribute to chronic diseases, including cancers. Nutrition interventions including ones that target SSBs reduction seem to have a positive impact on reducing the development of these non-communicable diseases and are also associated with better prognosis and survival chances in cancer patients. However, the implementation of SSBs taxation and mass awareness campaign interventions remains poor due to lack of policy development and regulation for these beverages. The control of SSBs intake across the world requires rigorous research to construct efficient and practical policies to reduce the accessibility and marketing of SSBs while simultaneously increasing awareness in the public regarding the health risks of these beverages. To achieve this, a coordinated approach involving different public and private sectors is needed.

Keywords: Sugar sweetened beverages; Chronic diseases; Breast cancer; Nutrition; Health policy

Introduction

Over the recent years, sugar sweetened beverages (SSBs) have gained a lot of attention due to their associated health risks. The WHO defines SSBs as those containing free sugars as an ingredient (1). Common examples of SSBs include fruits and vegetable juices (100%), both carbonated and non-carbonated soft drinks, flavored water and milk, instant teas and coffees, and all types of sports and energy drinks (2). The SSBs are currently the highest source of sugar intake globally, an example of which are the approximately 150 calories and 35 g of free sugar derived from 355 ml of soda (3).

The increasing trends of SSBs consumption are not only detrimental to health but also pose threats to meeting healthcare costs due to increased individual and national health expenditures owing to the treatment of SSBs related metabolic diseases (4). Additionally, the development and execution of interventions to reduce their consumption is made difficult due to the lack of data on SSBs related intake trends and how they have evolved over the decades and what differences exist among various regions. Moreover, there is a lack of studies focusing on the association of SSBs consumption with different socio demographic variables such as education level or income, which limits the development of SSBs specific interventions (5). The WHO has proposed SSBs taxation in an attempt to make them non-affordable (6), and while the policy was positively received and implemented by national governments globally, the beverage industry has opposed these SSBs taxations owing to their alternative interests (7).

Despite these regulatory actions, the prevalence of SSBs consumption and their associated health risks continue to grow, as evidenced by their doubled caloric contribution from 1977 to 2001. SSBs now contribute approximately 39% of the daily sugar content in adults and 12% of the population consumes more than 3 servings per day (8). Ruyter et al.'s study found an increased cardio metabolic risk associated with 250ml of SSB consumption on a daily basis in children aged 4 to 11 years. The anthropometric measurements were significantly increased in these children (9), thereby imposing increased health risks, particularly that of metabolic syndrome (10). The association of SSBs with all of the prior mentioned diseases and health conditions make them a priority health concern and require investigations into their current trends and interventions for successful control.

Current Trends of SSB Consumption

As of 2018, 8.9% of the global population displayed an average of more than seven SSBs servings per week. Mexico, Ethiopia, America and Nigeria reported the highest intakes while consumption of SSBs was lower in India, China and Bangladesh. Gender differences in consumption were also prominent with males having higher intakes than females. Intake levels also varied according to age, with the 20-24 year age group reporting the highest intakes (11 servings per week), while those aged more than 85 years and above had the lowest intakes (3.9 servings per week) (5). However, when compared with data from previous years, the intake of SSBs has declined significantly for all races, ethnicities, and age groups. Although an increase in non-traditional SSBs such has sweetened milk beverages in children and teas and coffees with added sugars in adults (11).

In children the SSBs consumption was highest in China with mean intakes of 710ml per day while Australia had the lowest intakes (115 ml per day) (12). About 33.9% adolescents consumed more than 1 soft drink per say, however, the intake was lower in countries who imposed taxes on consumption of sugar sweetened beverages. The lowest intake levels of SSBs per day were observed in Iceland (3.3%) while Niue reported the highest intake of sweetened beverages (79.6%) (13). Approximately 50% of the American adult population consumed at least 1 sugar sweetened beverage per day, which accounted for 6.9% and 6.1% caloric contribution in men and women respectively. In Asian countries, the caloric contribution of SSBs ranged from 32 to 82 calories per day in South Korea, while half of the Chinese population consumed some form of SSBs (14). The highest consumption of SSBs among adults was seen in males aged 20 to 19 years in Tobago and Trinidad, while Chinese women aged 80 years and above had the lowest per day intakes (0.031 servings per day), globally (15).

There has been a decrease in the intake of SSBs worldwide, as compared to consumption levels in the past (16-18). The intake levels decreased or remained stable among all population groups in countries like Canada, America, Australia, Russia, and China. Norway reported a prominent decrease in SSBs consumption among all age groups, while in the United Kingdom, there was an increase in SSBs intakes among children aged 4 years old while intake levels dropped or remained stable among the rest of the groups (19).

SSBs and Risk of Chronic Diseases

The association between chronic diseases and SSBs can be attributed to the additional calories they contribute to the daily energy intake, which results in an increased body mass index (BMI). Each serving of SSBs increases the BMI by 0.05 kg/m^2 each year in children, while it caused an increase of 0.12kgs in adults annually. This increased BMI subsequently increases the risk of developing obesity and various other metabolic diseases (3). SSBs also pose adverse health risks due to various additives such as inorganic phosphates which increase the renal burden. However, the majority of the morbid effects of SSBs are linked to their high fructose concentration, which leads to steatohepatitis which further contributes to the development of metabolic syndrome (20). This is because fructose consumption increases fatty acid synthesis by the liver. Liver cells are able to increase their lipogenic activity in response to continuous fructose intake. Furthermore, fructose, as well as sucrose, increase the fractional secretion rate (FSR) of fatty acids and fructose increases the uptake of glucose by hepatocytes, thereby, increasing the amount of glycolytic and lipogenic substrates available to the liver. This mechanism supports the 'monosaccharide flooding' hypothesis, that monosaccharide compositions and levels greatly influence lipogenic gene activity and lipid synthesis by the liver (21).

The number of global deaths attributed to SSBs consumption is 184,000, out of which the highest occurred due to diabetes (133,000), followed by cardiovascular diseases (45,000), and cancers (6450) (22). SSBs increased the risk of metabolic diseases significantly including 10% and 20% higher risk for stroke(23-25) and type 2 diabetes (26- 28), respectively. There are two mechanisms that have been used to explain how SSBs contribute to NCD development. Firstly, excessive calorie intake that results in weight gain and subsequent lipid accumulation. Secondly, high SSBs consumption also increases the glycemic load which then triggers insulin resistance, altered blood lipid levels, and inflammation in the body (29). Meeting 10% to 25% of daily energy intake via beverages containing high fructose corn syrup, result in raised post prandial triglyceride, fasting LDL cholesterol and 24 hour uric acid levels. All of these factors further exacerbate the cardiometabolic risk imposed by SSBs (30). An array of evidence shows strong associations among various chronic diseases and SSBs consumption through biochemical pathways, particularly through weigh gain and increased adiposity (31-34).

Obesity and Breast Cancer

Breast cancer is one of the most common cancers in women worldwide, with 2.3 million new cases and 685,000 cancer deaths annually (35). There are a number of environmental and lifestyle factors that play a role in breast cancer development and progression, out of which obesity or having excessive body fatness is of particular interest. Most studies have used BMI as an index of obesity, and found positive associations of a higher BMI with an increased risk of breast cancer, as well as with poor prognosis and treatment results (36). Several mechanisms explain how increased body adiposity contributes to high breast cancer incidence. Firstly, obesity disrupts the normal adipokine hormone levels in the body which has been associated with metastasis and cancer development. Additionally, increased body fat has positive associations with insulin resistance and dyslipidemia, both of which lead to increased incidence and poor prognosis of breast cancer (37). Women over 20% of their ideal body weight were seen to have larger tumors, an increased risk of lymphatic invasion and 11% decreased survival rates as compared to patients with a normal body weight. (38). The association between obesity and breast cancer is also dependent on postmenopausal status of women, as the risk of cancer is higher as compared to premenopausal women. A 30% higher breast cancer risk in obese females aged 50 to 64 years has been reported. This is due to varying estrogen levels, as the estrogen production decreases and shifts to peripheral tissues like the adipose tissues as women age. In obese women the estrogen concentrations can increase up to 10 times which further exacerbates the risk of malignant breast cancer (39).

SSBs Consumption and Risk of Breast Cancer – A Mechanistic Approach

The role of dietary choices in development of breast cancer has been widely explored and links have been established between high sugar and fat intake with breast cancer incidence. Sugar sweetened beverages have gained interest in this regard due to their high sugar content resulting in insulin resistance, metabolic syndrome, type 2 diabetes and other such conditions. Hence, it can also lead to developing carcinogenesis and in this case breast cancer (40). The high sucrose and fructose content of SSBs result in an increased glycemic response which in turn increases the levels of insulin like growth factors (IGF), hyperinsulinemia and altered glucose tolerance, all of which have been evidenced to promote tumor development and migration of cancer cells (41). The high concentrations of rapidly absorbable sugars in SSBs such as fructose corn syrup, dramatically increase the blood glucose insulin levels which in turn stimulate cell proliferation and repress the apoptosis mechanisms. Furthermore insulin and IGFs increase estrogen production by decreasing the levels of sex hormone binding globulin, which enhances breast cancer risk (42). IGF-1 depicts mitogenic and antiapoptotic activities that have been linked with increased cancer prevalence. IGF influences the estrogen signaling pathways which are linked with higher incidence of hormone sensitive breast cancer development. Insulin also enhances estrogen levels and increases the cell proliferation rate resulting in increased breast cancer incidence (43).

Chemical additives such as 4-methylimidazole, which imparts caramel color in beverages, as well as some pesticides that may find their way in 100% fruit juices and contribute to breast cancer development (44). Furthermore, SSBs have increased breast tissue density by increasing the fibroglandular tissue proportion within the breast, and the cause has been hypothesized to be increased glycemic and inflammatory response caused by chemical additives present in these beverages. Additionally, increased body fat levels have also been associated with increased breast density and as SSBs have been linked to obesity, they can be indirectly related to breast density which is a biomarker for breast cancer (45). Lastly, cancer cells are heavily dependent on sugar as their primary source of energy, and require a consistent supply of blood glucose for their proliferation. These malignant cells also heavily prefer fructose over glucose as a fuel and use it for their growth and nucleic acid formation, making SSBs containing high fructose corn syrup, a serious threat to cancer development (46).

Nutrition Intervention and Prevalence of Breast Cancer

Despite the fact that except alcohol, no other food group had statistically significant associations with breast cancer (47), diet effects the pathogenesis of this disease (48). Adopting healthy dietary choices, such as increased fruits, vegetable, fish and while grain consumption has been evidenced to improve prognosis of initial stage breast cancer, while increased intake of highly refined, processed and fatty foods have been found to worsen survival rates in these women (49). Increased intakes of olive oil nuts, legumes, dairy products and eggs, have found lower mortality risk in breast cancer patients and improved chances of survival. Additionally, dietary supplements, including multivitamins and antioxidants supplements can have beneficial or harmful reactions with cancer specific medical therapies (50). Several studies have established a positive association between a high fat diet, and an increased risk of progesterone and estrogen-positive breast cancer (51-54). Additionally, consumption of red meat contributes to tumor development and this is assumed to be because of their ability to initiate menarche at an early age, which is a risk factor for breast cancer (55). With each 100g increase in red meat intake, the risk of breast cancer also increases, and consuming 150g of red meat per day has shown to increase the risk of breast cancer by 10%. The carcinogenic activity of red meat is linked to its high temperature cooking by-products, which result in inflammation and tumor development. Furthermore, the saturated fats, heme iron and N-glycolyneuraminic acid found in red meat increase oxidative stress in humans, thereby increasing their risk of developing breast cancer (56). It is therefore recommended to substitute red meat with fish and poultry, both of which have low saturated fat and heme iron levels, and hence are not associated with breast cancer development (57).

In contrast, some studies have suggested that phytoestrogens and isoflavones in soy may have a protective effect against hormone-associated cancers (58-60). Similarly, polyunsaturated fatty acids (PUFAs) may also help reduce breast cancer risk as they are well known anti-inflammatory components, can reduce blood triglyceride levels, and alter the functioning of cancer related receptors, and transcription factors (61). Low glycemic index foods have been found to produce only slight increases in post-prandial blood glucose levels, which in turn reduces insulin levels thereby decreasing the overall breast cancer risk. Moreover, vitamin D has protective effects against breast cancer development, and vitamin D deficiency has been linked to increased apoptosis, carcinogenic cell proliferation and division, and enhanced metastasis risk. It is recommended that breast cancer patients consume 2000-4000 IU/day of vitamin D via supplements to reduce the breast cancer incidence by 25% (62). Evidence has suggested the anti-cancer properties of vitamin D due to its role in preventing inflammation, cellular apoptosis and autophagy. It also suppresses breast cancer progression by influencing cancer stem cell development, and epithelial-mesenchymal transitions (EMT) (63).

Carbohydrates, especially refined carbohydrates tend to increase IGF-1 levels which then contribute to cellular proliferation. Studies conducted on dietary consumption of breast cancer patients depict an increased intake of simple sugars and high glycemic index carbohydrates (refined carbohydrates) (64, 65). These high glycemic index foods increase the blood glucose levels leading to increased insulin secretion, which then raises the level of insulin growth factors such as IGF-1. This IGF-1is further associated with suppressing the cellular apoptotic processes, resulting in higher risk of cancer development (66). Red and processed meats provide high amounts of n-nitroso compounds, polyaromatic hydrocarbons, and heterocyclic amines, all of which are carcinogenic. Trans-fatty acids increase the risk of elevated blood and visceral lipid profiles which then lead to obesity, and insulin resistance, both of which are breast cancer risk factors. Omega 6 fatty acids are pro-inflammatory and influence metabolic reactions, gene expression and cell signaling which promotes proliferation (67).

Role of Governing Bodies and Policies Related to SSBs

The most commonly used policies to reduce SSBs intake at mass level include the use of food labels, imposing taxes on all SSBs and marketing restrictions. A meta-analysis reported that SSBs taxes depicted a 10% decline in the usage of these beverages (68). Taxation produces significant reductions in SSBs intake, as evidenced by an 82% reduction in SSBs sales solely due to SSBs taxes. The average reduction across countries was reported to be 15%, given that the taxes imposed were very low and had an incomplete pass through (69). However, the implementation of these policies, especially tax policies, remains challenging. Many factors influence tax policy development and implementation, such as stakeholders who may play a positive or negative influential role in SSBs taxation. (70). Alternatively, information policies involving the use of food labels, marketing restrictions and awareness campaigns, and default policies like automatic inclusion of healthy drinks in kids' meals at restaurants, can be used to reduce SSBs intake. Furthermore, policies regulating the availability and access of SSBs can also be used to minimize their procurement at different levels. Whichever policy may be chosen, three key factors need to be kept in mind for optimum implementation and results; equity, feasibility and impact of the policy (71). Numerous barriers like the ones discussed here, as well as an extensive policy making process, and resistance and lobbying from the SSBs industry and influential stakeholders, is the reason why, despite constant urging from WHO and positive response from the policy makers, several countries have not been able to implement SSBs taxations. Political commitment and regulation is needed to address these challenges and successfully adopt SSBs taxation and other policies that can reduce SSBs consumption at the mass level (72).

A Way towards the Future: Recommended Actions and Suggestions

The most commonly recommended actions to control SSBs consumption at mass level can be grouped into 6 key themes; limiting physical access, increasing public education, initiating campaigns, pricing and taxation, advertisement, and capacity building for adoption of healthy behaviors, in regard to SSBs intake. Of these, physical access interventions are the most suggested, education strategies are incorporated during counselling of the community, marketing strategies enforce restrictions on the advertisement of SSBs, and capacity building strategies aim to provide technical and financial resources to implement SSB related policies (73).

The most successful SSBs interventions were the ones that targeted vulnerable population groups rather than the population as a whole (74-76). For instance, SSBs reduction strategies focused on children and adolescents had a more positive impact and reported a higher contact with the target population. The four most commonly used strategies for children included both individual and group education for both children and their families, the use of electronic media and cell phones to spread awareness, training parents and care providers, and reducing physical access to SSBs at home and in schools. All four of these themes require changes at the political, system and environment (PSE) level yet this area remains highly neglected when it comes to SSB policy development and implementation. Hence, the PSE framework needs to be assessed and modified in order to make effective SSB reduction regimes (77).

Overall, the public health agenda for SSBs control needs to incorporate nutrition education, technology-based interventions, access to SSBs alternatives such as fruit juice, changes in the community environment, and SSBs related campaigns run by health professionals. A modular approach is required by developing policies and actions that aim to first cut down the SSBs intake of the population and then move to altering their health-related behaviors as this allows individuals to focus on one goal at a time and provide more efficient results. Additionally, there is a lack of research involving interventions to reduce SSBs intake. Such research may provide the basis for future policy development and offer sustainable solutions to tackle the growing SSBs concern across the world (78).

Conclusion

This review addressed the growing epidemic of sugar sweetened beverages and their association with several chronic diseases, particularly breast cancer. SSBs due to their high sugar content impart serious health risks across population groups, which has led to increased morbidity, mortality and health expenses in many countries around the world. Most of this health burden can be attributed to diabetes mellitus and cardiovascular diseases, both of which can be prevented by reducing SSBs intake. This reduction can be achieved by putting in place effective health policies regarding SSBs access and taxation, which can reduce the SSBs consumption at population level. Additional specific interventions can be aimed at vulnerable groups such as children to target SSBs intake in childhood to reduce the early onset of risk factors associated with several non-communicable diseases.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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