RESEARCH
Review

Substitution of Sugar-Sweetened Beverages with Other Beverage Alternatives: A Review of Long-Term Health Outcomes

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ABSTRACT

Background Excessive consumption of sugar-sweetened beverages (SSBs) has become an intractable public health concern worldwide, making investigation of healthy beverage alternatives for SSBs imperative.

Aim To summarize the available evidence on the effects of replacing SSBs with beverage alternatives on long-term health outcomes.

Method We systematically retrieved studies from six electronic databases from inception to November 2013. Prospective cohort studies and randomized controlled trials (RCTs) examining the effects of substituting beverage alternatives for SSBs on long-term health outcomes in both children and adults were included. The quality of included studies was assessed using the Scottish Intercollegiate Guidelines Network 50 methodology checklists.

Results Six cohort studies and four RCTs were included in the systematic review with the quality rating ranging from acceptable to high. Evidence from both cohort studies and RCTs showed substitution of SSBs by various beverage alternatives was associated with long-term lower energy intake and lower weight gain. However, evidence was insufficient to draw conclusions regarding the effect of beverage substitution on other health outcomes, and which beverage alternative is the best choice.

Conclusions Although studies on this topic are sparse, the available evidence suggests a potential beneficial effect on body weight outcomes when SSBs are replaced by water or low-calorie beverages. Further studies in this area are warranted to fully understand the long-term health implications of beverage substitutions.
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EXTENSIVE EVIDENCE HAS ASSOCIATED SUGAR-sweetened beverages (SSBs) consumption with increased energy intake and weight gain in both children and adults.[1,2] In addition, evidence relating SSBs consumption to development of metabolic syndrome, type 2 diabetes, and cardiovascular disease later in adulthood is also accumulating.[3-5] SSBs are defined as calorie-containing carbonated drinks, fruit-flavored drinks, energy drinks, sports drinks, and vitamin water drinks, but exclude 100% fruit juices.[6] Limiting SSBs has been widely promulgated by public health policy and scientific documents as a prudent strategy for promoting optimal nutrition and health.[7-9] Several policy intervention strategies have been undertaken to reduce SSB consumption, such as reducing accessibility of SSBs in public facilities, restricting SSB marketing, and adopting taxes on SSBs.[10,11] Recently, the first soda tax in the United States was passed in the City of Berkeley, Alameda County, CA.[12] However, whether reducing SSB consumption will have anticipated beneficial effects in curbing its associated health outcomes remains unclear.[13] Evidence from evaluations of the effectiveness of taxing SSB revealed a reduction in SSB consumption, but had minimal influence on body weight outcomes.[14,15] This was attributed to higher energy intakes from other unhealthy foods or beverages in individuals who reduced their SSB consumption.[15] Therefore, reducing SSB consumption may be more effective when it is given together with a message of suitable healthier alternatives.

Beverages that are either lower in calories or higher in nutritional value such as plain water, artificially sweetened beverages (ASBs), coffee, tea, 100% fruit juices, and milk have been proposed as healthier alternatives to SSBs.[5] Evidence has shown water, as a natural calorie-free beverage, has a potentially important role in reducing energy intake and, consequently, in obesity prevention.[16,17] Recommendations to promote water consumption in lieu of SSBs have been proposed for obesity prevention.[18] ASBs may also be an

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acceptable alternative to SSBs because they contain negligible calories; however, the existing literature fails to draw consistent evidence on the long-term health implications of ASB consumption.[19] Although not conclusive, emerging data also indicate some beneficial effects of regular coffee and tea consumption on body weight regulation, diabetes, and cardiovascular disease risk in adults, possibly attributable to the caffeine and/or catechin content.[20-22] It should be noted that coffee and tea consumption are not recommended for children and adolescents due to the caffeine content.[23] Pure fruit juice, when consumed in moderate amounts, and low-fat/nonfat milk have also been considered as better alternatives to SSBs in fulfilling nutrient adequacy in both children and adults.[24-26] Milk proteins may contribute to accretion of lean tissue mass.[27] In addition, there is some indication of a protective effect of milk consumption on body weight outcomes.[28,29]

However, the effects of replacing SSB with these beverage alternatives on long-term health outcomes remain unclear. Furthermore, it is unknown whether beverage substitutions with different beverage types would confer a similar advantage. The type of beverage alternative for SSBs suitable for children and adults may differ. Beverage substitution can be examined either in intervention studies or by using a statistical substitution model in prospective cohort studies. Substitution modeling is an innovative statistical technique that formulates dietary components (nutrients or foods) in a specific way that could simulate the effects of replacing a dietary component with another dietary component on disease risks.[30] The aim of this systematic literature review was to examine the effects of substituting beverage alternatives such as plain water, ASBs, coffee, tea, 100% fruit juices, and milk for SSBs on long-term ($\geq$4 months) health outcomes in both children and adults.

METHODS

Systematic Literature Search

Electronic searches were conducted in Cochrane library, Embase, PubMed, Medline, ScienceDirect, and Web of Science from inception to November 2013 using key words to identify all prospective cohort studies and randomized controlled trials (RCTs) examining associations between substitutions of beverage alternatives for SSBs and long-term health outcomes in both children and adults. Two main search terms: *sugar-sweetened beverages* (*calorie-containing sweetened beverages, sugary drinks, soft drinks,* and *soda*) and *substitution* (*substituting, replacement*, and *replacing*) were used. We also manually searched the reference lists of all relevant articles to identify potentially related articles that were not identified in the original electronic search. Furthermore, the Internet search engine Google Scholar was searched for additional relevant references. Searches were limited to studies that were conducted in human beings and written in English with access to full text articles. This study was deemed exempt from institutional review board under federal regulation.[31]

Eligibility Criteria

Prospective cohort studies or RCTs were included if they documented the effect of replacing SSBs with at least one beverage alternative on a long-term health outcome. For prospective cohort studies, substitution modeling was required to evaluate the association between substitutions of SSBs with beverage alternatives on the outcomes of interest. Eligible RCTs were those investigated the provision of alternative beverages to displace SSBs (ie, home delivery of milk or low-calorie beverages among intervention households) on long-term health outcomes. Education programs targeted at reducing SSB consumption alone or along with modification of multiple health behaviors without provision of alternative beverages were excluded. Studies whose primary focus was exercise training, meal replacements, or included subjects with a specific disease or severe illness were likewise excluded as were cross-sectional studies, quasi-experimental studies, letters, and conference abstracts. This was due to the higher potential for bias in these study types or lack of peer review. This systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses criteria.[32]

Study Extraction

Data extraction was performed by two authors (M.Z. and A.R.) with differences of opinion resolved through discussion. All identified references were imported into ENDNOTE X6 (Thomson Reuters) and checked for duplicates. Based on screening of titles and abstracts, articles that were irrelevant to the subject of the review were excluded. Full texts of the articles meeting the inclusion criteria as indicated by the titles and abstracts were retrieved and scrutinized for eligibility by two reviewers (M.Z. and A.R.). When the relevance of the articles could not be determined by its titles and/or abstracts, full text of articles were retrieved. The consensus on inclusion of final articles to the review was reached between two reviewers.

Quality Assessment

Quality assessment was conducted by two independent reviewers (M.Z. and A.R.) to minimize bias using the Scottish Intercollegiate Guidelines Network 50 (SIGN-50) methodology checklist for cohort studies[33] and RCTs.[34] This checklist has been recommended as the most appropriate tool for rating the methodologic quality of cohort studies and RCTs.[35] SIGN-50 addresses five essential domains for good practice studies: comparability of subjects, exposure/intervention, outcome measure, statistical analysis, and funding.[36] Accordingly, the studies were rated as one of three quality scores: high, acceptable, or low. Studies that met all or the majority of the quality criteria and had little or no risk of bias were awarded as high quality. Studies that met most of the quality criteria but had some flaws in the study design with an associated risk of bias were graded as acceptable. Low quality was awarded to studies that met few or none of the quality criteria or had significant flaws in study design.

RESULTS

Study Selection

A total of 443 citations were identified from the literature search and an additional 27 citations were identified from searches of reference lists and Internet search engines. Of these, 155 citations were excluded as duplicates and 264 citations were excluded following the screening of titles and abstracts for relevance. As a result, 51 citations were assessed for eligibility based on full-text articles. A further 41 citations