Review Article

Impact of Drinking Water on Weight Loss: A Review

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ABSTRACT

Adequate water intake is essential for health, but any benefit for weight management remains unclear. Drinking water is often applied as a dietary means for weight loss and overweight/obesity prevention, but no evidence-based recommendation exists for this indication. The objective of the study is to note the impact of drinking water consumption on weight outcomes from the evidence of existing studies. A direct causal relationship between water consumption and bodyweight outcomes can't be achieved due to inadequate literature resources. Studies of individuals dieting for weight loss or maintenance suggest a weight-reducing effect of increased water consumption, whereas studies in general mixed-weight populations yielded inconsistent results. Though effect of water in weight loss fluctuates, it is clearly evident that replacing water with sugar sweetened beverages (SSB's), fruit juices or any other non-nutritive beverages show inverse association with weight loss and the risk for other risk factors also increases. These findings, along with epidemiologic and intervention studies suggested a potentially important role for water in reducing energy intakes, and by this means a role in obesity prevention. Further need for randomized-controlled trials exists. Lifestyle treatments for weight loss focus on reducing energy intake and increasing physical activity through diet, exercise and behavioral measures. In general, a combination of treatment is most effective way to achieve weight loss.

Keywords: Water, sugar-sweetened beverages, juice, non-nutritive sweetened beverages, weight gain.

INTRODUCTION

Water is truly the beverage for life. It prevents dehydration and is an important source of a nutritious diet. We are aware of the importance of fluids for survival. Without water humans survive for 2–4 days. Water comprises about 60% of our body weight and is critical for life. Every cell, tissue, and organ in your body needs water to work properly to maintain body temperature, remove waste, and lubricate your joints. Water is needed for overall good health. In an article published online in Critical Reviews in Food Science and Nutrition, The statement, "Drinking more water will reduce energy intake and will lead to weight loss or less weight gain, regardless of whether one intentionally makes any other changes to one's behavior or environment" was classified as a presumption. Data from short term controlled experiments suggest that drinking water may promote weight loss. Most people have been told they should drink 6 to 8, 8-ounce glasses of water each day. That is a reasonable goal. However, different people need different amounts of water to stay hydrated. Most healthy people can stay well hydrated by drinking water and other fluids whenever they feel thirsty. Water is best for staying hydrated. Other drinks and foods can help you stay hydrated. However, some may add extra calories from sugar to your diet. Fruit and vegetable juices, milk, and herbal teas add to the amount of water you get each day. Health care professionals commonly recommend increasing water intake, typically to 8 cups per day (a total of 1.92 L of water per day), as part of a weight-reducing diet. Contrary to the study hypothesis, advice and behavioural support to consume 8 cups of water per day in context of weight reducing diet had no added benefits on body weight reduction among adolescents with overweight or obesity.[1] Recognizing signs of dehydration is important, it include: little or no urine, urine that is darker than usual, dry mouth, sleepiness or fatigue, extreme thirst, headache, confusion, dizziness or lightheadedness, no tears when crying. Water intake as a weight loss tool, however, is not an evidence-based recommendation. Recent studies have shown mixed results, likely because of limitations in the measurement of hunger and thirst, as well as the numerous social, cognitive, sensory, and logistical factors that influence eating and drinking behaviors.[2] Consumers of drinking water differ from non-consumers with respect to several key obesity risk factors, including other beverage intake, diet composition, physical activity, stress and smoking. [3] While some propose that promoting the single behavior of drinking water instead of other beverages may be effective against obesity.[4,5]

Obesity continues to be prevalent, debilitate, impair the physical function, increased morbidity and mortality and greater health care costs.[6-10] Sugar sweetened beverages (SSB's) consumption is associated with weight gain [11-13], increased risk of type 2 diabetes [14-20], risk of cardio metabolic disease [15,20-23] and gout.[24] Large intake of fructose is related to lipid disturbances in small dense LDL cholesterol in children.[25] Factors that contribute to metabolic syndrome include high fat &carbohydrate intake and sedentary lifestyles. Research scientists have been studying how drinking water compared with sugar-

sweetened beverages, such as soda or juice, affects children's health. In the USA, beverages accounts to a fifth of the dietary energy intake in children and adolescents[26,27], and the proportion has increased substantially during the last decades[28]. Several national pediatric, dietary institutions as well as international authorities have already recommended a restricted consumption of soft drinks in children.[29-32] Drinking water vs. no beverage increases energy expenditure and rates of lipolysis.[33-36] Drinking water instead of caloric beverages lowers total energy intake by eliminating beverage calories.[11,37-47] Although the causal role of sugar-sweetened beverages in the development of obesity is still debated[12,48-49], a recent meta-analysis proposed that decreasing their consumption could reduce the obesity epidemic.[13] While guidelines include recommendations on changes in physical activity and diet, often little or no advice is offered on the importance of healthier hydration practices, neglecting to highlight the contribution of beverages high in sugar, alcohol or additives.

Public health initiatives of various countries like U.S, U.K, Australia and France are actively promote drinking water for weight management.[50-67] To date, recommendations to drink water for weight management have primarily been motivated by evidence that drinking water can decrease energy intake (EI). While drinking water can lower energy intake [39], it does not always have this effect. Under some conditions, drinking water has no effect[68,69] or even increases energy intake.[70] Drinking water, furthermore, has heterogeneous effects on key intermediates besides energy intake, namely energy expenditure(EE)[34,71–73] and fat oxidation(FO).[73-75] Various mechanisms may plausibly associate increased water intake with weight loss. These mechanisms include consumption of food with higher salt content which drives the need of increased water uptake[76], increased gastric distension[77,78] , fullness[79-81] or energy expenditure via water-induced thermogenesis[72,82]; decreased hunger,[79,81] energy intake,[80] or consumption of solid food from decreased thirst cues that were mistaken for hunger cues[83]; reduced activation of adipose tissue renin-angiotensin system components associated with dehydration[84]; displacement of calorie-containing beverages[4,42,85,]; and improvements in quality of the diet.[86-88] The exact mechanisms of the effect water consumption on body weight changes are still unclear. While some studies report that drinking water significantly increases weight loss[79,87]others report less weight gain,[4,89,90] no effect[91,92] or less weight loss.[93]

Scientific community also remains uncertain whether water has a causal effect in weight management or is complemented to other factors as well.[76,94] Many reviews juxtapose short term effects of drinking water to energy intake and longer term effects to weight change,[76,95,96] rather they don't consider short term effects of drinking water in fat oxidation or energy expenditure, which might also mediate weight change effects. It is unknown whether drinking water promotes weight loss over time under free-living conditions, independent of diet and activity, or whether water has benefits distinct from other unsweetened or non-caloric beverages. In this work, the aim of the study is to note the impact of drinking water (Plain) consumption on weight outcomes from the evidence of existing studies.

Advantages of drinking plain water over other beverages?

- To maintain the balance of body fluids/hydration
- To control calories
- To energise muscles
- To keep skin looking good
- Detoxification
- To maintain normal bowel function

Effect of other beverages on weight related conditions

Sugar sweetened beverages

SSB's mainly constitute of dietary fructose. The use of high-fructose corn syrup(HFCS), sucrose has magnificently increased over past decades in U.S.[97,98] One serving of SSB per day may result in approximately 50kg (110 pound) increase in body mass over 10 years.[42,99,100] fructose can increase energy intake and decrease energy expenditure which may leads to obesity.[100] Rapid absorption of carbohydrates from sugars and HFCS in SSB increases the risk of type 2 diabetes[17-19] due to high glycemic load which can lead to insulin resistance, impaired β cell function.[20,23]

Fructose metabolism in liver results in fructose-1-phosphate which serves as a backbone for triglyceride molecule[97,101-103] thereby increasing de novo lipogenesis.[98,104-107] Consumption of fructose in SSB is associated with increased visceral adiposity, hepatic lipogenesis and decrease insulin sensitivity[101] Both systolic and diastolic blood pressure increased after administration of fructose.[108] Long term use of soft drinks contributes to metabolic syndrome, increases cardiovascular risk,[109,110] gout.[24] SSB also encourage dependence because of their sweetness.[111,112]

Fruit juices

Fruit juices when taken without added sugars are not harmful but with high amounts of sugar produce risk.[19,113,114] Drinking lemon juice is an effective way to reduce weight as it increases the body's metabolic rate. For people looking to use lemon for its weight loss abilities, drinking lemon juice with warm water on an empty stomach every morning can produce amazing results. Along with the weight loss benefits, drinking warm lemon water every morning also has numerous other benefits, it possess immense health benefits ranging from its antibacterial and antiviral properties to its immune boosting abilities. However, many people do

not recognize that fruit juice sometimes contains just as much, if not more, sugar and calories than sugar-filled soft drinks. Even the highest quality juice goes through a manufacturing process that causes it to lose flavor which requires producers to add "flavor packs" to restore its natural flavor. Increased consumption of fruit juices may contribute to weight gain and increased risk of diabetes.[19,115,116] Chronic kidney disease and increased risk of kidney stones[117,118] in normal/healthy kidneys are also seen in daily intake of fruit juices along with added sugars.

Non-nutritive beverages

Non-nutritive sweeteners (NNS) like 'Diet', 'Light' or 'zero-calorie' often promoted as low/no-calorie alternatives to SSB's. It contains at least one non caloric sweetener[119,120] (aspartame, saccharin, neotame, sucralose); though these substances reduce the calorie intake, general and dental health can be affected when compared to drinking water.[121] Epidemiological studies show positive reports in weight gain,[122] impaired glucose control and developing of type 2 diabetes[123] associated with intake of NNS. Consumption of NNS could affect glucose homeostasis and absorptive capacity, increased palatability results in large food intake and changes in body mass index (BMI).[124,125] Diet soda was also associated with metabolic syndrome.[101]

First Author	Sample Characteristics: N(analysed), sex, age, study period)	Study design, Statistical analysis	Outcome
Johnson et al.[126]	1342(1203),M/F, age5-7years, 4years	Observational longitudinal study: Design: GLM model of fat mass at age 9y as a function of beverage consumption at ages 5 and 7y.[a] Water category included flavored water. Statistics: analysis of variance, multivariable linear regression	No association between water consumption (1 serving) at age 5 or 7 years and change in fat mass (in 1 kg) at age 9 years adjusted for sex and height and(mean change: -0.15, 95% CI:-0.57-0.27 and 20.14, 95% CI:-0.43-0.15) and adjusted for other factors[a] (mean change: 0.25, 95% CI: -0.15-0.65 and 0.06, 95% CI: -0.16-0.28)
Stookey et al.[87]	173F, 25–50years,1year	Longitudinal study; Design: Used nested mixed models to estimate effects of absolute and relative changes in water intake on weight gain. Participants from four diet groups.	Individuals drinking>1L water/day lost on average 2.3kgmore weight and2.3cm WC than those drinking<1L/day[b]. Replacing 1% of SSBs with water significantly reduced weight (0.3kg), WC(0.03cm) and body fat (0.03%).
Sichieri et al.[127]	1134 (n.r), M/F, age range: 10-11 years,8months	Longitudinal study; Design: secondary analysis of a cluster randomized controlled trial on the effect of a nutritional program that focused on reducing soft drink consumption. Statistics: multivariable linear regression	Significant inverse association between highwater consumption (>3 glasses/day)compared to low water consumption (≤3glasses/day) at baseline and change in BMI (kg/m^2) after 8 months adjusted for age and sex (β=-0.20, 95% CI:-0.40—0.004) and adjusted for baseline BMI, age, sex, physical activity, and intervention group (β=-0.21, 95% CI:0.41– -0.01). This association was only significant in the subgroup of the children in the control group (β=-20.31, 95% CI:-0.57– -0.05) but not in the intervention group (β=-0.08, 95% CI:-0.37– 0.24).No association between baseline water consumption (1 glass/day) and change in BMI (kg/m2) after 8 months adjusted for baseline BMI, age, sex, physical activity, and intervention group (β=-0.03, 95% CI: -0.01-0.07).
Dubuisson et al. [128]	322 (144), M/F, age range: 4-19years,5years	Observational longitudinal study; Design: retrospective analysis of longitudinal data of an interdisciplinary, Individually adapted obesity treatment program after 5 years. Participants with intervention period ≥1 year were included. Statistics: quasi-likelihood estimation with a linear link with an autoregressive correlation matrix for repeated measures.	Significant inverse association between water consumption at baseline and change in BMI after 9 months: Decrease in BMI z score was lower in participants with no or not every day water consumption (0.16±0.04) than in participants with high daily water consumption (-0.25±0.04, P=0.046).
Kant and Graubard[86]	3,978 (3,867), M/F, age range:2-19 years, 1year	Cross sectional study: Design: analysis of NHANES data. BMI categories defined according to CDC growth charts. Statistics: multivariable linear regression.	Significant direct association between water consumption and BMI category (in 3 categories). Adjusted mean (±SE) consumption of plain water(in g) significantly differed between underweight/ normal-weight children (550±33), overweight (582±52), and obese (720±44, P=0.01), adjusted for other factors.[c]

Park et al.[129]	11,049 (9,704 and 9,077), M/F, age: students from school grades 9-12,1year	Cross sectional study; Design: analysis of the National Youth Physical Activity and Nutrition Study. Statistics: chi-square test, multivariable logistic regression.	Significant direct association between low water consumption (<3 times/day) and BMI category (in 3 categories) adjusted for age, sex, race/ethnicity, consumption of various beverages, fruits, and vegetables, eating at fast-food restaurants, physical activity and television watching behavior. Obese children had less often a low water consumption than underweight/normal-weight children (OR=0.7, 95% CI: 0.58-0.93). Overweight children did not differ from underweight/normal weight children with respect to low water consumption (OR=0.9, 95% CI: 0.72-1.01). No association between water consumption (in 4 frequency categories) and BMI categories (in 3 categories)(P=0.11).
Fiore et al.[130]	n.r.(1,890), M/F, age range: 12-16 years,6years	Cross sectional study; Design:analysis of NHANES data. Statistics: bivariate analysis, multivariable logistic regression. Subgroup analyses of children with any or no obese parent.	Significant direct association between water consumption category and BMI category: Children with high water consumption (>48 oz/day) were less likely to be normal weight (vs. overweight/obese) compared to children with low water consumption(<22 oz/day) (OR=0.50, 95% CI: 0.33-0.77, P<0.01), also after adjustment for age, sex, race/ ethnicity, poverty-to-income ratio, parental weight category and education, hours of television viewing, exercise and exercise programs, intake of energy and dietary fiber, and eating breakfast (OR=0.55,95% CI: 0.34-0.90, P<0.05). This difference was also significant in the subgroup of adolescents with one or two obese parents (OR=0.05, 95% CI:0.26-0.97, P<0.05), but not in the subgroup with two non-obese parents (P≥ 0.05).
Lee et al. [131]	1,288 (1,270), M/F, age range:15-18 years,3years	Cross sectional study: Design: analysis of Korea National Health and Nutrition Examination Survey data. Statistics: chi-square test, multivariable logistic regression	Significant direct association between water consumption category and BMI category: Water Consumption differed by BMI category (4 categories) (chi-square test:P<0.0001). Children with low water consumption (<4 cups/day) were less likely to be underweight, overweight, or obese (vs. normal weight) than children with high water consumption (4 cups/day) (OR=0.7, 95% CI: 0.44-0.96, OR=0.4, 95% CI: 0.18-0.90, OR=0.5, 95% CI: 0.34-0.84), adjusted for age, sex, milk, soda, coffee drink, fruit, and vegetable consumption, frequency of eating out of home, sodium intake, and physical activity. No association between very low water consumption (<2.5 cups/day) and BMI category (in 4 categories), adjusted for the covariates.
Papandreou et al.[132]	655 (607), M/F, age range:715years,2years	Cross sectional study; Statistics: One-way analysis of variance (ANOVA).	No association between water consumption (in ml/day) and BMI category (in 3 categories): Water consumption in normal weight, overweight, and obese was 891±5 ml/day, 853±9 ml/day, and 801±11 ml/day, respectively (P=0.05).
Makkes et al.[133]	583 (356), M/F, age range:8-10years,1year	Cross sectional study; Statistics: logistic regression, adjusted analyses reported only with sample size sufficient to provide stable estimates.	No association between water consumption during the last 24 h (yes vs. no) and BMI categories (stunting: OR=0.87, 95% CI: 0.46-1.67, overweight: OR=0.84, 95% CI: 0.46-1.52, and obesity OR=1.33, 95% CI: 0.63-2.80). Adjustment not reported. No association between water consumption and BMI z score or BMI-for age centile (P=0.05)
Cullen et al. [134]	210(145), F, age range:8-10years,3years	Cross sectional study; Design: exploratory analyses of a pilot RCT. Statistics: Pearson correlation, multivariable (hierarchical stepwise) regression with backward deletion.	Significant direct association between water consumption (number of servings/day) and BMI: Pearson correlation coefficient r=0.239 (P<0.01). No association between water consumption (number of servings/day) and BMI, adjusted for socio-demographic characteristics, energy consumption, social desirability and field center (P-value not reported, because only significant results or statistical models with $R^2 \leq 0.10$

Muckelbauer et al.[90,135,136]	3,190 (2,950), M/F, mean age± SD: 8±1 years,	Interventional studies; Design: 17 intervention schools in one city, 5 control schools in another city. Intervention: promotion of water consumption by providing water fountains in schools and educational units. Control group: no intervention. Statistics: general estimation equation models considering cluster (schools) design, chi-square test. Subgroup analysis by migrational background.	Significant intervention effect on prevalence of overweight (primary outcome) after follow-up: Children in the intervention group were less likely to be overweight (including obesity) compared to the control group (OR: 0.69, 95% CI:0.48-0.98, P50.040), adjusted for baseline prevalence of overweight and clustering in schools [90] Significant intervention effect on incidence of overweight (excluding obesity): Children in the intervention group compared to the control group were less likely to become overweight (P50.018) [135] No intervention effect on the change in the BMI SD-score (in 1 unit, estimated group difference: -0.004, 95% CI:-0.045-0.036), adjusted for baseline BMI and clustering in schools. [90] No intervention effect on remission of overweight (excluding obesity)(P=0.485) and on incidence and remission of obesity (P=0.390 and P=0.251). [135]. Subgroup analysis: Intervention effect on prevalence and incidence of overweight only significant in children without migrational background (OR: 0.51 95% CI:0.31-0.83 and OR: 0.46, 95% CI:0.26-0.80) but not in children with migrational background. [136]
James et al.[84]	2950 kids, 8.3±0.7y,1year	Interventional studies; Primary school-level intervention to promote drinking water and reduce overweight. Intervention was both educational and environmental	Intervention group water intake was 220mL/day greater; Adjusted risk of overweight was 31% lower for intervention group. [OR=0.69 (95% CI 0.06, 1.91)] Intervention had no effect on soft drink and juice consumption.

[a]–Model was adjusted for sex, height at 9 y, child's body mass index at baseline, television watching, maternal education, paternal class, maternal body mass index, paternal body mass index, misreporting of energy intake (energy intake per estimated energy requirement), dietary energy density, percentage of energy intake from fat, and fiber density.
[b] –Model was adjusted for age, race/ethnicity, baseline status, and diet treatment group, energy expenditure, energy intake from food, and food macronutrient and water composition. WC-waist circumference
[c]–adjusted for sex, race/ethnicity, age, day of week of dietary intake, hours of television and computer use, physical activity, and season.

DISCUSSION

From the studies, it is clearly evident that less longitudinal study shows inverse association of increased water consumption resulting in decreasing the excessive weight gain in childhood; in contrast most of the cross sectional studies supports direct association in increased water consumption which was higher in children with a higher BMI. So, evidence for making a causal association between water consumption and body weight outcomes can't be achieved due to inadequate literature resources. In one review conducted by Daniels et al.[95] concluded that there might be an inverse association between water consumption and weight status studies on children and adults.

Short term RCT studies show effect of drinking water in weight management has various effects-lowers energy intake, increases energy expenditure and/or increases fat oxidation. Long term RCT studies show significant effects in weight changes under various types of exposure. Drinking water results in less weight gain for individuals with ad libitum diet and usual exercise, when it is consumed instead of all caloric beverages, not only SSB. Drinking water results in greater weight loss for overweight or obese individuals when diet is restricted, the usual level of exercise is maintained and the volume of drinking water exceeds 1 L/day, enough to dilute urine. In a study, the prevalence of childhood obesity decreased with fewer intakes of caloric beverages and increasing water consumption.[137] A study conducted between water drinkers and non-water drinkers, demonstrated that when combined with a hypo caloric diet, consuming 500 mL water before each main meal leads to greater weight loss than a hypo caloric diet alone in middle-aged and older adults.[79] In a randomized controlled trial, significant weight loss was monitored in the pre-meal water group, indicating self-monitoring of increased water consumption may provide additional weight loss maintenance benefits.[138]

Null effects of the drinking water are also seen in both short term and long term RCT studies. Short term studies show no effect in normal weight individuals who can alter fuel partitioning instead of energy expenditure, when anaerobic metabolism and carbohydrate oxidation predominate,[139] post prandial insulin levels after intake of high glycemic loads which don't vary significantly by beverage type,[140] No change in fat oxidation when water consumption less than 0.5L/dehydration, under fasting conditions, at rest or during low-to moderate-intensity exercise. Long term studies show no effect when not all caloric beverages are targeted for replacement/ displacement, when caloric beverages are not used as

control/reference condition, low intake of SSB, volume intake of drinking water is not sufficient to dilute the urine, when participants have restricted food intake.

LIMITATIONS

All references in published systematic reviews, meta-analyses, observational and interventional studies were not included in the study. Intervention study not met target are frequent in long term studies.[141] This review only explains about changes in the weight outcome caused by the drinking water rather than effect of water in energy intake, energy expenditure, fat oxidation. Low numbers of longitudinal, interventional studies were included. Depending on the water consumption, various heterogeneous groups were created especially in the cross sectional studies, water consumption rate was collected by asking one question on the usual consumption per day/week. These semi quantitative methods are more inclined towards recall bias which makes the study less accurate. In annex, under reporting of dietary intake was related to show increase in body weight in adolescents.[142] On the other hand, over reporting was shown in obese than normal weighed children because of water is regarded as a healthy food item in these population. The result are consistent for overweight or obese individuals with a restricted, low glycemic or hypo caloric diet who takes more than 1L/day.[79,138,141]

CONCLUSION

Studies report null, negative, positive effects of drinking water on weight changes. However, it is clearly evident that replacing water with SSB's can result in the increased risk factors apart from obesity. Obese showed greater weight loss when controlling the diet intake along with increased water consumption. In children, longitudinal studies show a direct relationship with the change in weight with increased water consumption but in cross sectional studies, water consumption was observed higher among children with higher body weight status. Interventional studies shows that risk of being overweight are lesser among increased water consumption group than the control groups. Effect of water consumption in weight changes are less studied among adolescents. Further studies should be conducted in future in order to conclude that increased water consumption have significant effect in weight loss.

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