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Original Article
CLINICAL TRIALS: BEHAVIOR, PHARMACOTHERAPY, DEVICES, SURGERY

Obesity

The Effects of Water and Non-Nutritive Sweetened Beverages on Weight Loss During a 12-week Weight Loss Treatment Program

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Objective: To compare the efficacy of non-nutritive sweetened beverages (NNS) or water for weight loss during a 12-week behavioral weight loss treatment program.

Methods: An equivalence trial design with water or NNS beverages as the main factor in a prospective randomized trial among 303 men and women was employed. All participants participated in a behavioral weight loss treatment program. The results of the weight loss phase (12 weeks) of an ongoing trial (1 year) that is also evaluating the effects of these two treatments on weight loss maintenance were reported.

Results: The two treatments were not equivalent with the NNS beverage treatment group losing significantly more weight compared to the water group (5.5 kg versus 3.8 kg; $P < 0.0001$) after 12 weeks. Participants in the NNS beverage group reported significantly greater reductions in subjective feelings of hunger than those in the water group during 12 weeks.

Conclusion: These results show that water is not superior to NNS beverages for weight loss during a comprehensive behavioral weight loss program.

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Introduction

Beverage consumption recommendations (1) suggest water as the gold-standard beverage for optimal health. The US Dietary Guidelines (2) suggest that while beverages with non-nutritive sweeteners (NNS) are preferable to those with caloric sweeteners, there is still a question about whether they are beneficial for weight management. While numerous clinical trials have examined the effects of nutritive sugar sweetened beverages (NS) compared to NNS beverages on weight loss, few studies have directly compared water and NNS beverages on weight loss using an equivalence trial design.

NNS were introduced into the food supply over 50 years ago and are being used in hundreds of different food and beverage products. Despite the long history of usage there continues to be considerable controversy concerning their role in the diet, particularly whether they are a useful tool as an aid in weight loss and weight loss maintenance (3-6). NNS provide sweetness equivalent to NS but contribute essentially zero energy. Since the 1980s a number of short-term experimental studies have compared NNS to NS and several comprehensive reviews have concluded that the evidence supports either a beneficial effect or no effect of NNS on appetite and energy intake (7-11). Other studies have reported findings of increased hunger with consumption of NNS (11) but generally without an accompanying increase in caloric intake.

Several observational studies have reported a positive association between NNS consumption and greater body weight and weight gain over time (4,12). Determining causality is not possible with these studies but it is possible that they represent "reverse causality" whereby obesity may cause people to seek diet beverages (10,13).

The largest and most recent randomized trial (14) to compare water, diet beverages and an attention control for their effects on weight loss used a superiority trial design. The authors found that the diet beverage treatment, but not water, significantly increased the probability of losing 5% of body weight over the 6-month study duration compared to a standard weight loss education and monitoring program. Subjects in both treatment groups lost a significant amount of weight but the amount of weight lost compared to the control was not different between treatment groups.

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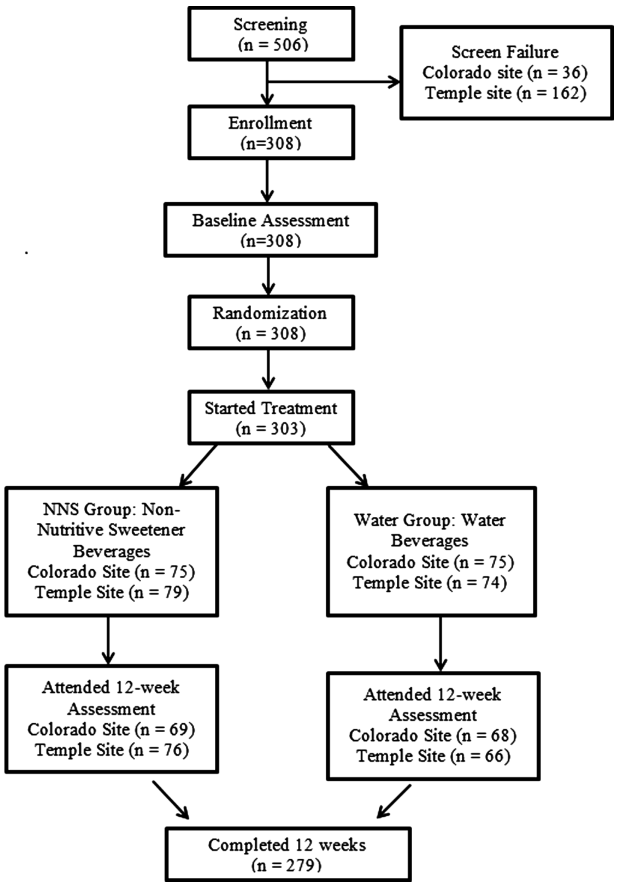

FIGURE 1 Screening, enrollment, randomization, and follow-up of study participants.

Given the great interest in losing weight, preventing weight gain and maintaining weight loss (15), it is important to understand whether NNS beverages are a benefit or a hindrance to people actively trying to manage their weight. As water has been deemed the "gold standard" beverage recommended for weight management it is important to assess, in a randomized trial, whether NNS beverages and water produce equivalent weight loss among people enrolled in a behavioral weight management program.

Here, we report findings from the 12-week weight loss phase of a 1-year randomized, clinical trial to test the hypothesis that the amount of weight lost (12 weeks) and maintained (9 months) in a behavioral weight management program will be equivalent in participants consuming beverages containing NNS compared to water.

Methods

Participants

Five hundred and six participants were screened and 308 were enrolled in the trial between October 2012 and April 2013 at University of Colorado (n = 151;4 cohorts) and Temple University (n = 157;5 cohorts), see Figure 1. Participants were male and female, ages 21-65, BMI 27-40. Enrollees represented a range of ethnicities and races (Table 1).

Screening was carried out over the phone or through completion of a secure web based screening form. Eligible participants had to report being weight stable within 10 pounds in the past 6 months, engaging in fewer than 300 min of physical activity per week and consuming at least 3 NNS beverages per week. Applicants were excluded if they were lactating or pregnant within the past 6 months or were planning on becoming pregnant during the time frame of the study. Other exclusions included but were not limited to: diabetes, CVD, uncontrolled hypertension, and use of current medications affecting weight and metabolism. Participants needed physician approval stating they were in good general health and that nutrition and exercise requirements would not be contraindicated.

The study was approved by the Western IRB at the University of Colorado site and the Temple University IRB. Informed consent was obtained from all participants.

Study design

The study was designed as a 1-year equivalence randomized trial composed of a 12-week weight loss phase followed by a 9-month weight maintenance phase. Participants were randomly assigned to the NNS beverage or water treatment arms by a computer-generated randomization schedule that ensured an equal distribution of women and men in each behavioral weight loss treatment group. Participants

TABLE 1 Baseline subject characteristics by group[a]

Characteristic	NNS group (n = 158)	Water group (n = 150)
Age (y)[b]	48.3 ± 10.4	47.3 ± 10.6
Gender [*n*, (%)]		
Female	130 (82%)	125 (83%)
Male	28 (18%)	25 (17%)
Ethnicity [*n*, (%)][c]		
Hispanic/Latino	23 (15%)	12 (8%)
Not Hispanic/Latino	133 (85%)	138 (92%)
Race [*n*, (%)]		
White	107 (68%)	101 (67%)
Black/African American	42 (27%)	43 (29%)
Asian or Pacific Islander	1 (0.6%)	4 (3%)
American Indian or Alaskan Native	1 (0.6%)	0 (0%)
Multiracial Origin	1 (0.6%)	1 (0.6%)
Other	6 (4%)	1 (0.6%)
BMI (kg m^{-2})[d]	33.92 ± 4.25	33.30 ± 3.98
Baseline weight (kg)	93.92 ± 13.29	93.03 ± 12.99
Systolic BP (mm Hg)	118.79 ± 12.08	117.87 ± 12.58
Diastolic BP (mm Hg)	76.70 ± 7.56	76.21 ± 7.29

There were no significant differences between the two groups in demographic profile.
[a]Chi-square analyses completed for Gender, Ethnicity, and Race. Chi-square analysis showed no between group differences.
[b]Two sample t test statistics showed no between-group differences. Two sample t test analyses completed for age, weight, systolic BP, diastolic BP, BMI. Mean ± SD (all such values).
[c]n = 156 in NNS group.
[d]n = 156 in NNS group and n = 147 in Water group.

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had to be willing to discontinue drinking NNS beverages for the 1-year study should they be randomized to the water treatment group.

The protocol specified preplanned data analyses to be conducted on the primary outcome of weight loss at 12 weeks (weight loss period) and at the end of 1 year (weight loss maintenance).

Intervention

All participants. All participants received a comprehensive cognitive- behavioral weight loss intervention called The Colorado Weigh (16). Participants attended 12 weekly, 60-min group meetings that were led by registered dietitians or clinical psychologists. Participants attended group meetings organized by treatment (NNS or Water) and were instructed on behavioral weight loss strategies. Weekly weigh-ins were conducted at each group meeting. Examples of weekly topics include self-monitoring; portion sizes, reading food labels; physical activity and insights into weight loss maintenance from the National Weight Control Registry (16-19).

Individual energy targets for weight loss were set as equal to each participant's estimated resting metabolic rate (RMR), rounded up to the nearest 100 kcal, determined using a Tanita Model TBF-300A bioelectrical impedance device that assesses body composition and provides an imputed RMR. Energy targets were adjusted, as needed, by the group leader in an attempt to achieve a weight loss of 1 to 2 pounds per week. Weekly physical activity targets were set based on increasing moderate to vigorous activity by 10 min $week^{-1}$ above the subject's usual activity level with a target goal to reach 60 min day^{-1}, 6 days $week^{-1}$. Physical activity was assessed by two methods; (1) participants wore a Body Media armband (Manufacturer: BodyMedia, Model AB155) for 1 week during weeks 1 and 12, and (2) participants reported daily physical activity minutes on exercise logs turned in weekly. Participants received the same curriculum regardless of which treatment arm they were assigned to with the only difference being discussion of the type of beverages they were instructed to consume during the study.

NSS beverage group. Participants randomized to the NNS beverage group were asked to consume at least 24 fluid ounces of NNS beverage per day and their water consumption was not restricted. An NNS beverage qualified if it had <5 kcal per 8 ounce-serving, was pre-mixed, and contained non-nutritive sweeteners.

Water group. Participants randomized to the water group were asked to consume at least 24 fluid ounces of water per day, and not drink any NNS beverages. They could, however, eat foods that contained NNS (examples: artificially sweetened yogurt, gum, candies, cookies, ice cream, gelatin, pudding), but could not intentionally add NNS (examples: aspartame—NutraSweet or Equal, sucralose—Splenda, stevia—Truvia; as well as diet creamers) to beverages such as coffee.

Participants were given manufacturers coupons weekly (from the three largest beverage manufacturers: The Coca-Cola Company, PepsiCo and Dr Pepper Snapple Group), redeemable for bottled water or NNS beverages at retail stores. Participants were asked to record their beverage intake daily, and this information was used to assess treatment adherence.

Measurements

All assessments, except for height, were conducted at baseline and after 12 weeks of treatment. Height without shoes was measured to the nearest 0.1 cm at the screening visit using a wall-mounted stadiometer. Body weight in light clothing and without shoes was measured to the nearest 0.1 kg on a digital scale. Waist circumference was measured at the top of the iliac crest until two consecutive measures within 0.5 cm were obtained. Resting blood pressure was measured while the subjects were seated after a 5-min rest; the average of two measures was used. Blood samples were collected using standard venipuncture method after a 10- to 12-h fast for measurement of lipids and glucose. Participants provided a urine sample collected in a sterile container for measurement of urine osmolality. Blood samples from both study sites were analyzed at the University of Colorado Hospital laboratory. Urine samples collected at the Colorado site were measured at the University of Colorado Hospital laboratory; those from Temple University were measured at Quest Diagnostics, Madison, NJ.

Participants completed questionnaires at baseline and 12 weeks to assess changes in perceived hunger (using a 100 mm visual analog scale anchored at "not at all hungry" and "extremely hungry"). Beverage treatment adherence was determined from daily beverage logs, collected weekly, on which participants recorded all beverages consumed.

Participants received $75 for completing the assessment visit at 12 weeks and $50 for completing at least 9 of 11 food and beverage logs during the 12-week weight loss intervention. Total compensation if they completed all requirements was $125.

Power of the study

The primary outcome addressed in this report is change in body weight during the 12-week weight loss phase of this 1 year trial. The study was designed as an equivalence trial with the hypothesis that there would be no clinically meaningful difference in weight change between those consuming NNS beverages or water. Specifically, the bounds of equivalence for between-group difference in 12-week weight loss were prespecified to $\pm$ 1.7 kg. Assuming the true difference was 0.57 (1/3 of the equivalence margin) and common SD of 3.9 kg, a sample size of 150 per arm was required using two, one-sided t tests to ensure at least 80% power with an alpha level of $P < 0.05$ to establish equivalence.

Statistical analysis

Intent-to-treat (baseline observation carried forward) was used as the primary analysis for efficacy of weight loss using the weekly body weights as the dependent variable. As a secondary analysis we also looked at only participants who completed all 12 weeks of the trial. Five participants were randomized but did not begin treatment (Figure 1) and were excluded. The primary outcome measure was change in body weight from baseline to 12 weeks. The results were the same using baseline carried forward or a mixed model (accounting for missing data) analytic schemes.

The primary hypothesis tested in this study was that water and NNS beverage treatments would be equivalent with upper and lower bounds of equivalence set at $\pm$1.7 kg. This body weight difference was chosen as a value that would not be meaningfully different in a

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clinical setting. To be considered equivalent, the mean and the upper and lower 90% confidence limits for the difference in weight loss between NNS beverage and Water groups would have to be within the pre-set upper and lower bounds of equivalence, ±1.7 kg. Other weight-related outcomes included weight change from baseline for participants who completed all 12 weeks of the trial (for whom we had a 12-week body weight) and percentage of participants who lost at least 5% of their initial weight. Differences between treatment groups for weight loss were assessed using several different methods: a mixed model, ANCOVA and two independent *t* tests (or chi-square when appropriate). All methods showed the same results. We report here the *t* test results [two one-sided *t* tests; the standard approach for evaluating equivalence (20)] and 90% confidence intervals. Secondary outcomes (waist circumference, systolic blood pressure, blood measures, urine osmolality, hunger, and physical activity) were analyzed using linear mixed effects model which consisted of classification variables of time (baseline or 12 weeks) and group (NNS or water) as well as their interaction term as fixed effects and an unstructured covariance. Between-group and within-group contrasts were tested under this model.

Results

A total of 303 participants began the study treatment and 279 participants completed the 12-week weight loss phase of the study, representing 92% of the starting population (Figure 1). Study dropouts were similar across the two study sites (9.27% at Colorado, 9.55% at Temple) as well as between the treatment groups (5.8% for NNS, 10% for water). There were no significant baseline differences in age, gender, race/ethnicity or other study measures between the water and NNS beverage treatment groups (Table 1). Almost 80% of the participants were female, 68% white, and 27% African American.

There were no significant differences between groups in adherence to the study beverages as assessed by the weekly beverage consumption logs. Percent adherence for reported daily consumption of at least 24 ounces of NNS or water was 96.6% vs. 95.7%, respectively ($P = 0.34$). Weekly group meeting attendance was also not different between the groups (attendance: 90.8% for NNS; 89.7% for Water, $P = 0.24$).

The mean weight loss difference between Water and NNS was −1.85 kg (90% CI: −1.12 kg, −2.58 kg). Because the lower confidence limit (−2.58 kg) was outside of the equivalence bounds set *a priori* in our hypotheses, the two treatments were not equivalent and paired comparisons were conducted. This analysis indicated that weight loss in the NNS beverage group [5.95 kg ± 3.94 kg (SD)] was significantly greater than the Water group (4.09 kg ± 3.74 kg (SD), $P < 0.0001$) using an intent to treat (LOCF) analytic scheme (Table 2). Similar findings were observed using observations only from those completing the 12-week assessment (Table 3). In the Water group, 43.0% of participants lost >5% of their body weight, while 64.3% of participants in the NNS beverage group lost > 5% ($P = 0.0002$; Figure 2).

After 12 weeks of treatment, changes in waist circumference, glucose, systolic blood pressure, HDL, triglycerides and urine osmolality were not significantly different between treatment groups. Reductions in total cholesterol and LDL were significantly greater in the NNS group than in water group (Table 4).

There was no significant difference between groups in change in physical activity over 12 weeks as determined by either armband or activity log measures. Hunger increased slightly in the Water group while it declined slightly in the NNS group, resulting in a significant between group difference ($P = 0.013$, Table 4).

Discussion

In this 12-week weight loss study, consuming water and NNS beverages were not equivalent for weight loss, with the NNS group losing significantly more weight than the water group. The results provide support for the use of NNS beverages in the context of a behavioral weight management program and should be reassuring for people who choose to consume NNS beverages. It demonstrates that they can drink a NNS beverage without the caloric contribution of nutritive sweeteners and without concern that their weight loss efforts will be undermined and, in fact, may be slightly enhanced. It should be noted that because eligible subjects were already NNS drinkers assignment to the NNS treatment did not require as great a behavior change as the Water group who had to abstain from NNS beverages for the trial. We chose this design rather than admitting all comers in order to ensure that subjects assigned to NNS would adhere to the treatment giving us the ability to see if NNS adversely affected weight loss. Despite this, subject completion was high and did not differ between groups and adherence to the treatment was >95% based on beverage logs.

These findings build on the only other published study similar to the present trial. Tate et al. (14) compared water, diet beverages and an attention control over 6 months of intentional weight loss using a superiority trial design in 318 participants. Those authors found no significant differences in mean weight loss between the water and diet beverage groups when compared to the attention control group. However, the probability of losing 5% of body weight was significantly better in the NNS group compared to the attention control group ($P = 0.04$). The likelihood of achieving a 5% loss was not different between the group assigned to water compared to the attention control ($P = 0.13$). A significant difference between that study and the present trial is the intensity of the intervention. Tate et al. asked participants to make a single substitution in their diet, changing beverage options, while in our study participants in both the water and NNS groups received a comprehensive behavioral treatment program. Participants in the Tate trial lost <2% of body weight on average over the first 12 weeks while participants in the present trial lost between 4 and 7% of body weight. Taken together, results from both studies suggest that NNS beverages can be an effective strategy for weight management both in low intensity and high intensity behavioral interventions. Furthermore, in the present study NNS beverages performed better than water in supporting weight loss during the 12-week weight loss phase.

The purpose of this trial was to compare directly the "gold standard" beverage for supporting good health, water, with NNS beverages in the context of weight loss. This is an important question as many people choose to consume NNS beverages as part of a weight management strategy, and others may be more likely to do so if they

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TABLE 2 Baseline-carried-forward analysis for absolute weight loss (kg)

Group	Baseline weight (kg)	Week 12 clinic weight (kg)	Change	90% CL mean change	*P* value for change
NNS ($n = 154$)	93.91 (13.46)	87.97 (13.39)	−5.95 (3.94)*	−5.42, −6.47	**<0.0001**
Water ($n = 149$)	93.15 (12.94)	89.06 (12.86)	−4.09 (3.74)*	−3.59, −4.60	**<0.0001**
NNS—water	0.76 (13.21)	−1.09 (13.13)	−1.85 (3.84)*	−1.12, −2.58	**<0.0001**

Analysis includes those participants who dropped out of the study in the analysis, using the baseline observation carried forward. This analysis mimics the clinical setting. Although equivalence cannot be established, participants lost more weight in the NNS group as compared to the water group. All analyses were completed using a Satterthwaite two sample *t* test. All values are Mean (SD) unless otherwise noted. Statistically significant values ($P < 0.05$) are shown by an asterisk (*) and statistically significant *P* values are shown in bold.

had confidence that it would not hinder their success. The popular media continues to raise questions about the value of NNS beverages in weight loss (21,22) citing concerns from some experts that NNS beverage usage is associated with obesity and weight gain in observational studies (21-23). The current results, along with results of Tate et al. (14), provide strong evidence from large randomized controlled trials that NNS beverages do not hinder and can help with weight loss when compared to water. In addition, Phelan and Wing examined the use of NNS beverages by those in the National Weight Control Registry and found that successful weight losers drank three times the NNS beverages compared to those who had never lost weight (24).

We chose 12 weeks as the weight loss phase because most studies show that weight loss slows considerably after 6 months of treatment with more than half of the weight loss occurring in the first 12 weeks (25,26), probably owing to difficulty with longer term adherence to a hypocaloric regimen. Furthermore, it is now recognized that weight loss is a different process from weight maintenance, both behaviorally and physiologically, so it is important to study treatment effects on these two processes separately (27). The benefit of the current 1 year trial is that we will be able to compare both weight loss and weight loss maintenance within the same group of participants. The trial was designed to allow preplanned analysis of the treatment effects after just the 12-week weight loss phase as well as after 9 months of weight maintenance (still underway) which will be reported separately.

While most secondary outcomes were not different between the groups, the NNS group showed greater reductions in total- and LDL-cholesterol. This may be due to the greater weight loss in the NSS group. There was also no significant difference between the groups in urine osmolality although osmolality decreased slightly in the water and increased slightly in the NNS group. It is unlikely that changes in hydration status were responsible for the significant differences in body weight between treatments. The small changes observed were well within the normal range for urine osmolality (500-800 mOsmol kg^{-1}) suggesting no adverse effect on fluid intake regulation. Physical activity increased significantly in both groups as a function of the behavioral treatment but was not significantly different between groups. Sedentary behavior actually decreased significantly in the Water group over time but not the NNS group. The changes over time were not significant between groups. Taken together, changes in physical activity and sedentary behaviors cannot account for the difference in weight loss observed.

Based on the design of this study we are unable to say, what is the mechanism for the greater weight loss in the NNS group compared to the water group. Weekly hunger scores were significantly lower among the NNS group than the water group although the absolute changes were small. While it is plausible that the NNS participants were more likely to adhere to the dietary recommendations due to less hunger than the Water group we cannot conclude this based on this study. Some authors (3,5,6) have suggested that use of NNS may increase appetite for sweet foods and disrupt regulation of energy balance. Weight loss results for the present study suggest that NNS consumption did not increase energy intake from other foods compared to water. This is consistent with other studies that have not found increased consumption of sweet or high energy foods while using NNS (28,29). Further studies will be needed to ascertain the mechanism(s) that may be responsible for the weight loss results.

TABLE 3 Absolute weight loss (kg) for completers

Group	Baseline weight (kg)	Week 12 clinic weight (kg)	Change	90% CL mean for change	*P* value for change
NNS ($n = 142$)	93.56 (13.23)	87.11 (12.85)	−6.45 (3.68)*	−5.94, −6.96	**<0.0001**
Water ($n = 134$)	93.88 (12.99)	89.33 (13.07)	−4.55 (3.67)*	−4.03, −5.08	**<0.0001**
NNS—water	−0.32 (13.12)	−2.22 (12.96)	−1.90 (3.67)*	−1.16, −2.63	**<0.0001**

Analysis including participants who completed 12 weeks of the trial. Although equivalence cannot be established participants lost more weight in the NNS group as compared to the water group. All analyses were completed using a Satterthwaite two sample *t* test. All values are Mean (SD) unless otherwise noted. Statistically significant values ($P < 0.05$) are shown by an asterisk (*) and statistically significant *P* values are shown in bold.

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TABLE 4 Cardiometabolic, hunger, physical activity, and sedentary activity changes from baseline to week 12 in the NNS and water groups[a]

	Assessment period[b]			
Outcome variable and group	Baseline	Week 12	Change	*P* value for change
Waist circumference (cm)				
NNS	108.00 (0.86)	102.27 (0.88)	−5.73 (0.49)*	**<0.0001**
Water	107.10 (0.87)	102.74 (0.90)	−4.36 (0.50)*	**<0.0001**
NNS—water	0.90 (1.22)	−0.46 (1.26)	−1.36 (0.70)	0.0528
Systolic BP (mm Hg)				
NNS	118.84 (0.00)	112.60 (1.07)	−6.25 (0.95)	**<0.0001**
Water	117.93 (1.01)	113.71 (1.10)	−4.23 (0.97)*	**<0.0001**
NNS—water	0.91 (1.42)	−1.11 (1.54)	−2.02 (1.36)	0.1372
Glucose (mg dl^{-1})				
NNS	91.44 (1.45)	93.59 (0.95)	2.15 (1.03)*	**0.0375**
Water	90.92 (1.47)	93.40 (0.98)	2.48 (1.05)*	**0.0193**
NNS—water	0.52 (2.07)	0.19 (1.37)	−0.33 (1.47)	0.8224
Cholesterol (mg dl^{-1})				
NNS	190.68 (2.76)	173.92 (2.70)	−16.76 (1.99)*	**<0.0001**
Water	193.23 (2.80)	184.38 (2.77)	−8.86 (2.05)*	**<0.0001**
NNS—water	−2.56 (3.93)	−10.46 (3.87)*	−7.90 (2.86)*	**0.0061**
HDL (mg dl^{-1})				
NNS	53.67 (1.65)	50.55 (1.17)	−3.12 (1.36)*	**0.0224**
Water	55.91 (1.68)	52.00 (1.20)	−3.91 (1.39)*	**0.0053**
NNS—water	−2.24 (2.36)	−1.45 (1.68)	0.79 (1.94)	0.6831
LDL (mg dl^{-1})				
NNS	114.92 (2.42)	103.39 (2.34)	−11.53 (1.72)*	**< 0.0001**
Water	116.44 (2.45)	110.77 (2.39)	−5.68 (1.77)*	**0.0015**
NNS—water	−1.52 (3.44)	−7.38 (3.34)*	−5.86 (2.47)*	**0.0184**
Triglycerides (mg dl^{-1})				
NNS	120.71 (6.35)	104.16 (6.43)	−16.56 (5.12)*	**0.0014**
Water	119.20 (6.46)	109.30 (6.59)	−9.90 (5.28)	0.0617
NNS—water	1.51 (9.06)	−5.14 (9.21)	−6.65 (7.35)	0.3662
Urine osmolality (mOsmol kg^{-1})				
NNS	567.36 (21.35)	597.67 (22.88)	30.31 (25.44)	0.2346
Water	592.54 (21.71)	565.79 (23.53)	−26.75 (26.10)	0.3063
NNS—water	−25.18 (30.45)	31.88 (32.82)	57.06 (36.45)	0.1186
How hungry did you feel over the past week (scale 1–100)?				
NNS	51.91 (1.57)	48.42 (1.47)	−3.49 (1.92)	0.0694
Water	47.93 (1.62)	51.34 (1.53)	3.41 (1.99)	0.0877
NNS—water	3.98 (2.25)	−2.92 (2.12)	−6.90 (2.76)*	**0.0130**
Total moderate PA (hrs/week)				
NNS	4.30 (0.23)	6.09 (0.26)	1.79 (0.25)*	**<0.0001**
Water	4.40 (0.24)	5.49 (0.27)	1.10 (0.26)*	**<0.0001**
NNS—water	−0.10 (0.33)	0.59 (0.37)	0.69 (0.36)	0.0547
Total sedentary activity (hrs/week)				
NNS	158.06 (1.92)	156.39 (2.27)	−1.67 (2.55)	0.5129
Water	160.78 (1.96)	155.03 (2.34)	−5.75 (2.63)*	**0.0305**
NNS—Water	−2.71 (2.74)	1.36 (3.26)	4.07 (3.67)	0.2685

[a]All analyses are from mixed effect models. Statistically significant values ($P < 0.05$) are shown by an asterisk (*) and statistically significant *P* values are shown in bold. NNS, Non-nutritive sweetener group; water, water group; BP, blood pressure; PA, physical activity. For systolic BP and waist circumference: $n = 142$ for NNS and $n = 134$ for water. For glucose, cholesterol, HDL, and triglycerides: $n = 142$ for NNS and $n = 133$ for water. For LDL: $n = 140$ for NNS and 131 for water. For urine osmolality: $n = 141$ for NNS and $n = 133$ for water. For "How hungry did you feel over the past week": $n = 132$ for NNS and $n = 122$ for water. For total moderate PA: $n = 136$ for NNS and $n = 126$ for water. For total sedentary activity: $n = 134$ for NNS and $n = 123$ for water.
[b]All values are means; Standard Error in parentheses.

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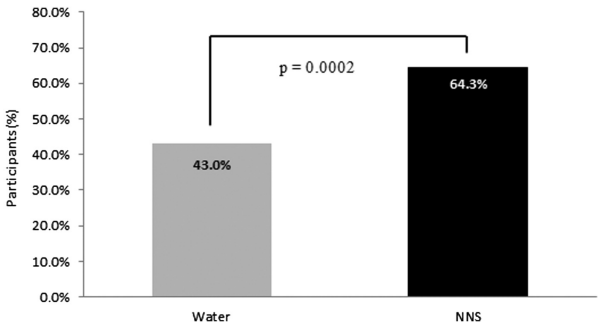

FIGURE 2 Percent participants who achieved at least 5% weight loss. Results based on Chi-square analysis. Analysis includes those participants who dropped out of the study in the analysis, using the baseline observation carried forward. This analysis mimics the clinical setting. Difference = 0.2133 or 21.33% difference between groups with 90% CI (0.1212−0.3054). n = 154 for NNS, n = 149 for Water.

These results strongly suggest that NNS beverages can be part of an effective weight loss strategy and individuals who desire to consume them should not be discouraged from doing so because of concerns that they will undermine short-term weight loss efforts. A longer term follow-up of this randomized cohort, now underway, will clarify the utility of NNS beverages in weight loss maintenance. O

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