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The Impact of an m-Health Application Intervention Program on Sugar Sweetened Beverage Consumption among College Students: A Randomized Controlled Trial

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Abstract

Context: Researchers and others can benefit from using mobile health apps to improve healthy lifestyle choices. m-Health initiatives that focus on a single dietary behavior, such as the recommendation of Sugar-Sweetened Beverages (SSBs), may enhance overall dietary health and provide encouragement for people to adopt more beneficial dietary choices.

Objective: To improve the healthy lifestyle behavior associated with SSBs consumption using m-Health app among college students. It investigates the effectiveness of tailored feedback (tracking SSBs consumption, labeling caloric intake, and the serving size) as a method to decrease the consumption of SSBs and increase the consumption of water.

Design: A 12-week randomized controlled trial.

Setting: Texas A&M University-College Station.

Participants: College students (n=130) were randomized to intervention (n=55) and control (n=58) conditions.

Interventions: Intervention (n=55) and control (n=58) groups received SSBs education *via* smartphone. Intervention-group also received *via* smartphone their goals for SSBs reduction (<=240mL SSBs/d (<=8 floz SSB/d)), and smartphone-based progress tracking/feedback.

Main outcome measures: Sugar sweetened beverages consumption, water consumption, and SSB-s consumption self-efficacy scores.

Results: During the intervention periods, there was a statistically significant difference in SSB consumption among intervention participants (X2(3)=13.571, P=0.004). Furthermore, from week 1 to week 12, there was a substantial increase in water consumption among intervention participants (Mean differences=-1.652; P=0.00). However, neither the control group (mean=-0.06207, t57=-0.620, p=0.54) nor the intervention group (mean=-0.17321, t55=-1.594, p=0.12) showed any significant changes in post-SSB consumption self-efficacy scores.

Conclusions: An m-Health app intervention may provide the participants encouragement and support to adopt healthy behaviors related to decrease their consumption of SSBs, and consume water instead of SSBs.

Keywords: m-Health; Sugar sweetened beverages; Self-efficacy; College students

Introduction

Obesity has become a worldwide problem that affects both developing and developed countries [1]. Physical inactivity and unhealthy dietary habits are the main risk factors for obesity and overweight. The "energy gap" between weight maintenance and weight gain has been estimated to be around 100 kcal/day [2,3]. Sugar Sweetened Beverages (SSBs) could be adjusted to improve weight stability and obesity prevention by providing a clearly visible source of calories that contribute to this energy imbalance. Half of the US population consumes SSBs on a daily basis, according to the National Health and Nutrition Examination Survey (NHANES), with 5% consuming at least 567 calories (equal to four cans of soda) [4].

These values far surpass the World Health Organization's (WHO) and the 2015 dietary guidelines advisory committee's recommendations of no more than 10% of total energy intake from Added Sugars (AS) [4]. Despite their vulnerability to weight gain, there has been little research on the consumption of SSBs by college students [5,6]. From a public health standpoint, behavioral change interventions are critical; however, it is unclear which type of intervention is most effective in lowering SSB consumption and increasing water intake in people of all ages [7]. m-Health apps are becoming more widely utilized in public health interventions, such as promoting healthy eating patterns, which including reducing SSB consumption and increasing water consumption [8].

As a result, the goal of this 12-week RCT is to enhance healthy lifestyle behaviors linked with SSB consumption among college students using an m-Health app. It looks into the effectiveness of personalized feedback (monitoring SSB consumption, labeling caloric intake, and serving size) as a way to reduce SSB consumption while increasing water consumption.

Methods

Design and setting

The study used a theory-based m-Health app intervention to promote healthy living behavior linked with sugar sweetened beverage consumption among college students in a 12-week RCT involving 130 students from Texas A&M university/college station campus. The research team used university networks to issue email invites to students throughout campus after the university of Texas A and M Institutional Review Board (IRB) approved the study protocol (#2018-0022D). Participants who were interested in participating in the study were screened to ensure that they met the study's inclusion and exclusion criteria. The informed consent forms were signed and returned by those who agreed. Healthy college students aged 18 years-30 years old, engaged in a healthy lifestyle, with a BMI of 18.5 kg/m^2, and access to a smartphone were eligible for the study (i-phone or android). Participants who are pregnant, lactating, have undergone bariatric or recent surgery, or have any of the diagnosed chronic conditions such as musculoskeletal problems, heart failure, diabetes mellitus, hypertension, dyslipidemia, or cancer were excluded from this study. Following the screening visit, eligible participants were randomly assigned to one of two groups: Intervention (m-Health intervention app) or control (control group). All of the participants had the Smartphone app installed on their phones.

To guarantee that the intervention and control groups had identical numbers of participants, random permuted blocks were used for randomization. Using the "Research Randomizer" computer software program (www.randomizer.org/form.htm), the researcher was in charge of generating the allocation sequence. The researcher cracked the randomization code at the end of week one. Participants were aware that two groups existed, but they were unaware of the differences between them. Due to the nature of the study and the ongoing communication between the participants and the researcher during the intervention period, blinding the researcher was not possible.

Need assessment phase: Phase one

Health related behaviors: Participants' health-related habits were assessed using a survey tool that includes the following validated questionnaires:

Sugar Sweetened Beverages (SSBs) Intake: The SSB consumption was assessed using the Beverage Intake Questionnaire-15 (BEVQ-15). This self-administered, valid, reliable, and sensitive beverage assessment test is used to assess beverage consumption habits. It could be used by researchers and practitioners who are evaluating and developing interventions for adults' beverage consumption patterns. The "How often" area has responses ranging from "never or less than once per week" to "up to 3+ times each day"; "How much" has responses ranging from "less than 6 floz (3/4 cup) to "more than 20 fl oz" (2.5 cups). To calculate the average daily beverage consumption in fluid ounces for the BEVQ-15, the frequency "How frequently" is converted to the unit of times per day and then multiplied by the amount eaten "How much". Regular soft drinks, juice drinks, sweet tea, coffee/tea with creamer and/or sugar, mixed alcoholic drinks, meal replacement drinks, and energy drinks all fall into the SSBs group [9,10].

Sugar Sweetened Beverages (SSBs) self-efficacy: Three questions about the participants' self-efficacy to drink water instead of sugar-sweetened drinks were included in a brief survey based on social cognitive theory and taken from prior studies [11-13]. Based on social cognition theory, the dependability of nutrition habits was acceptable (=0.96). "Not at all sure (1)," "Sightly sure (2)," "Moderately sure (3)," "Very sure (4)," and "Completely confident (5)" were the response possibilities. A higher overall score suggests greater self-efficacy in reducing SSB consumption, whereas lower scores reflect participation in health-damaging activities. In addition to all participants received a presentation on a healthy lifestyle, nutrition recommendations, the therapeutic advantages of physical exercise, and a CDC handout about SSB intake (rethink your drink) at their baseline appointment.

Measures:

- Demographic data: Age, gender, ethnicity/race, and major (Questionnaire).
- Sugar-Sweetened Beverages (SSBs) consumption: Self-reported (floz/day) [10].
- Self-efficacy scores: SSBs consumption related self-efficacy scores [11,14,15].

m- Health Applications Intervention: Phase Two

Commercially available app: We used my fitness pal, one of the most widely used public weight-loss applications (MFP). My fitness pal has got the highest possible rating of 5 stars and is available for free download. MFP involves self-monitoring, goal planning, and feedback, which are all parts of social cognitive theory [16]. We sought to test if tracking SSB and water consumption with this free, widely used Smartphone app could enhance healthy living practices among college students.

Intervention group: They were given the task of meeting the SSBs recommendation of (=240mL SSBs/d (=8 floz SSB/d). To properly target SSB reduction, participants were informed on CDC's rethink your drink: Options for reducing the number of calories you drink recommendations for all beverage categories (e.g., water, non-calorically sweetened beverages, milk). The intervention group also received training on how to: Scan the barcode of SSBs using the app; enter the intake of SSBs and water. Participants in the intervention group were contacted *via* SMS/e-mail at the end of each week (weeks 2–12) and requested to discuss their database usage with the researcher. The researchers urged this group to utilize the app to track their SSBs and water intake as well as receive feedback in order to meet their goals and improve their healthy eating habits.

Control group: The control group was given information about the SSB recommendation of no more than 8 fluid ounces per day, as well as information emphasizing the necessity of minimizing SSB consumption. They did not, however, get any nutritional advice or SMS messages regarding their SSB use.

Evaluation of m-Health applications intervention: Phase three

Measures:

- Sugar-Sweetened Beverages (SSBs) consumption: Daily fluid ounces of SSBs and water consumption were measured at four different time intervals. The time was coded on a continuous scale, with 0 at baseline and 4, 8, and 12-week follow-up evaluations using the m-Health app; however, BIQ-15 was applied after the end of the 12-week intervention [10].
- Self-efficacy scores: At the end of the intervention, SSBs' consumption-related self-efficacy scores were obtained [11,14-16].

Ethics: The study was carried out in accordance with the declaration of Helsinki's standards and was authorized by Texas A and M university's institutional review board and the human research ethics committee (IRB2 #018-0022D). At the start of the trial, all participants signed a written informed consent form.

Statistics: All analyses were conducted using IBM SPSS Statistics for windows, version 24.0. Armonk, NY: IBM Corpwith A 2-sided levels of α level set at $p<0.05$; data were assessed for normality. For categorical variables, the variables were reported as a percentage, and for continuous data, the means plus standard deviation were used. The baseline variations in participant characteristics between the intervention and control groups were summarized using descriptive statistics. Paired t-tests were used for comparison between pre and post-intervention variables for both intervention and control groups. Independent samples t-tests were used for comparison between intervention and control groups. Wilcoxon signed ranks Z-tests were used to assess the changes in SSBs consumption across all weeks of the intervention (baseline (T1), week 4 (T2), week 8 (T3), and week 12 (T4), and for changes in BEVQ-15.

Results

Demographics

Participants' demographic features were similar in the intervention and control groups at the baseline (Table 1). The combined age of the two groups was 21.12 (± 2.2) years, with a mean BMI of 22.87 (± 3.8). Females made up 80.7% of the participants, and whites made up 49.1%. Only 114 (87.6%) of the 130 participants followed up, with the majority of the missing data occurring during the follow-up week (week #12).

	Overall	Control	Intervention	P-Value
Total, no.	114	58	56	
Age (Years), mean (SD)	21.12 (2.2)	21.46 (2.6)	20.76(1.8)	0.94
Female, no. (%)	92 (80.7)	46 (79.3)	46 (82.1)	
Male, no. (%)	22 (19.3)	12 (20.7)	10 (17.9)	
Race category, no (%):				
White	56 (49.1)	23 (39.7)	33 (58.9)	
Black or African American.	12 (10.5)	7(12.1)	5 (8.9)	
American Indian or Alaska Native.	16 (14.0)	11(19.0)	5(8.9)	0
Asian	20 (17.5)	10 (17.2)	10(17.9)	
Other	10 (8.8)	7(12.1)	3(5.4)	
BMI, mean (SD)	22.87 (3.8)	23.42 (4.4)	22.32 (2.9)	0.124

Table 1: Baseline characteristics of the participants according to group allocation.

Sugar Sweetened Beverages (SSB-s) consumption

During the intervention periods (week 1, week 4, week 8, and week 12), there was a statistically significant difference in Sugar Sweetened Beverage (SSB) consumption (Milliliters) among intervention participants. X2(3)=13.571, P=0.004 (Table 2). Wilcoxon signed-rank tests were used for post hoc analysis with Bonferroni correction, yielding a significant result of P=0.017. For the Baseline (week 1), week 4, week 8, and week 12, the median SSBs consumption was 0.00 (0.00 to 0.00), 177.45 (0.00 to 473.20), 0.00 (0.00 to 236.600), and 0.00 (0.00 to 236.60), respectively (Table 2). There were no significant variations in SSB intake between week 8 (Z=-1.93, P=0.054) and week 12 (Z=-1.12, P=0.265). However, when comparing week 4 to week 1, there was a statistically significant increase in SSB consumption (Z=-3.03, P=0.002) (Table 3).

	N	Percentiles			Friedman test		
Week		25th	50th (Median)	75th	Chi-Square	df	P-value
Baseline	56	0	0	0			
Week 4	56	0	177.45	473.2			
Week 8	56	0	0	236.6	13.571	3	0.004
Week 12	56	0	0	236.6			

Table 2: Sugar sweetened beverages (SSB-s) consumption (ml/day/week) among intervention group through intervention period.

	Z	P-value
Week 4-Baseline	-3.03	0.002
Week 8-Baseline	-1.93	0.054
Week 12-Baseline	-1.12	0.265

Table 3: Changes in sugar sweetened beverages (SSB-s) consumption (ml/day/week) among intervention group through intervention period. Wilcoxon Signed Ranks Test.

A significant level at p<0.008.

Water consumption

Repeated measure ANOVA revealed a significant increase in water intake among intervention participants from week 1 (Mean=3.63) to week 4 (Mean=4.74); (p=0.00), from week 1 (Mean=3.63) to week 8 (Mean=5.44); (p=0.00), and from week 1 to week 12 (Mean differences=-1.652; P=0.00) (Tables 4 and 5).

Measure: Water consumption (cup/day/week)			95% Confidence Interval	
Time	N	Mean (SD)	Lower bound	Upper bound
Baseline (week 1)	56	3.63 (1.54)	3.212	4.038
Week 4	56	4.74(2.41)	4.096	5.387
Week 8	56	5.44(2.64)	4.729	6.146
Week 12	56	5.28 (1.97)	4.75	5.803

Table 4: Water consumption (cup/day/week) among intervention group through intervention period. The mean difference is significant at the 0.05 level.

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Variable	Mean Differences (SD)	95% Confidence Interval for Difference[b]		P-value	Overall p-value
Water (cup/day/week)		Lower Bound	Upper Bound		0
Change in consumption					
Baseline to week 4	-1.116*	-1.957	-0.275	0	
Baseline to week 8	-1.813*	-2.764	-0.861	0	
Baseline to week 12	-1.652	-2.396	-0.907	0	

Table 5: Changes in water consumption (cup/day/week) among intervention group through intervention period. Based on estimated marginal means.

*: The mean difference is significant at the 0.05 level.

B: Adjustment for multiple comparisons: Bonferroni

Susceptibility to change S SB-s consumption us ing Beverage Intake Questionnaire 15 (BEVQ 15)

A Wilcoxon signed-ranks test revealed that post-intervention consumption of (water, sweet juice, regular soft drink, diet soft drink, sweet tea, coffee with creamer, and energy drink) among intervention group had no significant change when compared to pre-intervention consumption (Z=-1.28, -1.198, -1.16, -0.67, -1.05, -1.17, -0.33; respectively), P-value >0.05 (Table 6). Table 7 shows the susceptibility of the control group to change their SSB consumption utilizing (BEVQ 15). A Wilcoxon signed-ranks test revealed that post-intervention consumption of (water, sweet juice, regular soft drink, diet soft drink, sweet tea, coffee with creamer, and energy drink) among the control group was not statistically different from pre-intervention consumption (Z=-1.68, -0.75, -1.5, -0.15, -0.22, -0.28, -0.85; respectively), P-value >0.05 (Table 7).

		N	25th	50th (Median)	75th	Z	P-value
	Pre-Intervention	56	2.25	3	4.38	-1.28	0.2
Water/day	Post-Intervention	56	2.25	3	4		
	Pre-Intervention	56	0.38	0.38	1	-1.198	0.23
Sweet juice/week	Post-Intervention	56	0.38	0.38	0.75		
Regular soft drink/Week	Pre-Intervention	56	0.38	1	1.88	-1.16	0.25
	Post-Intervention	56	0.38	0.63	1.5		
Diet Soft drink /Week	Pre-Intervention	56	0.75	1	1.25	-0.67	0.5
	Post-Intervention	56	0.75	1.13	1.25		
Sweet Tea/Week	Pre-Intervention	56	0.38	0.75	1.5	-1.05	0.3
	Post-Intervention	56	0.38	0.75	1.5		

Coffee with C/ Week	Pre-Intervention	56	0.38	0.44	1	-1.17	0.24
	Post-Intervention	56	0.38	0.38	0.5		
Energy Drink/ Week	Pre-Intervention	56	0.38	0.75	1	-0.33	0.74
	Post-Intervention	56	0.38	0.5	1		

Table 6: Sensitivity to change SSB-s consumption among intervention group using Beverage Intake Questionnaire (BEVQ-15).

		N	25th	50th (Median)	75th	Z	P-value
	Pre-Intervention	58	2.25	2.25	4.5	-1.68	0.093
Water/day	Post-Intervention	58	2.25	3	4.5		
	Pre-Intervention	58	0.38	0.38	1	-0.75	0.452
Sweet juice/ week	Post-Intervention	58	0.38	0.5	1		
Regular soft drink/Week	Pre-Intervention	58	0.38	0.75	1.31	-1.5	0.133
	Post-Intervention	58	0.38	1	5.06		
Diet Soft drink /Week	Pre-Intervention	58	0.5	1	1.32	-0.15	0.883
	Post-Intervention	58	0.5	1	1.26		
Sweet Tea/ Week	Pre-Intervention	58	0.38	0.5	1	-0.22	0.823
	Post-Intervention	58	0.38	0.75	1		
Coffee with C/ Week	Pre-Intervention	58	0.38	0.38	0.81	-0.28	0.781
	Post-Intervention	58	0.38	0.38	0.75		
Energy Drink/ Week	Pre-Intervention	58	0.38	0.75	1.5	-0.85	0.395
	Post-Intervention	58	0.38	0.38	1		

Table 7: Sensitivity to change SSB-s consumption among control group using Beverage Intake Questionnaire (BEVQ-15).

Sugar-Sweetened Beverages (SSB-s) consumption self-eff cacy scores

Table 8 shows that there were no significant differences in pre-intervention SSB consumption self-efficacy scores between control (Mean SD; 3.740.90) and intervention (mean=3.960.85) groups; p=0.18. However, significant differences were identified between the control and intervention groups for post-intervention SSB consumption self - efficacy scores, with the intervention group scoring higher (Mean differences=-0.33, t112=-2.423, p=0.02). Table 9 shows the changes in the SSB's consumption self-efficacy scores between the control and intervention groups. Both the control group (mean=-0.06207, t57=-0.620, p=0.54) and the intervention group (mean=-0.17321, t55=-1.594, p=0.12) showed no significant changes in post-SSB consumption self-efficacy scores (Tables 8 and 9).

	Group	N	Mean (SD)	Mean Difference	t	df	P-value
Pre SSB-s-consumption self efficacy scores	Control	58	3.74 (0.90)	-0.22	-1.36	112	0.18
	Intervention	56	3.96 (0.85)				
Post SSB-s-consumption self efficacy scores	Control	58	3.8 (0.69)	-0.33	-2.42	112	0.02
	Intervention	56	4.14 (0.78)				

Table 8: SSB-s consumption self-efficacy score comparisons between control and intervention groups.

		N	Mean (SD)	Mean differences	t	df	P-value
	Pre-Intervention	56	3.96 (0.85)	-0.17321	-1.594	55	0.12
Intervention	Post-Intervention	56	4.14(0.78)				
	Pre-Intervention	58	3.74 (0.90)	-0.06207	-0.62	57	0.54
Control	Post-Intervention	58	3.80(0.68)				

Table 9: Changes in SSB-s consumption self-efficacy score among control and intervention groups.

Discussion

The use of m-Health applications to replace SSBs with water and other healthy drinking options is part of a campaign to minimize SSB consumption among college students. The amount of SSB consumed before (week 1) and after (week 12) the current m-Health intervention was not significantly different (z=-1.12, p=0.265). Our findings were explained by the fact that after 12 weeks of intervention, the intervention participants' SSBs self-efficacy to limit their use of SSBs had not changed significantly. Multiple studies, on the other hand, indicated that the intervention group using the m-Health app consumed much fewer SSBs than the control group [17-19]. Furthermore, the intervention group had a 145 kcal/day reduction in SSBs/juice, which is clinically significant and reduces the risk of becoming overweight or obese [7]. Using an m-health app to reduce SSB consumption through suggested portions, feedback, and positive rewards was related with a significant reduction in SBBs (-0.33, p=0.09), according to data from a study of low-income girls (9-14) years old. Although previous studies [7,17,18,20] indicated a significant reduction in SSB consumption, they were conducted over a longer period of time (6 months) and were entirely focused on this outcome. Reduced kcal/day intake as a result of reduced SSB intake may have a long-term impact on health. When compared to the baseline (week 1), however, the current data showed significant increases in water consumption during the intervention period of weeks 4, 8, and 12 (p=0.00).

The current findings are consistent with those of the Stanford A TO Z cohort, which found that replacing Sweetened Caloric Beverages (SCBs) with water was associated with a significant predicted reduction in total energy of 200 kcal/day over the course of a year among overweight women who consumed regularly (>12 ounces/day) at baseline [21,22]. Because SSB consumption accounts for roughly 10% of total energy intake in the United States, replacing SSBs with water could have a significant public health impact [23]. Using an m-Health app for regulating SSBs and water consumption and delivering tailored feedback has a lot of potential influence on health for m-Health promotion interventions targeting SSBs intake in college students. Both intervention and control participants had high self-efficacy to follow SSB recommendations and replace them with water at baseline (mean=3.96, 3.74, respectively), with a significant improvement in the intervention group compared to the control group by week 12 of the m health intervention (mean differences =-0.33, t112=-2.423, p=0.02). Self-efficacy scores in neither group improved significantly from pre- to post-intervention (P=0.12). Despite the fact that the rise in SSB self-efficacy among the intervention group was not statistically significant, it appeared to mediate the increase in water consumption. According to recent studies conducted among college students, differences in self-efficacy for improving particular health habits should be investigated [24,25]. Self-efficacy was discovered to mediate behavioral changes as an intermediary measure and target of lifestyle m-Health app interventions.

The findings show that an m-Health app intervention could motivate and help users to adopt healthy habits such as restricting SSB consumption and substituting water for SSBs. This positive experience can be just what college students need to keep and develop healthy lifestyle habits. As a result, m-Health applications are more likely to appeal to college students for future health promotion interventions focusing on good eating behaviors than other types of apps [26,27].

Limitations

The study's limitations include a small sample size, a high percentage of females in the sample, and a focus on college students, all of which could limit the findings' generalizability. Participant bias may have been exacerbated by the use of self-reported surveys. Finally, the trial was short (3 months) and there was no long-term follow-up.

Strengths

The current study used a randomized controlled design to determine the impact of employing an m-Health application to improve college students' healthy lifestyles. The adoption of a theory-based intervention, which was proven to be more effective, was strength. Finally, there are fewer exclusion criteria, which improve external validity and makes implementation easier [28].

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