A Text Messaging-Assisted Randomized Lifestyle Weight Loss Clinical Trial Among Overweight Adults in Beijing

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Objective: The impact of a text messaging-assisted lifestyle weight loss intervention on weight change among overweight adults in Beijing was examined.

Methods: It was a 6-month randomized two arm clinical trial. The control group received a brief advice session after randomization. The intervention group received three group sessions, five coaching calls, and a daily text message prompting participants to follow predetermined lifestyle goals.

Results: A total of 123 participants were randomized. At 6 months, controls gained 0.24 $\pm$ 0.28 kg (0.21% $\pm$ 0.38%) (NS) while intervention participants lost 1.6 $\pm$ 0.28 kg (2.31% $\pm$ 0.38%) ($p < 0.0001$). Intervention participants decreased waist circumference (WC) (-2.69 ± 0.43 cm, $p < 0.0001$), percent body fat (%BF) ($-0.66\% \pm 0.19\%$, $p = 0.0007$), and systolic/diastolic blood pressure (SBP/DBP) significantly ($-1.71 \pm 1.12/-3.24 \pm 0.87$ mmHg), while the controls had no change in WC and %BF and increased SBP/DBP by 2.43 $\pm$ 1.14/1.20 $\pm$ 0.88 mmHg (between groups: $p = 0.01/p = 0.0004$).

Conclusions: This text message-assisted lifestyle intervention was effective in reducing weight, WC, %BF, and improving BP. Coupled with the scalable feature of the intervention, this finding is intriguing in light of the potential reach of the intervention for countries like China where mobile phone penetration is high and the obesity rate continues to rise.

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Introduction

Obesity rates are increasing worldwide (1). Rapidly developing countries such as China are especially susceptible to lifestyle changes that promote weight gain. The prevalence of overweight and obesity continues to rise unabated, increasing by 67% and 167% from 1993 to 2009, respectively (2). In particular, the prevalence of abdominal obesity, a stronger risk factor for cardiovascular disease (CVD), diabetes, hypertension, dyslipidemia, cancer, and all-cause mortality than general obesity, has nearly doubled over the last 20 years, from 18.6% to 37.4% (2). The fast pace of economic development has resulted in increased access to lifestyles associated with overweight or obesity, notably the widespread availability of Western-style fast food, increasing use of automobiles, shifts away from occupations requiring physical activity, increased television viewing and other sedentary behaviors, and increased consumption of meals away from home (3). A systematic review of 20 intervention studies conducted in China showed that comprehensive behavioral interventions have demonstrated efficacy in promoting weight loss among children/adolescents, but few weight-loss interventions have been tested among Chinese adults (4).

A recent meta-analysis of behavior change interventions in Western populations supports the long-held notion that self-monitoring, coupled with other behavior change strategies, promotes weight loss (5). However, traditional self-monitoring (e.g., using food and activity records) can be burdensome and too time-consuming to maintain. Interventions that utilize mobile health technologies have shown potential for success (5) and, with 1.05 billion mobile phone users in China (6), there is promise for weight-loss programs that utilize mobile technology. Text messaging, the most widely used among all the mobile phone applications, is particularly popular in China. According to a 2012 survey by the Pew Research Center's Global Attitudes Project, 80% of China cell phone owners regularly use text messages which was higher than the comparable figure in the United States (67%) (7). In the United States, there is early evidence

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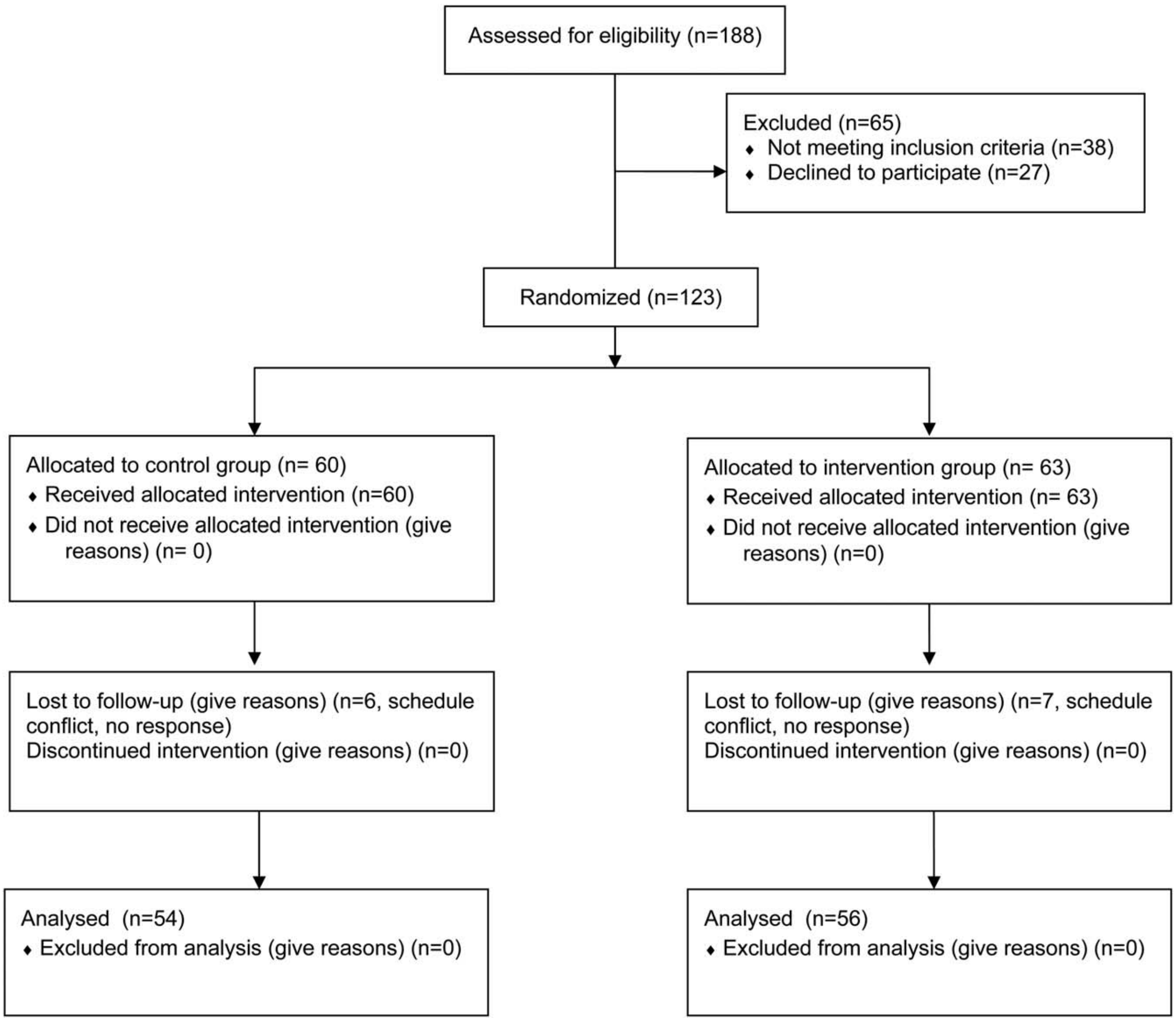

Figure 1 Study flow diagram.

suggesting that text messaging interventions can positively impact behaviors related to weight loss and general health (4). To-date, there is no evidence reporting the use of text messaging-assisted interventions for weight loss in China. Thus, we conducted a randomized controlled pilot trial testing the impact on weight change of a 6-month text messaging-assisted lifestyle weight loss intervention trial among overweight adults in Beijing.

Methods

Study design

This study was a 6-month, two-arm randomized trial comparing a lifestyle intervention group to non-treatment control for weight loss. The randomization scheme was created *a priori*, using a computer-generated algorithm with 1:1 ratio between the two arms. The primary outcome was weight change (kg) at 6 months. Secondary outcomes included change in blood pressure (BP), waist circumference (WC), percent body fat (%BF), dietary intake, physical activity, and psychosocial factors.

Participants

We recruited and randomized a total of 123 adults in Beijing (Figure 1) by posting advertisements and distributing flyers in local neighborhoods, hospitals, health centers, and commercial buildings. These flyers invited participants to call study staff and participate in a preliminary eligibility screen and then an in-person visit during which consent was obtained. Inclusion criteria included: BMI $\geq$ 24, age 30-50, current use of a mobile phone and interest in losing weight. Exclusion criteria included: pregnancy or plans to become pregnant within 6 months of recruitment, current lactation, having a close family member (spouse or member of the same household) participating in the study, occurrence of a major CVD event in the past 6 months, current cancer treatment, and major psychiatric or cognitive condition.

Measurement

All outcomes were assessed at baseline and 6 months post-randomization. We also collected anthropometrics and BP at the 3-month visit. A fasting blood specimen was collected at the baseline and 6 month visits, processed and analyzed for glucose, insulin, and lipids. All measurements were performed at clinic visits by trained, certified study personnel who were blinded to intervention assignment.

Weight was measured in light indoor clothes without shoes, to the nearest 0.1 kg by a high-quality digital scale (Tanita MD180, Japan). Height was measured by wall-mounted, calibrated stadiometer, to the nearest 0.1 cm. BMI was calculated by the quetelet formula (weight in kilograms divided by height in meters squared). WC was measured using the procedures of the NHANES III protocol (8) to the nearest 0.1 cm. Dietary intake was assessed with a food frequency questionnaire specifically designed for this study. Physical activity was assessed by the GPAQ questionnaire (9), which has been validated in diverse populations and correlates well with objective measures of physical activity. BP was measured with participants in a seated position, using the right arm and an appropriate size cuff and with a mercury sphygmomanometer (10). Participants were also asked to complete self-administered questionnaires to provide information on health conditions, medications, and relevant psychosocial variables. A self-report measure of intervention satisfaction was included in the 6-month follow-up survey for the intervention participants.

Intervention design

Participants randomized to the lifestyle intervention group were assigned a series of personalized behavior change goals (explained below) and were asked to self-monitor their adherence to these goals via a daily text message. Additionally, participants were asked to attend three group sessions and receive five coaching calls throughout the study. Participants randomized to the control group received a brief information session immediately after randomization. Control participants were also offered a similar version of the lifestyle intervention for 4 months after completing the final data collection visit, however, no study data were collected during this period of time.

Daily text messaging and tailored goal assignment

At baseline, all participants completed a self-administered survey that determined their need and self-efficacy to change a series of 11 behaviors associated with weight management (e.g., drinking sugar-sweetened beverages, watching two or more hours of TV daily, etc.; see Table 1). These 11 behaviors were chosen based on previous evidence for US adults, and represented a mix of the Interactive Obesity Treatment Approach (iOTA) (11) and the DASH eating pattern (12). iOTA, described elsewhere (11,13), is an evidence-based weight loss approach developed by study investigators. DASH eating pattern is effective for lowering BP, has been incorporated for successful weight loss in clinical trials, and is appropriate for populations at risk for type 2 diabetes and hypertension (12). DASH recommends higher fruit and vegetable intake and lower intakes of saturated fat, sweets, and sugar. These goals were then translated for the Chinese population and incorporated into the 11 behavior goals (Table 1). All 11 behaviors were then ranked for each participant based on an algorithm that determined the participants' self-reported need, self-efficacy, and estimated caloric deficit from performing that behavior. The top six goals were assigned to each participant with two for every 8-week cycle. In addition, all participants received a third goal during each cycle, which was to walk at least 7,000, 8,000, or 10,000 steps daily while tracking with a pedometer (Citizen, Japan, TW310). Thus, each participant received three goals daily to follow and track for each 8-week cycle. Tailored goals could be changed mid-cycle, with permission from the coach. However, no goals could be re-assigned to participants if they had already been assigned once during previous cycles.

After the first group session and daily thereafter, intervention participants received a text message at 8 a.m. asking for progress on the goals for the previous day. After the participants responded, they received another text message with tailored feedback on their progress (relative to previous days) and tips for continued improvement.

In addition, a score was given to rate the level of achievement for each goal. Every possible answer for each goal was associated with a score from 0 to 10, proportional to a predetermined range of possible answers. For example, if a participant reported that he/she drank 0, 1, 3, or $\geq$5 sugary drinks, he/she would be given a score of 10, 7, 3, or 1 for that goal, respectively. The scores for all three goals for that day were then averaged, and compared with the average score for the day prior and feedback messages were then sent accordingly. An example text message might say, "Your score is 6. You are doing better than last time. Keep making progress."

Group sessions and coaching calls

Each participant in the lifestyle intervention group was asked to attend three group sessions, delivered during weeks 1, 2, and 5. Each session lasted for 90 min. During these group sessions, the session leader reviewed the study concept and behavioral goals, how to interact with the text messages and discussed topics including the DASH eating plan, appetite awareness, eating out, portion control, finding ways to increase physical activity, building healthy eating habits, reasons for weight loss, social support, social eating and drinking, and long-term weight-loss maintenance. Each participant in the lifestyle intervention group also received five individual coaching calls from their assigned coach, delivered at weeks 3, 9, 11, 17, and 20. The calls were timed to coincide with behavior goal changes (at weeks 9 and 17) so that participants received specific support related to the goals assigned. Coaches were study investigators with training in nutrition and lifestyle intervention, delivering group sessions, conducting coaching calls, and the principles and skills of motivational interviewing (collaboration, empathy, autonomy, open-ended questions, reflective listening, and allowing the participant to pace him or herself) (14) prior to the beginning of the study. Each call lasted between 20 and 30 min. To ensure good attendance, participants were reminded before each of the group sessions and scheduled calls.

Statistical analysis

Since this study was intended to be a pilot study, a sample size of 120 was chosen based upon data collected from previous weight

TABLE 1 Tailored behavioral goals

Goal name and details	Tracking question sent to participants	Scoring: a score of 1 to 10 is assigned proportionally to the range of responses	
The following goals were assigned two at a time for every 8-wk cycle according to ranking. Goals are not repeated during subsequent 8-wk cycles.			
1. No sugary drinks-No soda, juice, energy drinks with sugar, sweetened milk, or tea drinks. Replace with water, green tea, sugar-free drinks	# Sugary drinks	Response	Score
		0	10
		1	7
		2	5
		3	3
		4	2
		≥5	1
2. Eat five or more cups of fruits and vegetables (this translates to about seven servings)	# Cups of fruits and veggies	Response	Score
		≥5	10
		4	8
		3	6
		2	3
		1	1
3. No packaged snacks or street food-no high-fat or high-calorie snacks (sweet snacks, fried snacks, cooked-meat snacks, instant noodles)	# Packaged or street snacks	Response	Score
		0	10
		1	7
		2	3
		≥1	1
4. Switch to low-fat dairy (instead of high fat dairy)-replace 2% or whole milk with 1% or skim milk instead (non- or low-fat yogurt, cheese, other dairy)	Had low fat dairy (y/n)?	Response	Score
		Yes	10
		No	1
5. No fast food-do not enter a fast food restaurant	Ate fast food (y/n)?	Response	Score
		Yes	1
		No	10
6. No fried food-do not eat any fried foods	# Fried foods	Response	Score
		Yes	1
		No	10
7. Eat breakfast-eat a healthy breakfast every day	Ate breakfast (y/n)?	Response	Score
		Yes	10
		No	1
8. TV for <2 h-watch <2 h of TV every day	Watched more than 2 h TV (y/n)?	Response	Score
		Yes	1
		No	10
9. no late-night snacking-No snacking or dessert after dinner (or <2 h before bedtime)	# Snacks after dinner	Response	Score
		0	10
		1	7
		2	3
		≥3	1
10. No more than one alcoholic drink per day-limit number of alcoholic drinks to 1 (if any) per day. -No binge drinking	# Alcoholic drinks	Response	Score
		0 or 1	10
		2	5
		≥3	1

TABLE 1 (continued)

Goal name and details	Tracking question sent to participants	Scoring: a score of 1 to 10 is assigned proportionally to the range of responses	
11. Eat lean protein instead of fatty red meat, two servings a day-have red meat as little as possible. At other times, eat lean protein (chicken, turkey, fish, beans)	# Fatty meats	Response	Score
		0	10
		1	9
		2	7
		3	5
		4	2
		≥5	1
The following goal was always assigned for every 8 wk cycle, starting from 7,000 steps:			
12a. Walking 7,000 steps	# Steps	Response	Score
		≥7,000	10
		6,300-6,999	9
		5,600-6,299	8
		4,900-5,599	7
		4,200-4,899	6
		3,500-4,199	5
		2,800-3,499	4
		2,100-3,499	3
		1,400-2,099	2
		0-1,400	1
12b. Walking 8,000 steps	# Steps	≥8,000	10
		7,200-7,999	9
		6,400-7,199	8
		5,600-6,399	7
		4,800-5,599	6
		4,000-4,799	5
		3,200-3,999	4
		2,400-3,199	3
		1,600-2,399	2
		0-1,599	1
12c. Walk 10,000 steps	# Steps	≥10,000	10
		9,000-9,999	9
		8,000-8,999	8
		7,000-7,999	7
		6,000-6,999	6
		5,000-5,999	5
		4,000-4,999	4
		3,000-3,999	3
		2,000-2,999	2
		0-1,999	1

loss trials in the United States to allow for a meaningful comparison between the two arms. Relevant prior data in Chinese populations is lacking for a formal rigorous estimate of sample size and statistical power. Intervention engagement was assessed by measuring the completion rate of daily goal tracking via text messaging and the achievement of the behavior goals. The completion rate of goal tracking was assessed by dividing the number of days of complete tracking received over the number of days a participant was expected to track. Due to intermittent server downtime and network reliability challenges that occurred during the intervention, participants were expected to track for a mean total of 137.40 ± 2.79 days.

Between-group differences of baseline categorical variables were compared using Chi-square tests. Univariate analyses of continuous variables were conducted to examine distributional assumptions and pooled-variance *t*-tests were used to test for between group differences in baseline characteristics. Treatment effects on the changes of primary and secondary outcomes variables over time were analyzed using a mixed methods approach with an unstructured covariance structure and a random intercept. Weight change correlations with adherence and self-monitoring scores were analyzed using an intent-to-treat approach in which all intervention participants were included and days of tracking lost to follow-up were considered expected but

TABLE 2 Baseline demographic characteristics

Variable	Total Mean (SD)	Control Mean (SD)	Intervention Mean (SD)	*p*-Value for group difference
n	123	60	63	
Age (yr)	38.21 (7.99)	38.07 (8.06)	38.35 (7.98)	0.85
Female, *n* (%)	74 (60.16)	36 (60.00)	38 (60.32)	0.97
Current smoker, *n* (%)	17 (13.82)	7 (11.67)	10 (15.87)	0.50
Ethnicity, *n* (%)				0.36
Han	119 (96.75)	57 (95.00)	62 (98.41)	
Man	4 (3.25)	3 (5.00)	1 (1.59)	
Marital status				0.35
Never married	14 (11.38)	9 (15.00)	5 (7.94)	
Currently married	99 (80.49)	48 (80.0)	51 (80.95)	
Divorced/separated	8 (6.50)	3 (5.00)	5 (7.94)	
Unreported	2 (1.63)	0 (0.00)	2 (3.17)	
Education (yr)	15.45 (3.82)	15.80 (3.80)	15.13 (3.83)	0.33
Work status, *n* (%)				0.14
Employed	104 (84.55)	47 (78.33)	57 (90.48)	
Student	5 (4.07)	2 (3.33)	3 (4.76)	
Unemployed	9 (7.23)	7 (11.67)	2 (3.17)	
Unreported	5 (4.07)	4 (6.67)	1 (1.59)	
Monthly income, *n* (%)				0.29
<US$800	31 (25.20)	17 (28.33)	14 (22.22)	
US$800-1,920	32 (26.01)	19 (31.67)	13 (20.63)	
>US$1,920	24 (19.51)	10 (16.67)	14 (22.22)	
Unreported	36 (29.27)	14 (23.33)	22 (34.92)	
General health rating, *n* (%)				0.80
Very good or Excellent	31 (25.20)	13 (21.67)	18 (28.57)	
Fair or good	87 (70.73)	44 (73.33)	43 (68.25)	
Poor	4 (3.25)	2 (3.33)	2 (3.17)	
Unreported	1 (0.81)	1 (1.67)	0 (0.00)	
Diabetes, *n* (%)				0.24
Absent	121 (98.37)	58 (96.67)	63 (100.00)	
Present	1 (0.81)	1 (1.67)	0 (0.00)	
Unreported	1 (0.81)	1 (1.67)	0 (0.00)	
Hypertension, *n* (%)				0.55
Absent	101 (82.11)	48 (80.00)	53 (84.13)	
Present	22 (17.89)	12 (20.00)	10 (15.87)	
Number of adults in household	2.76 (1.20)	2.73 (0.99)	2.78 (1.37)	0.84

missed. For these analyses, 6-month weight change was calculated using baseline-observation carried forward imputation for participants missing their final assessment. A two-tailed alpha of 0.05 was used to assess statistical significance for all tests. All analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC).

Results

As detailed in Table 2, no significant differences were observed in the baseline demographic characteristics between randomized groups. Overall, participants were 38.21 ± 7.99 years of age and had 15.45 ± 3.82 years of education, equivalent to a college education. More women (n = 74, 60.16%) participated in the trial than men (n = 49, 39.84%) and were overwhelmingly Han Chinese (n = 119, 96.75%). Most participants were married (n = 99, 80.49%) and employed (n = 104, 84.55%). A minority of participants were smokers (n = 17, 13.82%), and had hypertension (n = 22, 17.89%) or diabetes (n = 1, 0.81%). In general, participants rated their health as very good/excellent (n = 31, 25.20%) or good/fair (n = 87, 70.73%).

A total of 123 (100%), 109 (88.62%), and 110 (89.43%) participants completed the baseline, 3-month, and 6-month assessments, respectively. Attendance to group sessions was high, 87% completed at least two of the three sessions. Completion of the coaching calls was 100%. Table 3 summarizes the results of the mixed model analyses for the primary outcomes. Significant differences between groups were observed in weight change at 3 months with control participants gaining an average of 0.08 ± 0.28 kg while intervention

TABLE 3 Baseline and changes in weight and anthropometrics at 3 and 6 months

Outcome	Time	Control, M ± SE	Control, within group *p*-value	Intervention, M ± SE	Intervention, within group *p*-value	Difference, mean (95% CI)	Between group *p*-value
Weight (kg)	Baseline	78.57 ± 1.78	Ref	76.86 ± 1.73	Ref	1.71 (−3.18, 6.60)	0.49
	Δ at month 3	0.08 ± 0.28	0.77	−0.96 ± 0.28	0.0008	1.04 (0.25, 1.82)	0.01
	Δ at month 6	0.24 ± 0.28	0.41	−1.60 ± 0.28	<0.0001	1.83 (1.05, 2.62)	<0.0001
Weight (%)	Baseline	Ref		Ref			
	Δ at month 3	0.05 ± 0.38	0.89	−1.35 ± 0.38	0.0004	1.42 (0.35, 2.51)	0.009
	Δ at month 6	0.21 ± 0.38	0.58	−2.31 ± 0.38	<0.0001	2.58 (1.50, 3.67)	<0.0001
BMI (kg/m^2)	Baseline	28.41 ± 0.48	Ref	28.24 ± 0.47	Ref	0.17 (−1.15, 1.50)	0.80
	Δ at month 3	0.02 ± 0.11	0.85	−0.36 ± 0.10	0.0006	0.39 (0.09, 0.68)	0.01
	Δ at month 6	0.07 ± 0.11	0.51	−0.61 ± 0.10	<0.0001	0.68 (0.39, 0.97)	<0.0001
Waist circumference (cm)	Baseline	95.25 ± 1.35	Ref	94.08 ± 1.32	Ref	1.17 (−2.54, 4.89)	0.53
	Δ at month 3	−1.44 ± 0.43	0.001	−2.63 ± 0.43	<0.0001	1.19 (−0.01, 2.39)	0.05
	Δ at month 6	−0.13 ± 0.43	0.76	−2.69 ± 0.43	<0.0001	2.56 (1.37, 3.76)	<0.0001
Body fat (%)	Baseline	34.78 ± 0.90	Ref	34.33 ± 0.87	Ref	0.45 (−2.02, 2.91)	0.72
	Δ at month 3	0.29 ± 0.20	0.14	−0.23 ± 0.19	0.23	0.52 (−0.02, 1.07)	0.06
	Δ at month 6	0.36 ± 0.20	0.07	−0.66 ± 0.19	0.0007	1.02 (0.47, 1.56)	0.0003

participants lost an average of 0.96 ± 0.28 kg ($p = 0.01$). This trend continued at 6 months; control participants gained an average of 0.24 ± 0.28 kg (NS), while intervention participants lost an average of 1.6 ± 0.28 kg with a between group difference of 1.83 kg (95% CI: 1.05, 2.62, $p < 0.0001$). This corresponds to an average 6-month weight increase of 0.21% ± 0.38% by the control participants and an average reduction of 2.31% ± 0.38% by the intervention participants ($p < 0.0001$).

Consistently, as Table 3 relates, significant differences in BMI were observed between treatment groups at both 3 months ($p = 0.01$) and 6 months ($p < 0.0001$). Differences in WC changes were only marginally significant after 3 months ($p = 0.052$) but by 6 months intervention participants had a significantly greater reduction in WC as compared with that for the control participants (−2.69 ± 0.43 cm vs. −0.13 ± 0.43 cm, $p < 0.0001$). %BF also showed a similar pattern, in that the intervention participants had a significantly greater reduction in %BF ($p = 0.0003$) by month six. Intervention participants' %BF decreased significantly at 6 month (−0.66% ± 0.19%, $p = 0.0007$) while the control participants experienced an upward trend (0.36% ± 0.20%, $p = 0.07$).

Table 4 shows the cardiometabolic outcomes measured at baseline and follow up visits. By 6 months, significant differences between groups were observed in systolic blood pressure (SBP) ($p = 0.01$) and diastolic blood pressure (DBP) changes ($p = 0.0004$). Intervention participants had a reduction of 1.71 ± 1.12 in SBP ($p = 0.13$) and 3.24 ± 0.87 mmHg in DBP by month six ($p = 0.0002$). The control group had a mean increase in both SBP (2.43 ± 1.14 mmHg, $p = 0.03$) and DBP (1.20 ± 0.88 mmHg, $p = 0.18$) over the 6 months. We observed a marginal between-group difference in triglyceride change ($p = 0.052$). No significant differences were detected between treatment groups in the changes of high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol, insulin, or fasting blood glucose ($p > 0.05$).

Among the intervention participants ($n = 63$), the mean tracking completion rate was 68.19 ± 20.03% days tracked out of 137.40 ± 2.79 days expected. Age and total number of days with completed tracking were significantly correlated ($r = 0.33$, $p = 0.009$). For each additional year of age, participants tracked an average of 1.14 (SE: 0.42) more days than their younger counterparts. Age and tracking completion rate were likewise significantly correlated ($r = 0.32$, $p = 0.01$). For each additional year of age, the participants completed an additional mean 0.79% (SE: 0.31%) days of expected tracking.

Weight loss at 6 months was neither significantly correlated with the total days of tracking ($r = 0.14$, $p = 0.27$), nor was it significantly correlated with mean percent of days with tracking ($r = 0.14$, $p = 0.27$). However, the mean goal score calculated from participants' tracking (9.16 ± 0.52) was significantly correlated with weight loss at 6 months ($r = 0.26$, $p = 0.04$) (data not shown). Each additional unit of score was associated with an estimated additional 1.24 kg (SE: 0.58 kg) of weight loss. Individual models adjusting for age, sex, days of tracking completed, and percentage of days completed did not improve upon the unadjusted model.

Discussion

This study shows that a lifestyle intervention that asks participants to self-monitor using a modality that is well accepted (i.e., text messaging) and that utilizes behavior change principles well established among Western populations (e.g., group sessions and coaching calls) was effective for weight loss in a group of 123 Chinese adults. We observed that significant reductions in body fat and WC also accompanied weight loss. Additionally, the intervention produced clinically meaningful improvements in cardiometabolic markers for CVD, particularly BP. These improvements were especially impressive particularly in light of the modest weight loss observed—2.3% at 6 months. To illustrate, we observed that 6-month weight loss of 1.6

TABLE 4 Baseline and changes in cardiometabolic outcomes at 3 and 6 months

Variables	Time	Control, M ± SE	Control within group *p*-value	Intervention, M ± SE	Intervention, within group *p*-value	Difference, mean (95% CI)	Between group *p*-value
SBP (mmHg)	Baseline	113.81 ± 1.62	Ref	116.40 ± 1.58	Ref	−2.58 (−7.05, 1.89)	0.26
	Δ at month 3	2.23 ± 1.14	0.052	−0.16 ± 1.13	0.89	2.38 (−0.78, 5.54)	0.14
	Δ at month 6	2.43 ± 1.14	0.03	−1.71 ± 1.12	0.13	4.14 (0.98, 7.29)	0.01
DBP (mmHg)	Baseline	79.22 ± 1.25	Ref	83.00 ± 1.22	Ref	−3.78 (−7.23, −0.33)	0.03
	Δ at Month 3	1.71 ± 0.88	0.053	−1.85 ± 0.87	0.04	3.56 (1.12, 6.00)	0.005
	Δ at month 6	1.20 ± 0.88	0.18	−3.24 ± 0.87	0.0002	4.43 (2.00, 6.87)	0.0004
FBG	Baseline	5.43 ± 0.10	Ref	5.40 ± 0.10	Ref	0.03 (−0.24, 0.30)	0.84
	Δ at month 6	0.21 ± 0.10	0.09	0.22 ± 0.09	0.02	−0.01 (−0.28, 0.26)	0.96
Insulin	Baseline	13.96 ± 1.33	Ref	14.12 ± 1.30	Ref	−0.16 (−3.85, 3.54)	0.93
	Δ at month 6	7.70 ± 1.19	<0.0001	4.56 ± 1.16	0.0002	3.15 (−0.16, 6.45)	0.06
TC (mg/dL)	Baseline	4.82 ± 0.12	Ref	4.69 ± 0.11	Ref	−0.39 (−0.19, 0.45)	0.42
	Δ at month 6	−0.32 ± 0.09	0.0007	−0.39 ± 0.09	<0.0001	0.08 (−0.18, 0.33)	0.55
TG (mg/dL)	Baseline	1.59 ± 0.18	Ref	1.98 ± 0.18	Ref	−0.39 (−0.89, 0.11)	0.13
	Δ at month 6	−0.23 ± 0.13	0.07	−0.58 ± 0.12	<0.0001	0.35 (−0.003, 0.70)	0.052
HDL (mg/dL)	Baseline	1.17 ± 0.04	Ref	1.18 ± 0.03	Ref	−0.01 (−0.11, 0.08)	0.77
	Δ at month 6	−0.09 ± 0.03	0.006	−0.03 ± 0.03	0.37	−0.06 (−0.15, 0.03)	0.18
LDL (mg/dL)	Baseline	2.93 ± 0.10	Ref	2.61 ± 0.10	Ref	0.32 (0.03, 0.61)	0.03
	Δ at month 6	−0.12 ± 0.10	0.22	−0.09 ± 0.09	0.33	−0.03 (−0.30, 0.24)	0.84

kg (2.3%) was associated with a reduction in SBP/DBP by 1.71/3.24 mmHg. This is consistent with evidence from the United States. For example, a 2011 US study showed that weight loss between 2% and 5% was associated with significant improvements in CVD risk factors including BP and lipids (15).

The significant reduction in WC, SBP, and DBP observed in this study was intriguing, particularly in light of the fact that hypertension is a major risk factor for stroke which is suggested to be the main sequelae of obesity in China (16). In addition, abdominal obesity is strongly associated with many chronic diseases (2), and Chinese may be at a higher risk for hypertension at the same level of BMI than other populations (17). Thus, interventions that aim to increase physical activity and improve dietary intake through provision of self-monitoring using technology and social support, and take advantage of the ability to individually tailor, therefore, could be of great public health importance in a country as populous as China.

Many other studies conducted in the West have shown that a weight loss of 5%-10% is achievable from 6 to 12 month lifestyle weight loss interventions and is associated with significant improvement in health markers (10,15). The interventions in these studies commonly employ more in-person contact and greater intensity than our intervention employed. This may have explained the modest weight loss observed in the current study. Another study using similar intervention approach as tested in the current study reported comparable weight loss at 6 months among 365 US adult primary care patients with hypertension (13). The number of participants that technology-assisted interventions, such as the one tested in the current study, can reach greatly offset the modest loss in intervention intensity and impact.

The current finding is encouraging particularly in light of the significant cardiometabolic improvements resulting from a very streamlined and scalable intervention. Several factors may be amended or enhanced to further improve the clinical outcomes. First, the study intervention was derived from a proven model from previous US studies and subsequently modified and translated for this Chinese population. The current intervention may not have captured the most effective behavioral strategies for this population. Indeed, feedback from the participants, collected through the satisfaction survey and received by the coaches during coaching calls, indicates that certain intervention aspects could be modified further to be more helpful for weight loss. For example, the goal of walking 10,000 steps a day was not challenging enough for many participants in the study since walking is already a common part of their lifestyle. In addition, carbohydrate intake could be targeted more in the intervention because Chinese diet is typically high in carbohydrate. Nevertheless, as indicated by the significant association between goal score and weight loss, the chosen goals were effective in helping the participants to lose weight. Text messaging has been used in an increasing number of studies and it was well received by participants in this study, as reflected in the adherence to the study recommendation of responding to the daily messaging. On average, participants tracked their goals every other day throughout the study. In addition, according to the satisfaction survey, more than 95% of the participants reported that text messaging was helpful in achieving their weight loss goals and 94.6% of them indicated that replying to the text message daily was easy. This finding supports the notion that text messaging may be an important modality for future intervention design.

The tracking rate itself, however, was not associated with weight loss. This is somewhat surprising considering the common belief that the act of tracking food intake itself without knowing the nutrition analysis can be helpful for behavior change. Although self-monitoring itself, such as keeping a food journal, has been shown to be effective in helping with weight loss in other studies (18), more detailed tracking of dietary intakes and physical activity was typically employed. Some studies with technology-assisted self-monitoring have also shown effectiveness (19). Regardless, typical self-monitoring data are not objective and are subject to report bias. In this study, participants were asked to reply to the daily messages inquiring of their compliance to the specific lifestyle goals. This monitoring is relatively simple but it is unclear how its effectiveness in behavior change compares to keeping a detailed food or physical activity record. Future study is needed to compare the weight loss impact using either a traditional tracking or a simplified strategy like the current text-messaging assisted tracking.

There are limitations with the study. The intervention duration was relatively short, and the sample size was small. Future studies are needed to assess true generalizability in this population. Although the results of this study hold promise, having achieved a high engagement rate with text messaging as well as clinically and statistically significant weight loss, more research is needed to test and develop long-term sustainability strategies. Future research should also consider testing only the text-messaging component because such a model would be more scalable than the current model where group session and coaching calls were included. Another limitation is that the translation of the intervention, as previously mentioned, may not have captured the most effective components. This study provides valuable information for future intervention design and development. In conclusion, this study demonstrates the feasibility of an intervention approach that utilizes text messaging, ubiquitous in China, in addition to well-established behavior change strategies, to influence weight loss. In light of the growing obesity trend in China, future studies should assess the limits of reach and long-term effectiveness of this type of intervention on weight loss and clinical outcomes in a larger and more representative population. O

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