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Acceptability and efficacy of Ontrack: A pilot m-health obesity and overweight secondary prevention program for teens

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Abstract

Background: Economic incentives can reinforce health behavior engagement and might be readily implemented within a mobile health (mHealth) program to increase daily physical activity. This approach has not been tested for increasing physical activity in adolescents with overweight and obesity. We examined the feasibility and acceptability of a 12-week behavioral economic incentive physical activity mHealth program with health coaching, goal setting and self-monitoring for adolescents with overweight or obesity. We also assessed changes in physical activity via a fitness tracker, program engagement, and body mass and body fat via bioelectrical impedance analysis.

Methods: Adolescents ($N = 28$), aged 13 to 18, with a body mass index ≥ 90th percentile participated in the 12-week text-delivered program and wore a Fitbit band to track daily physical activity. Participants were provided monetary incentives for meeting daily and weekly goals.

Results: Participant-reported acceptability was high. There were also significant improvements in daily active minutes with metabolic equivalents >= 3 ($p = .05$) and body fat percentage ($p < .05$) in the overall sample. A sub-sample of participants who were highly adherent demonstrated a significant increase in daily steps taken ($p < .05$).

Conclusions: The pilot program improved adolescent physical activity with greater improvements in physical activity found in adolescents who routinely engaged in the program. A larger trial, with adaptive daily goals and a factorial design to clarify the role of coaching versus incentives in driving physical activity is warranted.

Keywords: mHealth program; Physical activity; Adolescent overweight; Adolescent obesity; Behavioral economic incentives; Secondary prevention

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Introduction

Acceptability and Efficacy of OnTrack: A Pilot mHealth Obesity and Overweight Secondary Prevention Program for Teens. Adolescence is a high-risk age demographic for overweight and obesity, which may be in part attributable to a decline in physical activity found in this age group. Fewer than 40% percent of adolescent girls and 30% percent of adolescent boys meet physical activity recommendations, (10,000 steps/day with 6,000 during moderate to vigorous physical activity), with even lower estimates found for older adolescents [1,2]. In contrast to in-person, family-based treatment programs for overweight and obesity, mobile health (mHealth) physical activity programs are reportedly less costly and do not involve in-person attendance [3,4]. Instead, there is a reliance on an array of remote components, including passive sensing to track behavior (e.g., momentary feedback via a pedometer)[5-7] and text-based coaching with goal setting [8,9]. Unfortunately, mHealth physical activity programs that provide only weekly or daily text-delivered messages to youths evidence limited efficacy in improving physical activity [8,9]. In contrast, there is evidence in adults with obesity that mHealth programs targeting physical activity that include individualized, adaptive goal setting and behavioral economic incentives might be efficacious in preventing continued sedentary behavior [5].

Therefore, in addition to electronic tracking and feedback, the application of behavioral economic incentives within a mHealth program may reinforce physical activity goal achievement in youths with overweight and obesity. This is key, as the amount of weight loss required to achieve non-overweight status increases with age thus improved physical activity in adolescence is also key in preventing overweight and obesity in adulthood [10].

Behavioral economic incentives are an effective method with which to increase engagement in health behaviors in youths [11]. For example, incentives were effective in facilitating health behavior change in adolescents with chronic health conditions, including type 1 diabetes [12,13] and tobacco and substance use disorders [14-17]. Theories suggest that behavioral economic incentives might support immediate improvements in physical activity through the use of positive reinforcement (i.e., provision of monetary rewards) that is provided with high frequency (i.e., daily or weekly) and predictability (i.e., always after a set number of times the individual meets the physical activity goal) [18]. However, due to extinction, long-term improvements in physical activity and physical health may not be found in response to behavioral economic incentives. Instead, behavioral economic incentives may function to help encourage short-term weight loss through reinforcing increased physical activity and allow for increased motivation for other health lifestyle changes (e.g., diet; improved sleep) associated with sustained weight loss and long-term physical health improvements [19]. Prior to investigating such long-term effects, it is imperative to conduct a preliminary analysis of whether adolescents with overweight or obesity may benefit from a short-term mHealth program that provides electronic tracking and feedback as well as behavioral economic incentives to reinforce physical activity goal achievement.

This manuscript describes the pilot testing of a 12-week mHealth incentive program to increase physical activity in adolescents with overweight or obesity. We conducted a single group pre-post pilot study of a physical activity program with fixed daily and adaptive weekly goals, economic incentives for meeting goals, and weekly text-based supportive coaching. Program adherence, program acceptability and program outcomes were examined. We also tested whether participation in the intervention was associated with increased physical activity from pre- to post-intervention. A series of exploratory analyses were run to clarify engagement and possible down-stream benefits of this intervention on body mass and body fat.

Methods

Participants

Participants included (N = 28) adolescents with overweight or obesity (55.6% male, M_{age} = 14.81, SD = 1.59, BMI %ile = 97.1, SD = 1.8, 92.6% Caucasian). Inclusion criteria included: aged 13-18, BMI percentile > 90, having broadband wireless internet at home, living at home, and permission from a treating physician to engage in a physical activity program, which was noted in electronic health records. Participation in this study also included neuroimaging, thus exclusion criteria included: contraindicated metallic objects in their bodies, psychiatric medication, pregnancy, neurological or health problems (other than obesity), morbid obesity that prevented entering scanner, and visual acuity that could not be corrected to normal.

Procedures

Ethics approval was received from the University Institutional Review Board (Study ID: 29591). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Study recruitment took place between November 2016 and March 2017. Power considerations were determined based on our previously published findings examining fMRI effect sizes in reward systems, and we planned to recruit a sample size of N = 30, accordingly.

A partial HIPAA waiver was obtained from the general pediatric clinic at XXXXXXX using data from electronic medical records (EMR) to proactively identify potentially eligible teens, based on age and BMI. Letters were sent to parents (N = 328), followed by calls from research staff. To reduce selection bias and increase the likelihood of recruiting families and youth who were not necessarily seeking an intervention and/or self-identifying as obese or overweight, we described the program focus as physical activity rather than a weight loss intervention. Twenty-eight teens enrolled in the study. Twenty-six participants completed their follow-up visits, one participant was lost to follow-up and one participant withdrew from the study. See (Figure 1) for further information on participant flow.

Informed consent and assent were obtained from parents and adolescents, respectively. All participants completed a baseline assessment that included a body composition assessment, questionnaires, and computer tasks. Adolescents received a Fitbit application set to track daily goals of 10,000 steps and 60 active minutes, as recommended by the Center for Disease Control [20] and American Heart Association [21]. Three adolescents were loaned iPod touches because they did not have a smartphone on which to use the Fitbit app to view activity.

The incentive program is described in (Table 1). Teens were provided a daily goal of >60 active minutes or 10,000 steps of exercise per day and asked to sync their device daily. Feedback and sync reminder texts were sent by staff on weekdays. As shown in (Table 1), the program proceeded through baseline, shaping, maintenance, and fading of incentives phases. Financial incentives for meeting goals were loaded onto a reloadable debit card once per week for the first 9 weeks, and then only at the end of the final week for the last three weeks in the program. Maximum teen earnings across the 12-week program were $510.

Following the program, adolescents and parents attended a post-study assessment. if distributed. Teens earned $100 for each assessment that included lengthy a fMRI session. Parents earned $25 for each assessment.

Measures

Program Acceptability

Participants rated the helpfulness of the text-based coaching, their enjoyment of the Fitbit, and their overall liking of the

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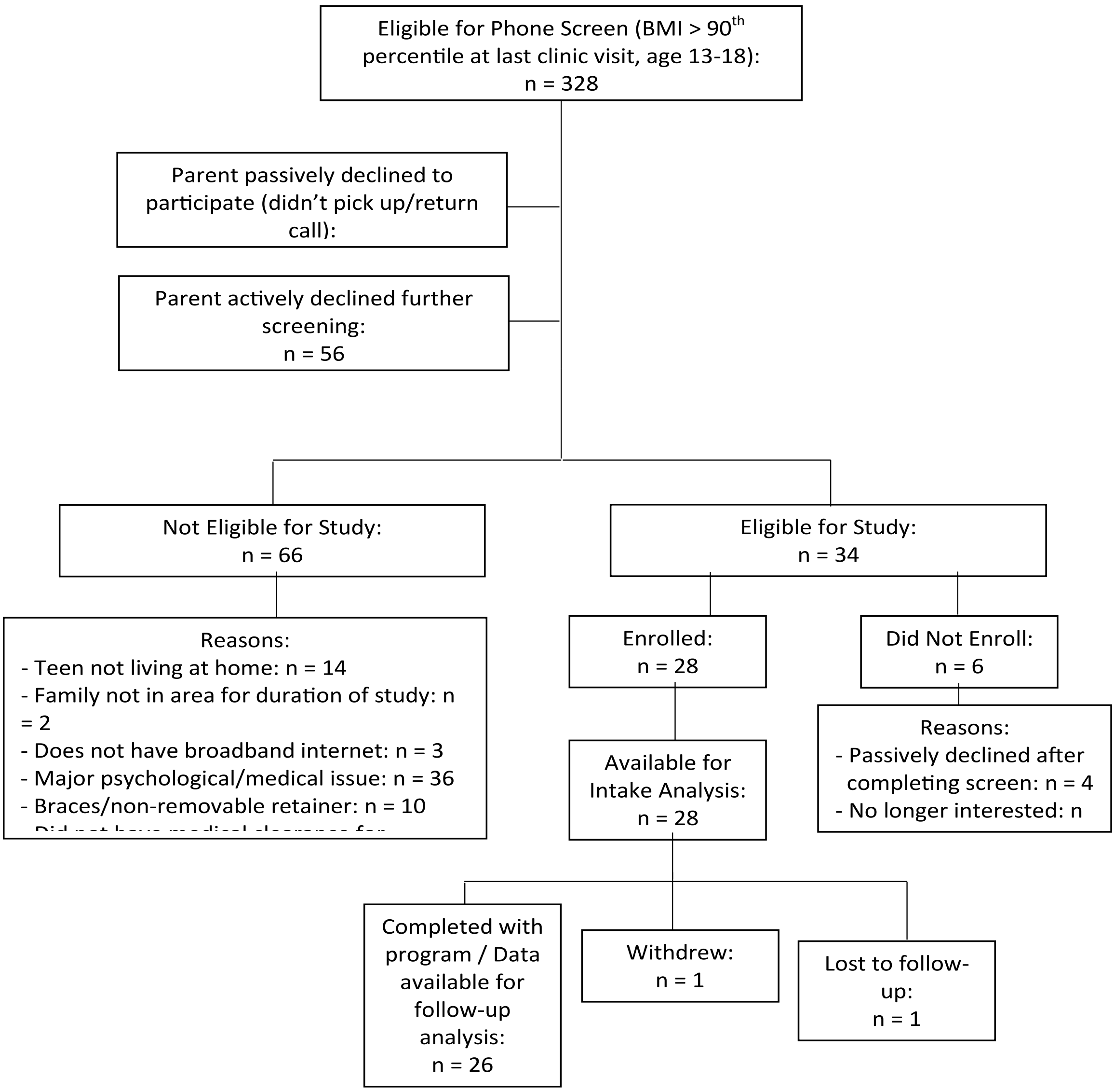

Figure 1 Participant Flow Chart.

Table 1: Program phases, weekly goals, and maximum incentives.

WEEK#	PHASE	GOAL	IF MEET GOAL	IF EXCEED GOAL	$/WEEK	TOTAL WHEN PAID
1	Baseline	Sync Fitbit >=5 of 7 days to establish starting level for weekly goals	$10.00	----	$10.00	$10.00
2	Shaping	Individualized Exercise Goal: Meet daily goal 1 day MORE than prior week (max=5 days)	$20.00	$10.00	$30.00	$30.00
3	Shaping	If goal MET, goal for next week increases by 1 day (max=5 days). If goal NOT MET, new goal is to match prior week	$25.00	$10.00	$35.00	$35.00
4	Shaping		$30.00	$10.00	$40.00	$40.00
5	Shaping		$35.00	$10.00	$45.00	$45.00
6	Shaping		$40.00	$10.00	$50.00	$50.00
7	Maintenance	≥60 minutes of exercise (or 10,000 steps), 5 days/week	$40.00	$10.00	$50.00	$50.00
8	Maintenance		$40.00	$10.00	$50.00	$50.00
9	Maintenance		$40.00	$10.00	$50.00	$50.00
10	Fading	≥60 minutes of exercise (or 10,000 steps), 5 days/week; Incentives paid at end of 3-week period	$40.00	$10.00	$50.00	
11	Fading		$40.00	$10.00	$50.00	
12	Fading		$40.00	$10.00	$50.00	$150.00
Total						$510.00

program on a seven-item scale. Participants also indicated whether they would like to continue wearing the Fitbit.

Physical Activity

The Fitbit Charge HR was used to measure physical activity. Fitbit's algorithm considers active minutes to be those with >=3 metabolic equivalents (METs) and only awards active minutes after 10 minutes of continuous activity. The Fitbit also tracks sedentary minutes and calories burned. The Fitbit Charge is a valid and reliable measure of physical activity [22].

Physical Health

A Tanita TBF-300A scale was used to measure body fat and weight. The Tanita scale uses bioelectrical impedance analysis to measure body fat. The Tanita TBF-300A scale has been shown to be a reliable and valid measure of body fat [23,24] and weight [25]. Height was measured using a stadiometer, then height and weight were used to calculate tri-ponderal mass index by dividing height (meter) by weight (mass) cubed. Prior studies have suggested tri-ponderal mass index is a more accurate calculation than BMI and is more sensitive to detecting obesity [26].

Analysis Plan

First, descriptive statistics were used to examine percentage of days of the Fitbit was worn, satisfaction, and program outcomes (i.e., weekly goals participants met, weekly bonuses met, amount of money received). Second, to assess changes in average daily active minutes, steps taken, sedentary minutes, and calories burned) from baseline to post-program, paired samples *t*-tests were used. Third, exploratory one-way ANOVAs were conducted to assess changes in physical activity by response type groups and on secondary outcomes including body mass and body fat. Change scores were used in all analyses (i.e., Week 12 minus Week 1, with positive change scores indicating increases in all outcomes). Due to measurement error, one participant was removed from tri-ponderal mass index analyses.

Results

Program Adherence, Acceptability and Outcomes

Descriptive statistics were used to assess program adherence, outcome, and acceptability see (Table 2). Participants wore the Fitbit on average >90% of days, and rated the text-based coaching, Fitbit enjoyment, and overall program highly (all means >5.5 on a 7 point scale). In addition, about 85% (n = 23) reported that they would like to continue to wear the Fitbit. Participants also showed success in meeting the program goals, meeting their weekly goals, and bonus goals an average of 7 and 5 of 11 possible weeks, respectively, earning an average of ~$300 each of the $510 maximum.

We further explored program adherence to index program engagement and response, identifying three subgroups: responders, non-sustainers, and non-responders. Responders (n = 11; 42.3%) included participants who met at least 80% of their weekly goals across the full post-baseline program period (i.e., Weeks 2-12). Non-sustainers (n = 7; 26.9%) included participants who met 80% of their weekly goals in the first half of the program during shaping (i.e., Weeks 2 to 6), but not during maintenance and fading (i.e., Weeks 7 to 12). Non-responders (n = 7; 26.9%) included participants who did not meet 80% of their weekly goals during either half of the program. One participant (3.8%) was not categorized and exhibited a delayed response (i.e., met 80% of weekly goals only during maintenance and fading).

Changes in Physical Activity

Paired samples *t*-tests were conducted to examine changes in average daily physical activity from Week 1 to Week 12 see (Table 3). Findings demonstrated a significant increase in average daily active minutes. Significant changes in average daily steps taken, sedentary minutes, and calories burned were not detected (*p's* > .05).

Changes in Physical Activity by Response Group

One-way ANOVAs examined whether differences in mean changes in physical activity were found across response groups see (Table 4). The delayed responder (n = 1) was not included in analyses. When comparing the change in overall number of steps from Week 1 to Week 12 across each response type group, significant group differences were found. The responder group was the only group to demonstrate an increase in their average daily steps from Week 1 to Week 12. Non-responders experienced a decline in average daily steps from Week 1 to Week 12. Non-sustainers also experienced a decline in average daily steps from Week 1 to Week 12, and this decline was steeper when examining changes from Week 6 to Week 12. Group membership did not differentiate changes in the remaining physical activity variables (*p's* > .05).

Changes in Body Mass and Body Fat

Paired samples *t*-tests were conducted to examine changes in body mass and body fat from Week 1 to Week 12 (Table 3). Findings demonstrated a significant decrease in body fat percentage from Week 1 to Week 12. Change in tri-ponderal mass index was nonsignificant (p > .05).

Changes in Body Mass and Body Fat by Response Group

One-way ANOVAs were used to examine differences in changes in body mass and body fat across response groups (Table 4). The delayed responder (n = 1) was not included in analyses. Response group did not differentiate changes in body fat percentage or tri-ponderal mass index (*p's* > .05).

Discussion

This was a single group pre-post pilot study testing a novel mHealth physical activity secondary prevention program for adolescents with overweight and obesity. Despite the lack of a control group, the current study provides preliminary evidence that an mHealth program with economic incentives can be an effective non-intensive alternative for increasing physical activity and physical health in adolescents with overweight and obesity. Adolescents reported a positive experience with each program component (i.e., text-based coaching, use of Fitbit), and with

Table 2: Intervention adherence outcomes and acceptability.

	M (SD)
Percent of days Fitbit was worn (>0 steps)	93.0% (12.0%)
How helpful were text messages (scale of 1 to 7)	5.77 (1.28)
How much did you enjoy wearing the Fitbit (scale of 1 to 7)	6.20 (1.26)
How did you like the program (scale of 1 to 7)	6.58 (.70)
Number of weeks of (maximum of 11) that participants met the weekly goal	7.22 (3.46)
Number of weeks (maximum of 11) that participants met the weekly bonus	5.26 (3.80)
Total incentives ($) earned during the intervention	$302.04 ($163.85)

Table 3: Descriptive statistics for physical activity and health outcomes at baseline to 12-week follow- up for the entire sample.

	Baseline *M* (SD)	Follow-up *M* (SD)	*t*	*p*
Average daily physical activity minutes	40.81 (30.95)	55.52 (43.79)	-2.07	.05
Average daily steps taken	7,645.11 (3,264.32)	8,177.02 (4,141.08)	-.77	.45
Average daily sedentary minutes	937.15 (213.72)	913.29 (267.58)	.48	.63
Average daily calories burned	2,881.24 (623.00)	2,949.74 (730.13)	-.56	.58
TMI	17.90 (1.87)	18.01 (2.13)	-.84	.41
Body fat percentage	35.54 (7.79)	34.61 (8.46)	2.17	.04

Note: TMI = triponderal mass index.

Table 4: Descriptive statistics for physical activity and health outcomes at baseline to 12-week follow- up by response group.

	Responder (n=11) *M* (SD)	Non-responder (n=7) *M* (SD)	Non-sustainer (n=7) *M* (SD)	*F*	*p*
Average daily physical activity minutes	33.79 (7.30)	5.90 (17.78)	1.45 (50.18)	2.37	.12
Average daily steps taken	2,874.18 (2,933.27)[a,b]	-353.37 (2,763.07)[a]	-1,510.78 (3,893.57)[b]	4.64	.02
Average daily sedentary minutes	-117.48 (175.41)	93.63 (283.24)	12.53 (343.66)	1.49	.25
Average daily calories burned	380.86 (768.98)	-80.37 (296.49)	-159.78 (612.94)	1.98	.16
TMI	.07 (.63)	.09 (.52)	-.18 (.63)	.42	.66
Body fat percentage	-.84 (2.50)	-.61 (2.47)	-1.04 (1.32)	.07	.94

Note. TMI = triponderal mass index; The responder group includes participants who met at least 80% of their weekly goals across the full post-baseline program period. The non-responder group includes participants who did not meet 80% of their weekly goals during either half of the program. The nonsustainer group includes participants who met 80% of their weekly goals in the first half of the program during shaping but not during maintenance and fading.

[a]Responder group significantly differed from Non-responder group

[b]Responder group significantly differed from Non-sustainer group

the program as a whole, and there was limited attrition (7.1%). These indicators of program acceptability were consistent with program adherence data which showed adolescents wore their Fitbit nearly every day. Participants also regularly met their weekly goals, especially in the shaping period of the program from weeks 1 to 6 during which 64.3% of participants met at least 80% of their weekly goals. Also, participants acquired bonuses for exceeding their pre-determined goals in about half of the total weeks (5.26 of 11 possible weeks), suggesting positive program outcomes. Across all enrolled participants, the intervention led to significant improvements in time spent engaging in daily active minutes with METs >=3 and reductions in body fat percentage, though no significant changes in steps taken, calories burned, sedentary minutes, or body mass were noted. However, the subgroup of program responders (~40% of the whole sample) who met more than 80% of goals throughout the 12-week period demonstrated a significant increase in average daily steps from Week 1 to Week 12. Notably, these changes in health behavior were achieved with minimal human resources (e.g., human contact involved one brief in-person “start-up” meeting with a bachelor’s level coach and then five text messages each week; incentives were delivered electronically).

Intensive, multi-component behavior modification studies for health behavior change have faced challenges in achieving high adolescent adherence and failed to maintain adolescent motivation throughout the intervention [27, 28]. One reason for the promising level of adherence found within this program may be the low burden of participation combined with incentives. Also, our use of sensor data collection, in lieu of self-report measures of physical activity, is likely less burdensome, as well as a more objective and continuous measure of physical activity [29]. This low level of burden can be contrasted with multi-component interventions for obesity that often involve parental engagement, family therapy, and nutritional changes [3,4]. The findings of this study are promising in that they suggest a mHealth program can facilitate relatively immediate health behavior change in adolescents with overweight or obesity through remote incentives, goal setting, and text-delivered support.

Although some research has shown increased physical activity predicts decreased body mass [30], this study observed no change in TMI, even among adolescents who were adherent to the physical activity goals. This finding is more consistent with well-established weight loss research indicating that dietary changes, rather than physical activity alone, drive weight loss among individuals with overweight and obesity [31,32]. Nevertheless, participants demonstrated an overall decrease in body fat, thus physical activity remains key for weight loss maintenance [33]. Dissemination of the piloted secondary prevention physical activity program may reduce risk of continued overweight and obesity, as well as endocrine and cardiovascular diseases [34] in adulthood.

Limitations

The findings of the study should be interpreted in the context of its limitations. First, the sample size was small and there were multiple sub-groups with varying mean levels of response and large standard deviations, such that data were underpowered to detect small to moderate effect sizes within the entire sample and across sub-groups. Second, participants were primarily Caucasian, and recruitment was conducted in a community with primarily middle-to-high SES families, thus the findings might not generalize to a more diverse sample. Third, there was no control group in the study, thus the effects found in the intervention cannot be assertively attributed to the intervention alone. Fourth, of the participants who were eligible to participate, we were able to successfully recruit twenty-eight participants. It is possible that participants who enrolled in the study were more motivated to increase activity than those who declined; though, to reduce risk of selection bias, we did not describe the program as a weight loss intervention for adolescents with overweight or obesity. Fifth, due to the novelty of the Fitbit and sharing of activity with the research team, there may have been an increase in activity during the baseline period relative to “usual” activity levels and the true baseline level of activity prior to receiving the Fitbit was unknowable. Sixth, follow-up assessments post-program were not conducted; as such, the long-term effects of this type of program are unknown. Last, because there were multiple treatment components, it is unknown which specific components guided treatment effects and whether the scalable intervention may remain as effective with even fewer treatment components.

Conclusion

This pilot study highlights the promising effects of a remote, mHealth program consisting of physical activity goals, behavioral economic incentives, and text-based support from health coaches to improve physical activity and associated health outcomes in adolescents with overweight and obesity. Future studies should investigate the incremental efficacy of each program component by using a factorial design to compare the efficacy of a text message only, incentives only, and text message plus incentives program in increasing physical activity among adolescents with overweight or obesity. Additionally, the text-based mHealth program used in the current study could be made even less resource-intensive by utilizing technology like the Fitbit API to automate goal setting and deploy reinforcing text messages. Future research may also consider assessing mediators and moderators of change, increasing the fading period (e.g., 12 weeks of weekly incentives, followed by 4-6 weeks of more gradual fading), and using daily adaptive goals to enhance program response. Last, future research should investigate whether engagement in a behavioral economic incentive program may increase motivation for additional lifestyle behavior changes (e.g., diet; sleep patterns) associated with adolescent overweight and obesity, as well as guide long-term prevention of overweight and obesity during adulthood.

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