Original Article
CLINICAL TRIALS AND INVESTIGATIONS

Obesity

Enhancing Physical Activity and Reducing Obesity Through Smartcare and Financial Incentives: A Pilot Randomized Trial

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Objective: A pilot randomized trial assessed the feasibility and effectiveness of an intervention combining Smartcare (activity tracker with a smartphone application) and financial incentives.

Methods: A three-arm, open-label randomized controlled trial design involving traditional education, Smartcare, and Smartcare with financial incentives was involved in this study. The latter group received financial incentives depending on the achievement of daily physical activity goals (process incentive) and weight loss targets (outcome incentive). Male university students ($N = 105$) with body mass index of $\geq$27 were enrolled.

Results: The average weight loss in the traditional education, Smartcare, and Smartcare with financial incentives groups was −0.4, −1.1, and −3.1 kg, respectively, with significantly greater weight loss in the third group (both Ps < 0.01). The final weight loss goal was achieved by 0, 2, and 10 participants in the traditional education, Smartcare, and Smartcare with financial incentives groups (odds ratio for the Smartcare with financial incentive vs. Smartcare = 7.27, 95% confidence interval: 1.45–36.47). Levels of physical activity were significantly higher in this group.

Conclusions: The addition of financial incentives to Smartcare was effective in increasing physical activity and reducing obesity.

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Introduction

Obesity, which is mainly attributed to physical inactivity and a high-calorie diet, is a major public health challenge (1). Increasing physical activity is a sensible strategy, not only for tackling obesity problems but also for reducing the burden of cardiovascular disease (2,3). However, in Korea, only 20% of all adults and 30% of young adults fulfill the total energy expenditure requirement recommended in current physical activity guidelines designed for the maintenance of general health (4). Traditional weight reduction programs involving nutrition and physical activity education are generally resource intensive, involve limited access, and often demonstrate insufficient efficacy (5,6).

The use of digital technology in health care is gaining popularity as a potentially cost-effective means of health promotion and disease prevention (7,8), and the Korean government promotes the approach as "Smartcare" (9). For example, wearable activity trackers motivate people to increase their physical activity by helping them track their own activity and receive feedback (10). The use of activity trackers has increased rapidly, and over 10% of adult consumers in the U.S. currently use them (11). However, one third of people cease using the devices within 6 months of purchase, suggesting low levels of long-term sustained engagement for some users (11). Ineffectiveness or low levels of effectiveness could be the reasons for this (9,12). Patel et al. suggested that wearable devices are facilitators, rather than drivers, of behavior change (13).

A potential strategy for increasing Smartcare engagement and effectiveness involves the use of financial incentives. This approach has been shown to be successful in motivating people to adopt healthy

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behaviors such as smoking cessation and weight reduction (14,15). Two studies from Singapore have attempted to combine activity trackers with the modern concept of behavioral economics, which uses financial incentives to promote physical activity in sedentary older adults (16) or employees (17). A few U.S. studies have also combined adaptive physical activity interventions with financial incentives to promote physical activity in overweight adults (18,19).

Therefore, we conducted a pilot randomized trial to assess the feasibility of the intervention that combines Smartcare with financial incentives and determined whether this strategy would be more effective in increasing physical activity levels and reducing weight relative to traditional education and Smartcare only models over a 12-week period. A previous report described the study design and trial participants' baseline characteristics (20), and we report the results of the trial below.

Methods

Study design and enrollment

The study comprised a three-arm, open-label randomized controlled trial design involving a traditional education model (Group 1), Smartcare alone (Group 2), and Smartcare with financial incentives (Group 3). The primary end point was the amount of weight lost, and the weight loss goals were 3%, 5%, and 7% of baseline at weeks 4, 8, and 12, respectively. The secondary end point was the participant's physical activity level, which served as the process indicator. As the primary study objective was weight loss and the study participants were generally healthy young adults without physical limitations, we set a higher activity level as a daily goal than that required for general health maintenance. The average weekly total activity level of the general population of the same age, sex, and body mass index (BMI) as the study population (i.e., men aged 20–39 with BMI $\geq$27 kg/m^2) was approximately 49.6 metabolic equivalent of Task (MET) $\times$ hours per week. This value was calculated from the Korean National Health and Nutrition Examination Survey data, which measured the physical activity of the general population via the International Physical Activity Questionnaire-Short Form (IPAQ-SF) (21) and is the sum of physical activity of walking, moderate, and vigorous exercise. In addition to this baseline physical activity level, we set additional physical activity for weight loss, which is double the amount of the general recommendation of leisure-time physical activity (150 min of moderate-intensity exercise = 10 METs $\times$ h/wk multiplied by 2 = 20 METs $\times$ h/wk). For example, a participant weighing 85 kg was given the physical activity goal of 845 kcal/d (i.e., 49.6 + 20) $\times$ 85 kg/7 d).

Participants were students from Seoul National University, and the following inclusion criteria were applied: (1) male sex, (2) age of 19 to 45 years, (3) BMI $\geq$27 kg/m^2, (4) smartphone use (either Android or iPhone), and (5) ability and willingness to attend four prespecified appointments during the study period. The following exclusion criteria were applied: (1) receipt of obesity treatment involving pharmacotherapy or surgery and (2) use of an activity tracker during the preceding 3 months. We included only male students as the obesity rate was too low in female students (1.6% and 4.4% of female students had BMI >27 kg/m^2 and >25 kg/m^2, respectively, according to the 2014 School Health Survey data), and inclusion of a small number of female students with obesity would have complicated the interpretation of this pilot study. All eligible participants were randomly assigned to one of the three study arms using a real-time, Web-based randomization system, which is run by Medical Research Collaboration Center in Seoul National University Hospital (http://mrcc.snuh.org). Details of enrollment and randomization procedures can be found in our previous article describing the study design (20).

The study was approved by the institutional review board at the Seoul National University Hospital (IRB No. 1504-050-663) and registered at www.clinicaltrials.gov (identifier: NCT02548182). Informed consent was obtained from all participants.

Intervention

Based on current guidelines and recommendations on diet, exercise, and physical activities (22), standardized education materials were developed by the authors and provided to all participants. Each participant received a one-to-one education on diet and exercise from a trained nurse for 5 minutes each session. The contents included the clinical consequence of obesity; a dietary recommendation for weight loss with an example of a 1,200 kcal diet menu; and a physical activity recommendation with specification of frequency, intensity, time, and type.

A Fitmeter accelerometer (Fit.Life^{TM}, Suwon, Korea) and smartphone application customized for the intervention were provided to participants allocated to the two Smartcare arms. The Fitmeter accelerometer has been validated for monitoring physical activity or exercise in an adult population with a mean measurement error of 20% compared with gold standard measures of energy consumption (23). The application for Group 3 included a feature designed to monitor and provide feedback of financial incentives.

Participants in Group 3 could earn financial incentives contingent on the achievement of daily physical activity goals (process incentive: 1,000 KRW per day and an additional 3,000 KRW for a full week [7 days] of meeting goals) and weight target (outcome incentive: 50,000 KRW for achievement of the weight loss targets of 3% and 5% of baseline body weight at weeks 4 and 8, respectively, and 100,000 KRW for the achievement of the final target of 7% at week 12) (1USD = 1,150 KRW, as of 2015). The total possible amount that could be earned was 120,000 KRW for process incentives and 200,000 KRW for outcome incentives. Process incentives were accumulated and paid out at the end of the study (week 12), and outcome incentives were provided after meeting goals at each visit (weeks 4, 8, and 12). All incentives were transferred to an individual's bank account within 2 weeks of the visits (Supporting Information Table S1).

Measures and follow-up

Data collection included anthropometric measurements (height, weight, waist circumference, muscle and fat mass, and blood pressure [BP]), questionnaire completion (medical history, smoking, alcohol consumption, physical activity [IPAQ-Short Form (21)], and diet), and laboratory measurements (fasting glucose, aspartate transaminase, alanine transaminase, total cholesterol, triglyceride, high-density lipoprotein [HDL], and low-density lipoprotein [LDL] cholesterol levels). Details concerning data collection are described elsewhere (20).

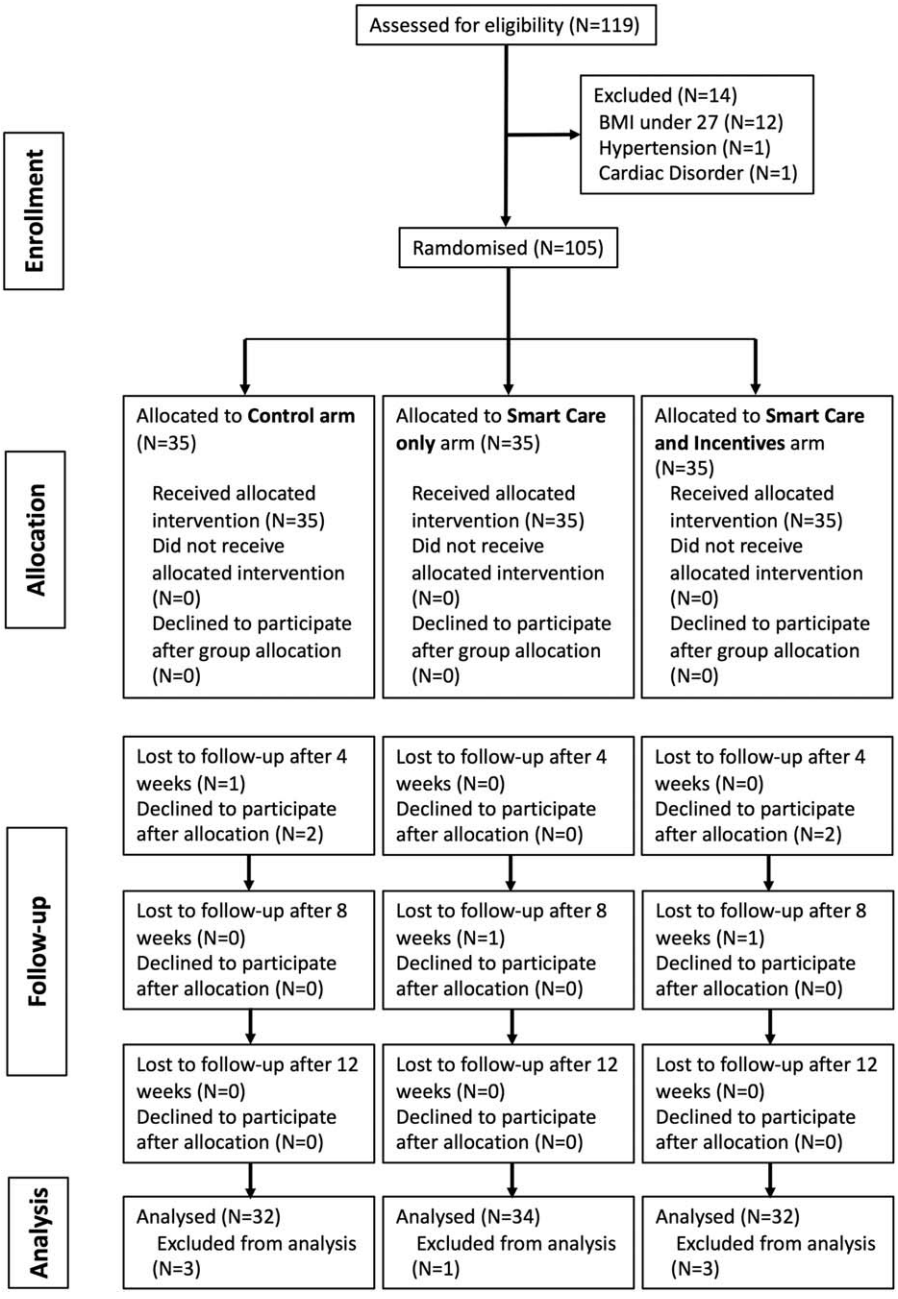

Figure 1 Flow of study participants.

Participants were followed up at weeks 4, 8, and 12. We attempted to call and send text messages to participants who had not attended appointments according to the protocol. We excluded those who expressed a wish to discontinue their participation and those whom we could not contact despite at least 10 attempts to do so.

Statistical analysis

We performed linear regression to analyze changes in weight at 4, 8, and 12 weeks from baseline measurements according to group. Changes in anthropometric measurements and laboratory test results, as well as physical activity and total calorie intake, were also compared between all of the groups. Levels of physical activity, measured using the activity tracker, were compared between Groups 2 and 3. Baseline characteristics were well balanced among groups. No covariates were included in the final analyses.

Additionally, generalized estimating equation analyses were performed for the changes of weight, BMI, waist circumference, and body fat percentage. Each variable was calculated as the difference from the previous visit, not from the baseline, to avoid the nested observation problem. Regarding nonlinearity of the model, we

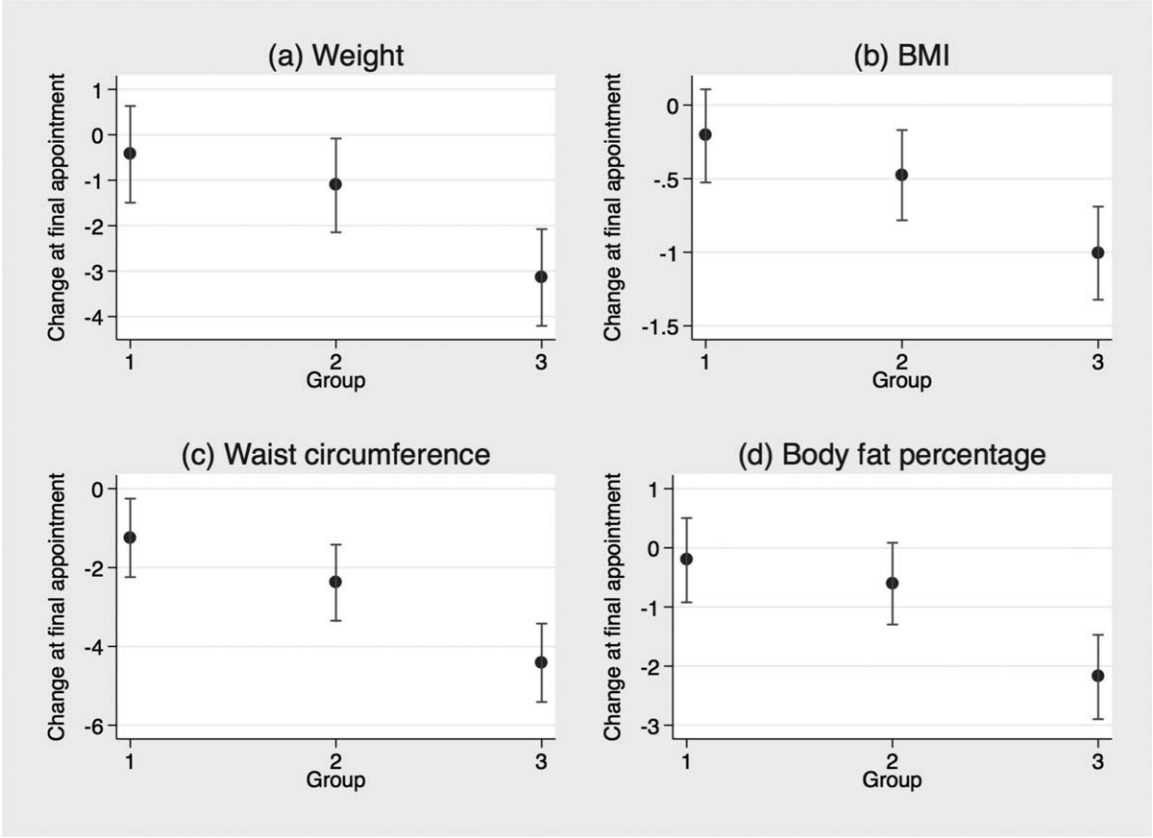

Figure 2 Changes in anthropometric measurements and body fat percentages at the final appointment. Group 1: Traditional education arm, Group 2: Smartcare only arm, Group 3: Smartcare and financial incentive arm. Error bars represent standard deviations of each value.

included each visit discretely as a covariate, not sequentially. The number of missing observations was small; therefore, we did not perform multiple imputation, though these were considered at the design stage.

We performed logistic regression to examine the association between the proportion of activity-achieved days and achievement of final weight loss goals. The probability of achievement of daily activity goals was assessed via multilevel analysis. The multilevel model included Smartcare with or without incentives, days elapsed since the initiation of the study, type of day (weekday or weekend), and the interaction between incentive and elapsed days as fixed-effect variables. Analyses were performed using Stata version 14.0 (Stata Corp, College Station, TX, 2014).

User interviews

We conducted focus group interviews to explore the user experience and perception of Smartcare with financial incentives. Ten interviewees (both achievers and nonachievers) were recruited via email upon completion of the study. Three interview sessions, each including three to four interviewees, were conducted by a trained nurse researcher and an assistant. Questions concerned participants' perceptions of the effects of the incentive on their motivation and actual behavior, the perceived appropriateness of the amounts of money offered via the financial incentives, users' experiences of Smartcare, and participants' intention to continue using the activity tracker subsequent to study completion. Interviews were conducted approximately 1 month subsequent to study completion.

Results

Study enrollment and follow up

Between June and July 2015, 119 potential participants contacted the research team, and their eligibility was determined in accordance with the study protocol. Ultimately, 105 participants were recruited, and 35 were allocated to each group (Figure 1).

Four withdrew their consent because of personal reasons, and three were lost to follow up despite more than 10 attempts to contact them via phone or SMS message. Of the seven participants who withdrew from the study, three, one, and three were from Groups 1, 2, and 3, respectively. Ultimately, 98 participants were followed up to 12 weeks and included in the final analysis.

Participants' baseline characteristics

Participants' baseline characteristics according to the study arm are shown in Supporting Information Table S2. Participants' average age was 27.8 years, their average BMI was 29.8 kg/m^2, and their average waist circumference was 98.3 cm. At baseline, 53.3% and

TABLE 1 Changes in outcomes and processes

	Changes from baseline at final visit						Between group differences					
	Group 1		Group 2		Group 3		Group 3–Group 1		Group 2–Group 1		Group 3–Group 2	
	Mean	SD	Mean	SD	Mean	SD	Mean	95% CI	Mean	95% CI	Mean	95% CI
Outcomes												
Weight (kg)	−0.4	2.5	−1.1	2.9	−3.1	3.7	−2.7	−4.3 to −1.1	−0.7	−2.0 to 0.6	−2.0	−3.7 to −0.4
BMI (kg/m^2)	−0.2	0.7	−0.5	0.8	−1.0	1.2	−0.8	−1.3 to −0.3	−0.3	−0.6 to 0.1	−0.5	−1.0 to0.0
Waist circumference (cm)	−1.2	3.0	−2.4	2.3	−4.4	3.3	−3.2	−4.7 to −1.6	−1.1	−2.4 to0.2	−2.0	−3.4 to−0.7
Muscle mass (kg)	−0.3	1.1	−0.5	1.4	−0.3	1.6	0.0	−0.7 to 0.7	−0.2	−0.8 to 0.4	0.2	−0.5 to 0.9
Skeletal muscle mass (kg)	−0.2	0.7	−0.3	0.9	−0.2	1.0	0.0	−0.4 to 0.4	−0.1	−0.5 to 0.3	0.1	−0.3 to 0.6
Body fat mass (kg)	−0.4	2.1	−0.4	2.1	−2.8	3.3	−2.5	−3.9 to −1.1	−0.6	−1.6 to 0.3	−1.8	−3.1 to −0.5
Percent body fat (%)	−0.2	1.9	−0.6	1.3	−2.2	2.7	−2.0	−3.2 to −0.8	−0.4	−1.2 to 0.4	−1.6	−2.6 to −0.5
Systolic blood pressure (mm Hg)	−2.3	11.1	−4.7	12.6	−10.0	11.1	−7.7	−13.2 to −2.1	−2.4	−8.2 to 3.5	−5.3	−11.1 to 0.6
Diastolic blood pressure (mm Hg)	1.9	7.6	−0.9	7.0	−4.2	9.1	−6.1	−10.3 to −1.9	−2.8	−6.3 to 0.8	−3.3	−7.3 to 0.6
Fasting blood glucose (mg/dL)	−0.4	7.2	−5.1	9.6	−2.5	9.8	−2.1	−6.3 to 2.2	−4.7	−8.9 to −0.5	2.6	−2.2 to 7.4
Total cholesterol (mg/dL)	1.8	34.4	4.2	19.7	−3.2	21.4	−5.0	−19.3 to 9.4	2.4	−11.3 to 16.1	−7.4	−17.5 to 2.7
Triglyceride (mg/dL)	−14.8	165.5	11.1	66.7	−29.9	74.2	−15.2	−79.3 to 48.9	25.8	−35.6 to 87.2	−41.0	−75.7 to −6.4
HDL cholesterol (mg/dL)	0.5	6.3	0.4	5.5	3.8	9.0	3.4	−0.5 to 7.3	−0.1	−3.0 to 2.8	3.5	−0.2 to 7.1
LDL cholesterol (mg/dL)	4.1	14.6	1.6	20.6	−0.9	18.1	−5.0	−13.2 to 3.2	−2.6	−11.4 to 6.3	−2.5	−12.0 to 7.1
AST (IU/L)	8.8	56.5	−4.1	16.3	−5.9	19.8	−14.7	−35.8 to 6.5	−12.9	−33.1 to 7.3	−1.8	−10.7 to 7.1
ALT (IU/L)	5.3	19.0	−7.6	32.6	−13.8	35.1	−19.2	−33.3 to −5.1	−12.9	−26.1 to 0.4	−6.3	−23.0 to 10.4
Process												
Physical activity (IPAQ) (kcal/wk)	532.3	2,050.1	304.6	3,129.1	3,747.9	5,954.8	3,215.6	990.1 to 5,441.1	−227.6	−1,537.3 to 1,082.0	3,443.2	1,123.7 to 5,762.8
Physical activity (IPAQ) (kcal/d)	76.0	292.9	43.5	447.0	535.4	850.7	459.4	141.4 to 777.3	−32.5	−219.6 to 154.6	491.9	160.5 to 823.3
Total calorie (kcal/d)	1.8	412.7	32.3	424.2	105.7	439.3	103.9	−116.3 to 324.2	30.5	−191.8 to 252.8	73.4	−156.3 to 303.2
Physical activity (AT) (kcal/d)[a]	NA		535.7	431.3	974.0	527.9	NA			NA	438.3	195.0 to 681.6

Group 1: Traditional education arm, Group 2: Smartcare only arm, Group 3: Smartcare and financial incentive arm.
[a]Activity level measured by activity tracker (AT) during the period between the third and the final visit.
BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; IPAQ, International Physical Activity Questionnaire; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

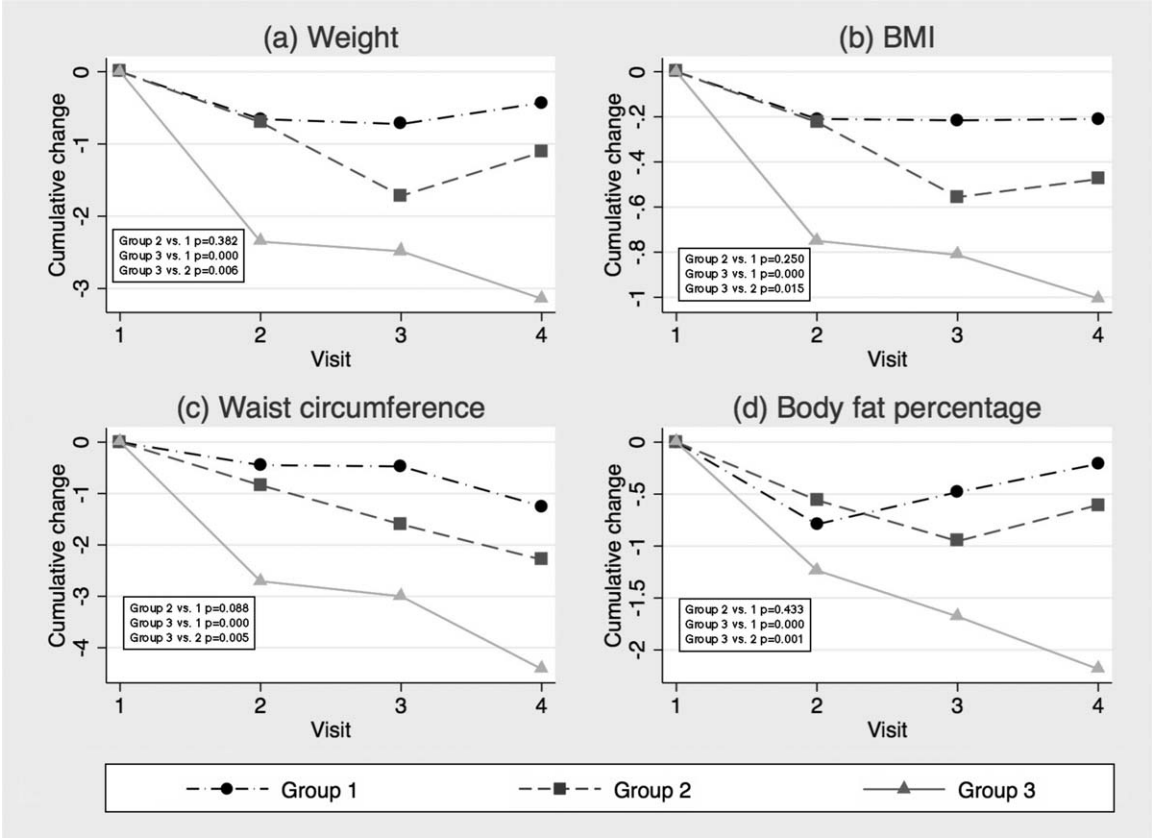

Figure 3 Cumulative changes in anthropometric measurements and body fat percentages according to appointment and group. Group 1: Traditional education arm, Group 2: Smartcare only arm, Group 3: Smartcare and financial incentive arm.

31.4% of participants met the physical activity requirements for self-reported usual health and weight loss, respectively. Demographics and other baseline characteristics did not differ significantly between the three groups.

Changes in outcomes: body weight, waist circumference, body fat, and laboratory test results

Average weight changes at the final visit in Groups 1, 2, and 3 were −0.4, −1.1, and −3.1 kg, respectively, and significantly greater weight loss was observed in Group 3 relative to that observed in Groups 1 and 2 (both Ps < 0.01). Additionally, reductions in BMI ($P < 0.01$ and $= 0.02$, respectively) and waist circumference ($P < 0.01$) were significantly higher in Group 3 relative to that of Groups 1 and 2. However, there were no significant differences between changes in anthropometric measurements between Groups 2 and 1 (Figure 2 and Table 1). The differences observed at 4, 8, and 12 weeks are shown in Figure 3 and Supporting Information Table S3. Group 3 showed a significant difference in changes compared with Groups 1 and 2, while Group 2 was not different from Group 1 via the generalized estimating equation analyses. The difference in weight change between Groups 1 and 3 was observed from the second appointment onward and was greater at the final appointment. Decreasing trends in BMI, waist circumference, and body fat were similar to that of weight change.

Final weight loss goals were achieved by 12 participants; 2 were in Group 2, and the others were in Group 3, while none of the participants in Group 1 achieved the goal. Group 3 included a higher level of weight loss goal achievement relative to that of Group 2 (odds ratio: 7.27, 95% confidence interval: 1.45–36.47; Table 2).

Other outcomes, such as changes in systolic and diastolic BP, triglyceride, HDL cholesterol, and alanine aminotransferase levels also improved significantly in Group 3. Fat-free and muscle mass did not differ between groups (Table 1).

Process: Physical activity and nutrition

Changes in physical activity measured via the IPAQ and physical activity measured via the activity tracker were significantly higher in Group 3 relative to that of Groups 1 and 2 (Ps < 0.01). However, there were no significant differences in total calorie intake between groups (Table 1).

Analysis of activity tracker data showed that the total number of days involving exercise goal completion was strongly correlated with final weight reduction goal completion (odds ratio: 1.05 per

TABLE 2 Characteristics of weight reduction success and mean amounts offered via incentives

Visit	Group	*n*	No. success	OR	95% CI	Mean process incentive per success	Mean result incentive per success
2 (Week 4)	1 (Ref)	32	5	1	-	-	-
	2	34	6	1.16	0.32 to 4.24	-	-
	3	32	18	6.94	2.13 to 22.65	KRW 28,258	KRW 50,000
3 (Week 8)	1 (Ref)	32	1	1	-	-	-
	2	34	2	1.94	0.17 to 22.47	-	-
	3	32	11	16.24	1.95 to 135.38	KRW 24,032	KRW 50,000
4 (Week 12)	1 (Ref)	32	0	-	-	-	-
	2	34	2	1	-	-	-
	3	32	10	7.27	1.45 to 36.47	KRW 22,379	KRW 100,000

Group 1: Traditional education arm, Group 2: Smartcare only arm, Group 3: Smartcare and financial incentive arm; for visit 2 and 3, reference is Group 1; for visit 4, reference is Group 2.
1 USD = 1,150 KRW, as of year 2015.

day, 95% confidence interval: 1.01–1.10). This indicates that daily exercise goal completion for 7 days increased the chance of final weight loss goal achievement $1.4 \times (1.05^7)$. Multilevel analysis showed that the probability of daily physical activity goal achievement was higher for Group 3 relative to that of Group 2, but this decreased gradually as the study progressed (Supporting Information Figure S1).

User interviews

Participants who earned high levels of incentives (defined as $\geq$50% of the possible total amount, that is, $\geq$160,000 KRW) generally agreed that the incentives exerted a motivational effect. One participant reported that he had a specific goal (to buy a camera lens with the money he earned via the incentives), and this helped him to maintain motivation and monitor and correct his behavior. However, some participants ($n = 2$) reported that the incentives were not sufficiently large to encourage the maintenance of motivation, but they helped them to lose weight, which they had yearned for. Regarding the incentives, many ($n = 6$) participants reported that the outcome incentive was much larger than the process incentive and therefore more motivational. Some participants ($n = 4$) regarded the amount earned via the incentive adequate, but some stated that 1,000 KRW per day was insufficient to motivate daily activity.

Although 1 month had elapsed since the study, a few ($n = 4$) participants reported that they continued to maintain their weight loss and physical activity levels and used the activity tracker. Others ($n = 3$) reported that they had regained some of the weight lost during the study, their physical activity levels had decreased, and they had resumed the habit of eating late. Some ($n = 2$) participants reported that switching to usual smartphone applications without incentive had caused them to cease using the device. Two participants changed their activity tracking to other activity trackers (such as smartwatches or smartphone pedometers).

Participants who did not earn high levels of incentives and failed to achieve target goals also agreed that the incentives played a role in motivation. However, many reported that failure to achieve weight loss goals at week 4 caused them to lose motivation. Moreover, failure to achieve daily physical activity goals for 7 days (e.g., failure on Monday or Tuesday) prevented participants from obtaining the 3,000 KRW bonus incentive for that week, which led to de-motivation. Therefore, they suggested continuous and meticulous adjustment of target goals for those who failed to achieve weight loss or physical activity goals. Subsequent to the intervention, some participants continued to use activity trackers (either Fit.Life or other brands) and were positive concerning activity tracking.

Discussion

This study demonstrated the feasibility and effectiveness of Smartcare combined with financial incentives in reducing weight and promoting physical activity.

Our results are comparable to those involving financial incentive interventions for weight loss developed by Volpp et al., in which deposit contract (14.0 lb) and lottery incentive groups (13.1 lb) reported greater weight loss relative to that of the control group (3.9 lb) during a 16-week intervention period (15). The mean difference in weight loss between the intervention and control groups was approximately 9 to 10 Ib, or 4 to 4.5 kg. In our study, this difference was approximately 2.7 kg during a 12-week period. Considering the difference in baseline weight (108 kg vs. 91.4 kg) and the duration of the intervention period (16 vs. 12 weeks) between the two studies, the effect of the intervention appears similar.

Our study involved strengths that were absent in the previous study, in that we analyzed various anthropometric factors and laboratory test results to observe the metabolic changes resulting from the intervention. Waist circumference and body fat percentage decreased with weight, while fat-free and muscle mass were maintained. Reductions in BP, blood sugar, triglyceride, and alanine transaminase were anticipated effects of the lifestyle modification. In this study, we advised participants to eat low-calorie diets and increase their physical activity levels to maintain a negative energy balance. The intervention was designed to increase physical activity, as it can

prevent fat-free mass loss during weight loss, which can be beneficial for long-term weight control (24). Indeed, there was no significant difference in reported calorie intake between the three groups, suggesting that the intervention met our intentions. Although exercise alone does not result in significant long-term weight loss (24), it can produce significant additional weight loss when combined with a low-calorie diet (25).

Our results showed that the addition of financial incentives enhanced the effectiveness of digital health technology in promoting physical activity and reducing weight. Physical activity goal achievement measured via an activity tracker was much higher in Group 3 compared with that of Group 2, which led to final weight loss goal achievement for many participants (Supporting Information Figure S2). This suggests that financial incentives improve patient engagement, which is essential for the long-term management of obesity.

Although the activity tracker combined with smartphone application did not induce significant additional weight loss, its use was essential. Activity trackers allowed the accurate measurement of physical activity and the distribution of process incentives according to measurement. We would not have been able to determine the achievement of daily and weekly activity goals without the activity tracker and reliance on self-report, which is not acceptable for the determination of financial incentives. Furthermore, the smartphone application provides the opportunity for frequent and real-time feedback, which can also enhance the effectiveness of financial incentives. Therefore, our study also implied that a combination of Smartcare and financial incentives would produce a synergistic effect, each enhancing that of the other.

Recently, U.S. insurance companies have begun to incentivize physically active living with the use of activity trackers. Oscar, a health insurer startup company, provides Misfit activity trackers to its members and pays $1 per day (monthly maximum of $20) if they fulfill their personalized fitness goals (26). John Hancock, a life insurance company, offers a discount of up to 15% or points that can be used to purchase other services for those who wear a Fitbit activity tracker (27). Our study could provide the scientific basis for examining the effectiveness of such interventions. While there have been concerns about the potential of financial incentives to undermine the intrinsic motivation, a 2013 review found that there is no evidence of such an undermining effect for health-related behavior (28).

The long-term cost-effectiveness of such interventions depends on the sustainability of desirable changes in health status and behavior. Our results showed that physical activity goal achievement decreased over time, although the relative difference between the incentive and no-incentive groups was maintained throughout the study (Supporting Information Figure S1). Maintaining the motivational effect of financial incentives is a challenging issue in incentive structure design. Our interview results suggested that early failure to achieve weight loss goals de-motivated participants in the further pursuit of remnant incentives, and continuous and meticulous adjustment of target goals is needed. Further studies are required to address the means of optimizing incentives, such as an intensively adaptive intervention or an escalating reward schedule with a reset contingency, which appear to be more effective than static intervention and more effective in promoting longer duration of intervention effect (5,18,19,29,30). It has been suggested that financial incentives could promote habit formation, even after discontinuation (31,32). Effectiveness decreases significantly during the post-intervention period (25), with a nonsignificant effect after 12 to 18 months (33,34). However, this problem is not unique to financial incentives and applies to all health promotion interventions (25). In our study, some participants reported that they continued to use Smartcare subsequent to the intervention, suggesting that the intervention aided habit formation (35). In this study, we will also evaluate the long-term effectiveness of our intervention at 3 and 6 months post-intervention.

Major limitations of this study include a pilot-scale small sample size and selected population of male college students. Further larger-scale studies with a more general population sample, including women, would be required to assess the effectiveness and confirm the generalizability of our findings.

Given the global increase in physical inactivity and obesity, there is a growing need for effective, scalable, and affordable health promotion strategies. Our results suggest that the addition of financial incentives to Smartcare is effective in increasing physical activity and reducing obesity. The long-term effect and cost-effectiveness of such approaches requires elucidation via further research. O

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