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Research Article

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Mobile Engagement Behaviors Associated with Sustained 15% Weight Loss

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Abstract

Background: This study aimed to report weight loss outcomes and evaluate behaviors of high performing participants who achieved ≥ 15% weight loss at 6 and 18 months in a precision medicine weight loss program, which incorporates clinical visits, a mobile application (mHealth) and tailored nutritional programming.

Methods: A retrospective analysis was performed on participants, aged ≥ 18 years with BMI ≥ 25 kg/m^2, who enrolled in Enara Health's weight loss program from March 1, 2015 to October 1, 2018. Participants were matched into 6 and 18-month cohorts. An analysis characterized high-performing participants who lost ≥ 15% of their starting weight. Behaviors evaluated included: monthly appointments, monthly coaching text conversations, weekly food pictures, percent of educational content completed, weekly weight monitoring, and number of days wearing an activity tracker.

Results: Average weight loss for the 6-month (n = 479) and 18-month (n = 145) cohorts was -12.40% and -13.99%, respectively. 32.57% of participants achieved 15% weight loss at 6 months and 41.38% of participants achieved 15% weight loss at 18 months. High achievers at 6 months had increased monthly appointments (3.05 ± 0.82 *vs* 2.72 ± 0.92, P < 0.001), weekly food pictures (40.64 ± 27.85 *vs* 33.61 ± 26.51, P = 0.011), educational activity compliance (60.98 ± 34.48% *vs* 47.10 ± 34.91%, P < 0.001) and weekly weights (3.11 ± 2.28 *vs* 2.55 ± 1.97, P = 0.011). High achievers at 18 months attended more monthly appointments (2.12 ± 0.58 *vs* 1.78 ± 0.70, P = 0.002), engaged in more monthly coaching text conversations (6.92 ± 5.61 *vs* 4.41 ± 3.65, P = 0.002), and weighed themselves more frequently beyond 12 months (1.92 ± 1.98 *vs* 1.26 ± 1.64, P = 0.47).

Conclusion: Participants in the Enara Health precision weight loss program lost an average of- 13.99% at 18 months. Self-tracking behaviors characterized high achievers at 6 months and increased number of provider-patient touchpoints characterized high achievers at 18 months. Mobile health applications may be better suited to achieve sustained weight loss by designing features that facilitate provider-patient interactions on top of self-tracking technology.

Keywords

mHealth, Mobile health, Obesity treatment, Weight loss, Behavioural modifications

Introduction

Recent studies have predicted that by 2030 nearly 1 in 2 Americans will struggle with obesity [1]. The exponential growth in incidence rates is correlated to

an increasing chronic disease burden and decreasing mortality after the age of 40 in this population [2]. Problematically what is often underestimated with respect to this growing epidemic is the difficulty of treatment.

Standalone approaches to obesity, whether economical, behavioral, lifestyle or pharmacological have not been able to demonstrate sustained outcomes. A recurring trend throughout these weight-loss interventions was poor attrition past 6-months [3, 4]. Several studies have shown that both self-tracking technology and programs with multicomponent approaches help reduce attrition in weight loss programs [5, 6]. The opportunity for mobile technology to help deliver and tailor multimodal obesity treatments has been widely explored over the last decade [7-9]. Almost 30% of all mobile health development has focused exclusively or partially on weight loss. We now have approximately 30,000 mobile applications to help with weight loss [10].

Research evaluating the effectiveness of mobile health interventions have demonstrated conflicting findings on whether technology improves weight loss outcomes [11-13]. Some meta-analysis of randomized control trials has found that web-based interventions did not improve weight loss over off-line counterparts [14] while others have found that they do exhibit a modest improvement in results [15-17]. The reason for this conflicting data is largely because mobile interventions are lumped monolithically when in fact they are widely divergent in the type of intervention they each deliver. Each application has varying degrees of self-monitoring, feedback, gamification, social support, and educational features. Current mobile health studies on weight loss have not taken this into consideration and as a result we do not have a good understanding on which features are most effective and in which settings [18, 19] Without a more nuanced examination, decision makers and developers lack information on how to improve mobile weight loss interventions. One study that did examine the impact of varying intervention features within a mobile application found text message based coaching conversation was associated with increased weight loss in females but not in males. This study is the first mobile health (mHealth) study that postulates that a mobile health intervention may need to be personalized by gender [20].

Enara Health is a comprehensive program, delivering behavioral, pharmacologic, and nutritional therapy via mobile and web-based application. The purpose of this study was to evaluate mobile engagement behaviors of high performing participants who achieved ≥ 15% weight loss at 6 and 18 months in a precision medicine weight loss program. The mobile application under study allows for examination and comparison of self-monitoring, feedback, support, and educational features within the same mHealth program. This may shed insight on which features and usage are better for sustained weight loss.

Methods

Study design

This is a retrospective cohort study analysing the mobile engagement behaviors of adults participating in a comprehensive precision weight loss program (Enara Health). Data were collected from the electronic health records of patients who enrolled and started a weight loss journey during the period from 1 March 2015 to 1 October 2018 (with follow-up through 1 April 2019). Enara Health provided the study investigators with all relevant data following de-identification of the entire dataset. The Hummingbird Institutional Review Board (Needham, MA, USA) approved the study protocol and deemed that the study met the requirements for exemption from the US Department of Health and Human Services regulations for the protection of human subjects (45 CFR 46.101[b][4]).

Weight loss program interventions

Enara Health is a medical company based in San Mateo, California, that offers a unique hybrid digital and in-person weight loss program. The Enara Health weight loss program has been operating since March 2015. By combining mobile technology with healthcare visits, the program provides patients with personalized physician-driven medical weight loss plans. Upon enrolment, patients are initially evaluated by a physician or physician assistant who determines the severity of obesity and the patient's readiness to change and performs a full metabolic workup and examination. Patients engage in one-on-one meetings with a registered dietitian on a weekly basis during the first 3 months, once every other week during the next 3 months and then once monthly for 6 months. Patients also see their physician or physician assistant on average once a month for the first 3 months, and then every 3 months thereafter. Patients may conduct their visits either in-person or via face-to-face video communication. There is a monthly fee of $50 for patients with insurance (most insurances accepted) or $300 without insurance.

Between visits, patients utilize a mHealth application, which delivers tailored educational content, messages of encouragement and support, nutritional and behavioral feedback, a review of meals and feedback by a registered dietitian, as well as exercise suggestions, planning and encouragement by a fitness trainer. Messages can be initiated by either patient or providers (physicians, dietitians, fitness trainers). Providers will typically respond within a 12-24-hour window; while it is not a 24-hour on-call messaging service, it allows for sufficient accountability, guidance, and support to patients throughout their week. Providers can also initiate conversations in response key alerts they receive on patients' appointment, exercise, food log, and weight trends. Patients may choose between an intense, rapid weight loss program (daily caloric intake: 800-1,000 kcal) or a non-intensive weight loss program that emphasizes non-processed foods but does not encourage calorie counting. Both options encourage whole, unprocessed, low glycemic foods. Although all participants are assigned a target exercise goal of 150 min week-1, a personal exercise coach determines the duration of exercise based on the patient's physical ability. Many patients utilize activity trackers such as Fitbit® or Apple Watch® to monitor weekly exercise.

Where appropriate, patients are prescribed medications

to assist with weight loss. Prescriptions are driven by the patient's request after attending an educational visit on anti-obesity medications (AOMs). AOMs are prescribed in accordance with the US Food and Drug Administration-labeled recommendations; however, in the event of non-coverage, generic equivalents are prescribed, and any off-label usage is discussed with the patient. The choice of medication is ultimately made by the patients and their physicians.

Prescribed weight loss medications include lorcaserin, phendimetrazine, diethylpropion, phentermine/topiramate, liraglutide and bupropion/naltrexone. Some patients may be prescribed more than one AOM. Routine follow-up visits with the provider are conducted to ensure that the patient is responding positively to the medication and is not experiencing adverse effects. All patients are started on the lowest dosage of medications, while dose adjustments are made on an individual basis as needed to achieve the desired outcomes.

Study cohort selection

Patients enrolled in the Enara Health weight loss program during the study period, who were aged ≥ 18 years with a BMI ≥ 25 kg/m^2 at enrollment, were eligible for inclusion. Patients who became pregnant during the study period were excluded from the analyses.

Assignment of mobile engagement cohort

Overall, participants were matched into a 6 and 18 month cohorts so long as their start date indicated that they could have participated in the study duration regardless of their engagement status at that time point. Completers were defined as any participant who logged a home weight ± 30 days from the cohort end date. High achievers were defined as participants who achieved greater than 15% weight loss.

Study data collection

Enara Health collected demographic and clinical data for all study patients at the initial clinic visit. Height, body weight, blood pressure, pulse and body composition were measured at the first appointment to establish baseline values and then rechecked in the clinic at every in-person appointment thereafter. Body weight was collected daily via the patient's home scale, which connected directly to Enara Health's provider dashboard. Mobile engagement data were collected from Enara's mobile app and included monthly appointments, monthly coaching text conversations, weekly food pictures, percent of educational content completed, weekly weight monitoring, and number of days wearing an activity tracker.

Study endpoints

The primary outcome measurements were total percent of weight lost and percentage of participants who were high achievers defined as those who lost ≥ 15% of their starting weight.

For each mobile engagement behavior in a subgroup, the average (± standard deviation) of the engagement values were calculated. The significance of the average engagement between the subgroups were measured using a t-test. All statistical analyses were performed using Python 3.6. Statistical significance was defined as $P < 0.05$.

For the 18-month cohort, sustained mobile engagement behavior was defined as behavior averages from months 12-18 within each subgroup. This allowed for exploration and comparison of behavioral markers of success at different time periods throughout a participant's journey.

Results

Selection of study cohort

Figure 1 shows the distribution and selection of the final study cohorts and high achiever subgroups. Data were obtained for 569 patients enrolled in the Enara Health weight loss program who met the study criteria during the study period. 84% (n = 479) of the 6-month cohort (n = 569) had weight data at the 6-month mark while 56% (n = 145) of the 18-month cohort (n = 261) had weight data at the 18-month mark. 32.57% (n = 156) of participants in the 6-month cohort were high achievers (≥ 15% weight loss) and 41.38% (n = 60) of participants in the 18-month cohort were high achievers (≥ 15% weight loss at 18 months).

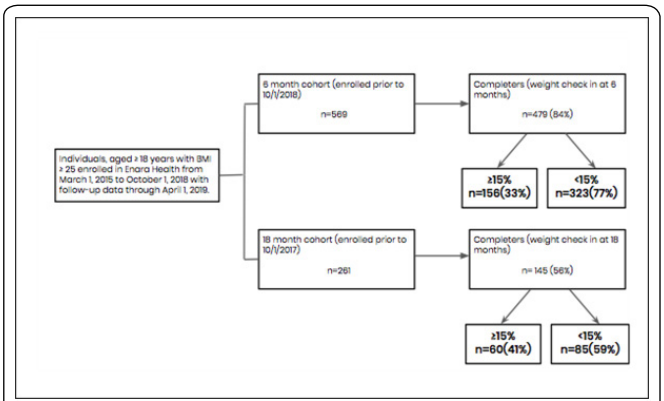

Figure 1: Distribution of enrollees. It represents the distribution of all enrolled participants into their appropriate cohorts and subgroups.

Baseline patient characteristics

Table 1 and 2 present the baseline characteristics between the subgroups of the 6-month cohort and 18-month cohort respectively. The mean age was 46 ± 13 years for both cohorts. In the 6-month cohort, high achievers had significantly higher starting BMI (35.90 ± 6.17 *vs* 34.24 ± 6.30, p = 0.007) and high triglycerides (143.50 ± 79.51 *vs* 121.34 ± 94.06, p = 0.018). There was no statistical difference between subgroups in the 18-month cohort for any baseline characteristics including anti-obesity medication use which was available for comparison in that cohort.

Comparison of changes in baseline weight in the 6-month cohort and 18-month cohort

Figure 2 and 3 demonstrate average weight loss for the 6-month (n = 479) and 18-month (n = 145) cohorts of -12.40% and -13.99% respectively. Figure 4 shows the percentages of the 6-month cohort and 18-month cohort that achieved 10%, 15% and 20% weight loss. 64.7% and 32.6% of participants

achieved a 10% and 15% weight loss at 6 months. 72% and 41.40% of participants achieved a 10% and 15% weight loss at 18 months.

Table 1: 6-month cohort participant's characteristics at baseline.

Behaviors	≥ 15% weight loss (n = 156)	< 15% weight loss (n = 323)	P value
BMI*	35.90 ± 6.17	34.24 ± 6.30	0.007*
Age (year)	46.22 ± 13.51	45.84 ± 12.87	0.771
Gender (male), (%)	29.48 (n = 46)	25.07 (n = 81)	-
Gender (female), (%)	70.51 (n = 110)	74.92 (n = 242)	-
HbA1C (%)	5.53 ± 1.17 (n = 120)	5.382 ± 1.67 (n = 221)	0.337
Total cholesterol (mg/dL)	196.48 ± 43.21 (n = 126)	189.36 ± 49.60 (n = 247)	0.155
Triglycerides (mg/dL)*	143.50 ± 79.51 (n = 125)	121.34 ± 94.06 (n = 247)	0.018*
LDL-cholesterol (mg/dL)	118.53 ± 34.51 (n = 123)	114.68 ± 38.60 (n = 245)	0.335
HDL-cholesterol (mg/dL)	50.71 ± 16.13 (n = 126)	52.09 ± 17.10 (n = 247)	0.449
Glucose (mg/dL)	95.28 ± 30.81 (n = 120)	97.34 ± 33.62 (n = 227)	0.568

Values shown are n (%) or means ± standard deviation. * categories differ significantly from each other at P < 0.05. BMI: Body Mass Index, HbA1c: Haemoglobin A1c, HDL: High-Density Lipoprotein, LDL: Low-Density Lipoprotein.

Table 2: 18-month cohort participant's characteristics at baseline.

Behaviors	≥ 15% weight loss (n = 60)	< 15% weight loss (n = 85)	P value
BMI	36.10 ± 5.01	34.69 ± 7.63	0.183
Medication Use (%)	0.78 ± 0.12 (n = 36)	0.66 ± 0.09 (n = 35)	0.291
Age (yr.)	44.23 ± 12.76	47.94 ± 13.37	0.095
Gender (male), (%)	26.66 (n = 16)	36.47 (n = 31)	-
Gender (female), (%)	73.33 (n = 44)	63.52 (n = 54)	-
HbA1C (%)	5.88 ± 1.26 (n = 46)	5.80 ± 0.99 (n = 65)	0.726
Total cholesterol (mg/dL)	207.38 ± 41.11 (n = 48)	197.30 ± 35.97 (n = 77)	0.170
Triglycerides (mg/dL)	150.17 ± 86.39 (n = 48)	145.60 ± 124.80 (n = 76)	0.812
LDL-cholesterol (mg/dL)	123.53 ± 35.71 (n = 47)	120.20 ± 34.94 (n = 77)	0.615
HDL-cholesterol (mg/dL)	54.42 ± 16.29 (n = 48)	54.10 ± 15.34 (n = 78)	0.915
Glucose (mg/dL)	102.09 ± 44.44 (n = 47)	104.21 ± 29.13 (n = 70)	0.775

Values shown are n (%) or means ± standard deviation. * categories differ significantly from each other at P < 0.05. BMI: Body Mass Index, HbA1c: Haemoglobin A1c, HDL: High-Density Lipoprotein, LDL: Low-Density Lipoprotein.

Engagement characteristics of high achievers at 6-months

High achievers at 6-months attended 11% more appointments (3.05 ± 0.82 *vs* 2.72 ± 0.92, P < 0.001), took 21% more food pictures (40.64 ± 27.85 *vs* 33.61 ± 26.51, p = 0.011), completed 29% more educational activities (60.98 ± 34.48 *vs* 47.10 ± 34.91, P < 0.001) and stepped on the scale 25% more times per week (3.11 ± 2.28 *vs* 2.55 ± 1.97, p = 0.011) compared to non-high achievers (Table 3). There were no differences in monthly provider text message conversations or the frequency of activity tracking between the two groups.

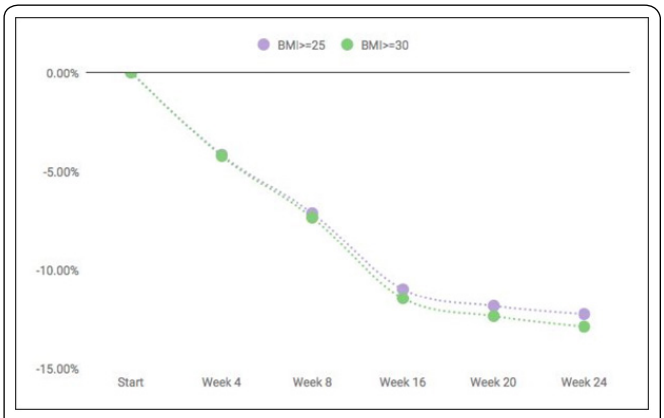

Figure 2: Average weight loss of 6-month cohort. It shows the average weight loss between the two subgroups of the 6-month cohort in 4-week intervals. The average weight loss for the entire 6-month cohort was-12.40% from baseline weight by week 24.

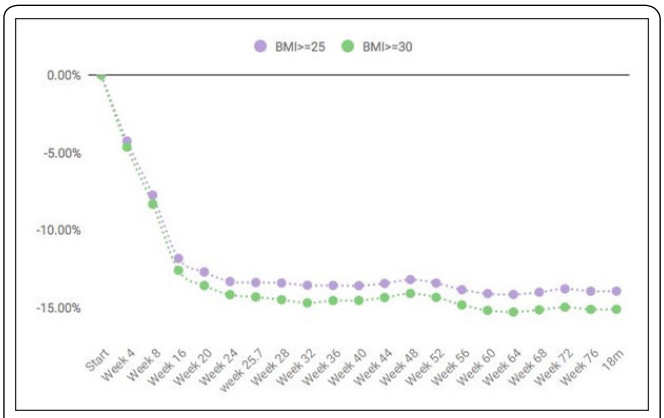

Figure 3: Average weight loss of 18-month cohort. It shows the average weight loss between the two subgroups of the 18-month cohort in 4-week intervals. The average weight loss for the entire 18-month cohort was-13.99% from baseline weight by 18 months.

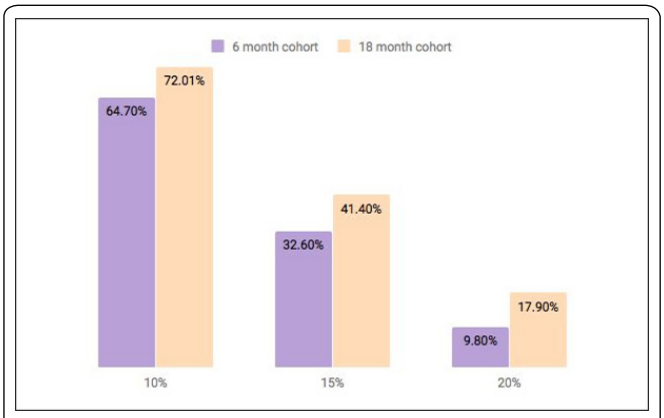

Figure 4: Percentage of cohort participants in each subgroup. It represents the percentage of cohort participants in each weight-loss subgroup.

Table 3: 6-month cohort-engagement behaviors of subgroups.

Behaviors	≥ 15% weight loss (n = 156)	< 15% weight loss (n = 323)	P value
Number of monthly appointments*	3.05 ± 0.82 (n = 156)	2.72 ± 0.92 (n = 323)	P < 0.001*
Number of monthly providers text conversations	10.37 ± 8.85 (n = 153)	9.76 ± 8.44 (n = 310)	0.486
Number of weekly foods pictures*	40.64 ± 27.85 (n = 150)	33.61 ± 26.51 (n = 306)	0.011*
Percent (%) of educational content completed*	60.98 ± 34.48 (n = 146)	47.10 ± 34.91 (n = 299)	P < 0.001*
Number of weekly weigh-ins*	3.11 ± 2.28 (n = 150)	2.55 ± 1.97 (n = 305)	0.011*
Number of days wearing an activity tracker	85.93 ± 56.36 (n = 124)	97.93 ± 56.89 (n = 128)	0.095

Values shown are n (%) or means ± standard deviation for the intention-to-treat population (N = 479). * categories differ significantly from each other at P < 0.05.

Engagement characteristics of high achievers at 18-months

High achievers at 18 months attended 19% more appointments (2.12 ± 0.58 *vs* 1.78 ± 0.70, P = 0.002) and initiated 57% more text-based conversations per month (6.92 ± 5.61 *vs* 4.41 ± 3.65) compared to non-high achievers. There was no statistical significance in food logging, exercise tracking, educational activities, and weight tracking between the two groups (Table 4).

Table 4: 18-month cohort-engagement behaviors of subgroups.

Behaviors	≥ 15% weight loss (n = 60)	< 15% weight loss (n = 85)	P value
Number of monthly appointments*	2.12 ± 0.58 (n = 60)	1.78 ± 0.70 (n = 85)	0.002*
Number of monthly provider text conversations*	6.92 ± 5.61 (n = 60)	4.41 ± 3.65 (n = 82)	0.003*
Number of weekly food pictures	25.56 ± 18.57 (n = 59)	21.12 ± 14.79 (n = 79)	0.136
Educational content completed (%)	53.21 ± 34.08 (n = 59)	50.87 ± 32.25 (n = 78)	0.687
Number of weekly weigh-ins	1.77 ± 1.79 (n = 60)	1.22 ± 1.61 (n = 77)	0.064
Number of days wearing an activity tracker	156.89 ± 147.58 (n = 75)	199.23 ± 174.15 (n = 43)	0.188

Values shown are n (%) or means ± standard deviation for the intention-to-treat population (N = 145). * categories differ significantly from each other at P < 0.05.

Sustained engagement characteristics high achievers at 18 months

A sub-analysis of engagement behaviors specifically between months 12 and months 18 showed the high achievers in the 18-month cohort were associated with 52% more weekly self-weigh-ins (1.92 ± 1.98 *vs* 1.26 ± 1.64, p = 0.047) and participated in 54% more text-based conversations with their providers (6.81 ± 5.90 *vs* 4.43 ± 3.8, p = 0.009) than non-high achievers (Table 5). When comparing activity from month 12-18 to months 1-12, weekly weigh-ins, educational activity, exercise tracking, monthly appointments, and food logging all dropped substantially while provider-patient text conversations persisted.

Table 5: 18-month cohort-sustained engagement characteristics.

Behaviors	≥ 15% weight loss (n = 60)	< 15% weight loss (n = 85)	P value
Monthly appointments	0.58 ± 0.29 (n = 60)	0.51 ± 0.29 (n = 77)	0.114
Monthly provider text conversations*	6.81 ± 5.90 (n = 60)	4.43 ± 3.83 (n = 74)	0.009*
Weekly food pictures	15.62 ± 18.37 (n = 59)	11.48 ± 14.23 (n = 71)	0.164
Percent of educational content completed	38.47 ± 37.22 (n = 59)	35.88 ± 38.74 (n = 70)	0.702
Weekly weight monitoring*	1.92 ± 1.98 (n = 60)	1.26 ± 1.64 (n = 69)	0.047*
Number of days wearing an activity tracker	65.56 ± 114.93 (n = 52)	91.13 ± 121.84 (n = 47)	0.292

Values shown are n (%) or means ± standard deviation for the intention-to-treat population (N = 145). * categories differ significantly from each other at P < 0.05.

Discussion

The results of our study provide direction in the future of obesity treatment. Our findings are consistent with prior research that show the importance of self-monitoring (in both weight and food intake) and frequent touchpoints with providers on the app for weight loss [21-24]. However, the most significant part of our study is the sustained weight loss we observed at 18-months and the behaviors associated with this long-term weight loss.

Beyond 6-months, we see certain behaviors that were crucial to initial weight loss start to drop off. While educational content and documenting food intake through photos made a significant difference between high achievers and low achievers at 6-months, these behaviors do not make an observable difference between high and low achievers at 18-months. It can be extrapolated that after 6-months, app users have reached a threshold of educational information and are capable of making good nutritional decisions on their own. They are not dependent on the educational modules nor on dietitian feedback on their food photos. These functions on the app become automated in the user's regular lifestyle and decision making, leading to a lower frequency of these behaviors in the app, while maintaining a similar level of weight loss.

As these behaviors that were essential to driving weight loss at the start of the program become statistically insignificant at the 6-month point, new behaviors emerge as better predictors of long-term weight loss [25, 26]. The difference in behaviors

between high achievers and low achievers during months 12 through months 18 provide a hint towards what is missing in the current treatment of obesity. We found that successful long-term weight loss was characterized by regular weigh-ins as well as initiating more text-based conversations. These two behaviors can be linked to long-term success because of their direct correlation with combating attrition and lack of motivation. Regular weight monitoring provides users with realistic data on their progress and helps patients avoid dramatic weight recidivism [27]. The high volume of in-app conversations emphasizes the important role that a provider-patient relationship plays in promoting behavioral changes [28-30]. Text-based conversations are a convenient way for patients to maintain touchpoints with their providers to receive personalized feedback and encouragement if they start to experience weight regain or loss of motivation.

It is also worth noting that our study utilized anti-obesity medications when deemed appropriate based on a decision made together by a medical provider and patient. While medication use did not differ significantly between high and low achievers in the 18-month cohort, it is included in our discussion to highlight the importance of multimodal treatments in a disease as complex as obesity [31, 32]. This study has the benefit of reflecting real-life situations and true clinical experiences, a perspective that randomized controlled studies do not.

Our study is unique from comparable studies on mobile engagement for obesity intervention in that it measures four different types of mobile engagement interventions: self-monitoring, feedback, support, and educational content. These distinctions help guide the future of mobile health apps by providing intervention-specific data. It also corroborates with other findings that meaningful and lasting weight loss requires a comprehensive set of interventions instead of a singular approach. Our findings suggest that mobile health applications may be better suited to achieve sustained weight loss by designing features that facilitate provider-patient interactions on top of self-tracking technology.

This study is also one of few that examines what happens to mobile engagement, and associated weight loss, over a duration of 18-months. While some studies have found short-term weight loss success through mobile app engagement, few have been able to show sustained weight loss beyond 6-months.

One limitation of our study design is the retrospective nature which does not allow us to control certain variables. In particular, the coaching in the mobile App was provided by obesity trained registered dietitians, physician assistants, and doctors. Hence, this may not be comparable to mHealth interventions where coaches are not specialty trained. Clinical expertise may be confounding the impact attributed solely through mobile coaching.

This study has demonstrated how delivering a comprehensive behavioral, pharmacologic, and nutritional weight loss program via a mobile health can help improve sustained weight loss. This is achieved by designing features within a mobile application that facilitate and elevate provider-patient relationships in order to limit and prevent weight recidivism. This study has demonstrated that technology enabled multicomponent approaches can play a significant role in the obesity treatment.

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