Drivers of weight loss in a CDC-recognized digital diabetes prevention program

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ABSTRACT

Introduction  To investigate the impact of the digital Livongo Diabetes Prevention Program (DPP) on weight at 12 months, understand participants’ self-monitoring behaviors associated with greater weight loss, and evaluate the impact of coaching interactions on more frequent self-monitoring behaviors.

Research design and methods  A retrospective analysis was performed using data from 2037 participants enrolled in the Livongo DPP who completed lesson 1 and recorded a starting weight during 2016–2017. Self-monitoring behaviors, including weigh-ins, food logging, activity, and coach–participant interactions, were analyzed at 6 and 12 months. Subgroup analysis was conducted based on those who were highly engaged versus those minimally engaged. Multiple regression analysis was performed using demographic, self-monitoring, and lesson attendance data to determine predictors of weight loss at 12 months and coaching impact on self-monitoring.

Results  Participants had a mean age of 50 years (SD ± 12), with a starting weight of 94 kg (SD ± 21), were college-educated (78%), and were female (74%). Overall, participants lost on average 5.1% of their starting weight. Highly engaged participants lost 6.6% of starting body weight, with 25% losing ≥10% at 12 months. Logistic regression analysis showed each submitted food log was associated with 0.23 kg (p<0.05) weight loss, each lesson participant message each week was associated with 1.4 more food logs per week, 1.6% increase in weeks with four or more weigh-ins, and a 2.7% increase in weeks with 150 min of activity.

Conclusions  Food logging had the largest impact on weight loss, followed by lesson engagement and physical activity. Future studies should examine further components that are associated with greater weight loss in a technology-based diabetes prevention program.

INTRODUCTION

Pre-diabetes is classified by a fasting blood sugar level between 100 and 125 mg/dL or hemoglobin A1c between 5.7% and 6.4%. Pre-diabetes affects nearly 40% of the US population and increases the risk of developing type 2 diabetes (T2DM), heart disease, and stroke; however, only about one in eight adults are aware they have the condition. 1 The National Diabetes Prevention Program established in 2010 by the Centers for Disease Control and Prevention (CDC) provides a 12-month structured program for individuals with pre-diabetes to achieve a moderate 5%–7% weight loss and increase physical activity to 150 min per week, which has shown to prevent T2DM by 58%. 2, 3 CDC-recognized programs include CDC-approved curriculum, a specially trained lifestyle coach, and a support group either in person or online. 3

Significance of this study

What is already known about this subject?

► Diabetes prevention programs recognized by the Centers for Disease Control and Prevention are effective at producing clinically significant weight loss, and individuals who are more engaged in program features (ie, food logging, attending lessons, and physical activity) are more likely to experience greater weight loss.

What are the new findings?

► The number of food logs per week, the total number of lessons attended, and the percentage of weeks with 150 min of activity were determined to be major predictors of weight loss at 12 months.

► Participant interaction with their coach increased the likelihood that a participant would be more engaged with program components, such as food logging, weigh-ins, and getting 150 min of activity each week.

How might these results change the focus of research or clinical practice?

► Understanding the behaviors and specific program components that are associated with greater weight loss in a technology-based diabetes prevention program can influence best practices for program creation and coaching to improve outcomes and decrease participants’ risk factors for developing type 2 diabetes.
The number of CDC-recognized digital diabetes prevention programs (DPP) is increasing with the growth in technological integration in healthcare. Studies have shown that digital DPP programs have similar participation rates and outcomes as inperson programs. Numerous digital DPP programs have reported outcomes ranging from 4.3% to 7.5% weight loss. Previous studies have also shown an association between coaching and engagement, specifically around loss. 

Livongo DPP is a digital CDC-recognized program offering participants interactive lessons and live personal expert coaching. The purposes of this study were (1) to understand participants’ self-monitoring behaviors associated with greater weight loss and (2) to evaluate the impact of coaching interactions on more frequent self-monitoring behaviors.

**METHODS**

**Study design**

A retrospective analysis was performed to analyze participants’ weight loss, program engagement, self-monitoring behaviors, and coach–participant interactions at 6 and 12 months. Subgroup analysis was also performed on highly engaged participants, in addition to multiple regression analysis to determine predictors of weight loss at 12 months and the impact of coaching on the predictors of weight loss in the highly engaged participants.

**Participants**

Participants included members of Livongo DPP who enrolled through an employer-sponsored program as part of their employer’s health benefits package. Members were considered eligible if they met the CDC program eligibility requirements, were determined at risk through the CDC Prediabetes Screening Test, and were previously diagnosed with gestational diabetes, or diagnosed with pre-diabetes through blood glucose testing (see box 1), and voluntarily enrolled into the program between May 23, 2016 and September 30, 2017, to allow for 12 months of participation in Livongo DPP.

**Box 1 CDC-recognized diabetes prevention program eligibility requirements**

The following criteria must be met to be eligible for a CDC-recognized Diabetes Prevention Program:

- At least 18 years of age
- Be considered overweight by a body mass index ≥25 (≥23 is Asian) and
- No previous diagnosis of type 1 or type 2 diabetes
- Within the past year have a blood test result of the following:
  - Hemoglobin A1c = 5.7% - 6.4% or
  - Fasting plasma glucose = 100 – 125 mg/dL or
  - Two-hour plasma glucose (after 75gm glucose load) = 140 – 199 mg/dL or
- Previously diagnosed with gestational diabetes

CDC, Centers for Disease Control and Prevention.

**Program**

**Livongo Diabetes Prevention Program**

Livongo’s CDC-recognized DPP lifestyle intervention program was created as a commercial entity selling this program into health plans, health systems, and self-insured employers. The Livongo DPP included an expert-moderated online community, interactive meetings and lessons, video conferencing coaching sessions, and unlimited coaching and community conversations through electronic messaging via mobile application (available through Google Play for Android phones and Apple App Store for iOS phones) or website served through an existing national weight loss company platform producing clinically significant weight loss outcomes. Thirty-one interactive, digital, skill-building lessons were available and emphasized self-monitoring of weight, food, and activity on an ongoing basis (see online supplementary table S1 for DPP lesson schedule and topics). Online communities consisted of 15–25 participants for social support. Each participant was provided a wireless Bluetooth scale, personal web-based dashboard, and mobile phone application for viewing lessons, informational content, self-monitoring, and communication with a community and expert coach. The mobile phone application also received and documented historical data from the Bluetooth scale and fitness tracker, if the participant provided access. All aspects of the program were available through the mobile application or website.

**Engagement**

**Highly engaged participants**

Highly engaged participants met the CDC high-engagement criteria by completing nine lessons within months 1–6 and three lessons within months 7–12 of the program with a minimum of 9 months between first and final lessons completed.

**Minimally engaged participants**

Minimally engaged participants include all participants not meeting the CDC high-engagement criteria.
Measures

All participants self-reported demographic characteristics at program registration, including age, gender, height, weight, education level, and risk factors for diabetes (ie, history of gestational diabetes, blood glucose test indicating pre-diabetes or the CDC Prediabetes Screening Test) (see box 1). Self-monitoring behaviors were captured remotely through program platform, including weigh-ins, food logging, and physical activity (ie, days wearing activity tracker, step counts, and active minutes) at 12 months.

Measures of self-monitoring behaviors

Weight-ins

All participants received a wireless connected scale that automatically connected with the mobile app via Bluetooth and securely transmitted weight data to a central data server for data collection and analytics. Manual entry of weight data was permissible if participants had difficulty setting up or syncing the provided Bluetooth wireless scale. Participants were provided instructions on how to use the scale and given unlimited access to Livongo DPP customer support. Baseline weight was defined as the average weight measurement received from the participant during the week after DPP lesson 1. Participants were encouraged to monitor weight by stepping on the scale and syncing weight daily with a program recommendation of no less than four weigh-ins weekly. The weight outcome at 6 months and 12 months was defined as the average weight measurement received from the participant during days 159–187 and days 300–367 after the first session, respectively. Average weight, change in pounds, percentage of weight change, and change in body mass index (BMI) were reported at 6 and 12 months for all participants and by participants’ level of program engagement. BMI was calculated as weight (kg)/height² (m²) using self-reported height at baseline and weight captured remotely from connected scales at 6 and 12 months. Weight at 6 months was captured at the participant’s program day 180 or, if not available, the closest weight within the window of 21 days prior to 7 days after day 180. Weight at 12 months was captured at program day 365 or, if not available, between 60 days prior to 7 days after day 365. Any participant weight input that was ≥5% change from both the median and the preceding value or both the median and the following value was flagged as an outlier and assigned a missing value.

Food logging

A private dashboard available through the website or mobile application allowed participants to record daily dietary intake through photo or text. Participants could log meals, snacks, treats, and beverages, along with a description, quantity, and photo. Each individual meal, snack, treat, or beverage was considered a single food log entry. Participants were encouraged to log all food and beverages consumed throughout the program with no limit on the number of food logs entered daily.

Physical activity

Physical activity was defined as the amount of time logged by the participant into the dashboard (1.5% of recorded activity entries) or the amount of time synced from their activity tracker (98.5% of recorded activity entries). The activity tracker calculated active minutes using metabolic equivalents (METs) and intensity of movement and provided this back to the participant through the mobile application and website dashboard. Participants were encouraged to achieve 150 min of physical activity each week per CDC recommendations of the National Diabetes Prevention Program. Participants’ active minutes per week were averaged, and a combined total of highly active (3 MET) and fairly active minutes per week was averaged to determine the percentage of weeks in program meeting the CDC recommendation of 150 min of physical activity each week.

Measures of coach–participant interactions

Interactive lessons

Thirty-one interactive, digital, skill-building lessons were provided emphasizing self-monitoring of weight, food, and activity (see online supplementary table S1 for DPP lesson schedule and topics). Lesson 1 was an interactive group lesson, and all the following lessons were completed individually through the program app or website. Lessons were offered weekly for the first 9 weeks and biweekly for the remaining 43 weeks of the program. Participants were encouraged to attend all lessons.

Coaching sessions

Participants were provided two 30 min one-on-one coaching sessions with an expert-certified DPP lifestyle coach. In addition to DPP lifestyle certification, Livongo expert coaches are registered dietitians, exercise physiologists, nurses, or social workers with master’s or doctoral degrees. Coaching sessions were scheduled at the participant’s convenience.

Coach/participant messages

Participants were able to send unlimited messages to their expert coach via the mobile app or website with a required coach response time within 24 hours Monday through Friday and within 48 hours Saturday and Sunday. Participants also had access to post messages within the mobile app or website to their assigned online community to receive support from and provide support to other participants.

Expert coach feedback

Livongo DPP coaches were required to review participants’ progress, food and exercise logs, and provide feedback two times per week between weeks 1 and 25 and once per week between weeks 26 and 52. Feedback was provided asynchronously and received as a written message within the participant’s mobile app or web page profile.
Statistical analysis

A retrospective analysis was performed to evaluate the effect of engagement, self-monitoring behaviors, and coach–participant interactions on weight loss outcomes during the 12-month Livongo DPP intervention. Descriptive statistics were used to describe participants’ demographics, characteristics, and distribution of population by program engagement. Program participation through self-monitoring and coach–participant interactions was analyzed at 6 and 12 months for all participants by engagement criteria and weight loss categories. Weight loss categories were set from the CDC DPP recommendations of losing 5%–7% of the starting weight and clinical recommendations of losing 5%–7% of the starting weight and clinical recommendations of 10% weight loss provided by the National Institute of Health.3 26 The mean value and SD or the percentage of total population was reported for each program feature. P values less than 0.05 were considered statistically significant. No adjustment for multiple comparisons was made.

Primary analysis

The association between program participation and percentage of weight loss was measured using multivariable linear regression modeling with normal distribution, controlling for participant-level characteristics of gender, age, education level, and initial weight. Variables measuring different attributes of program participation, including the total number of lessons, weigh-ins, food logs, weekly activity levels, coach messages, and member group conversations, were included in the model to test their adjusted association with weight loss outcomes. The quadratic transformation of the average number of food logs per week was included in the model to address potential decrease in marginal effect of food logs per week on weight loss outcomes as frequency of food logging increases. Interaction of the average number of food logs per week with the number of coach messages per week was included to check for additional changes in food logs on different coach message frequencies. Standardized coefficients are reported to account for different program features measured in different units of measurement and allowed ranking of program activities.

Secondary analysis

Previous studies have shown an association between coaching and engagement, specifically around self-monitoring components of an intervention.11-13 Therefore, multivariable regression modeling with normal distribution was performed to evaluate associations between coach–participant messages at 6 months and food logging, weigh-ins, and active minutes per week at 12 months, adjusting for participant characteristics of starting weight, gender, age, education, and engagement status. Multivariable logistic regression was also used to evaluate the association of coaching with the likelihood of being highly engaged.

RESULTS

A total of 2161 individuals enrolled during this period, and 2037 attended lesson 1 and provided a starting weight as inclusion criteria for participation in the study. Of the 2037 participants, 658 (32.3%) were considered to be highly engaged and 1379 (66.7%) were considered minimally engaged. Of the highly engaged participants, 649 (98.6%) registered a 6-month weight and 640 (97.3%) registered a 12-month weight. Of the minimally engaged participants, 834 (60.5%) had a 6-month weight and 715 (51.8%) had an available 12-month weight. Overall, 98.1% of recorded weights were automatically uploaded from the connected scale, while the remaining were manually entered by the participant.

Table 1 shows the demographic details at enrollment, engagement status, and weight loss outcomes. Minimally engaged participants were younger than highly engaged participants, had a higher starting weight, and had a higher BMI than highly engaged participants at baseline. Highly engaged participants were more likely to have a college education, more likely to be male, and with blood glucose test indicating diabetes risk compared with minimally engaged participants. Overall, 43% of participants of Livongo DPP lost on average 5.1% of their weight or 5.0 kg by 12 months. More than 50% of the highly engaged population and 35% of minimally engaged participants achieved clinically significant weight loss (>5%) at 12 months, with 25% of highly engaged participants losing ≥10% at 12 months. The percentage of weight and the average pounds lost are shown in online supplementary figure S1.

Program participation

Self-monitoring

Self-monitoring behaviors including weigh-ins, food logging, and physical activity over 12 months are reported by engagement and weight loss category (see online supplementary table S2 for program participation at 6 months and online supplementary table S3 for program participation at 12 months). Across all measures, a significant increase in frequency of self-monitoring behaviors was seen in highly engaged compared with minimally engaged participants.

On average, participants weighed in four times per week and entered 13 food logs per week. Highly engaged participants weighed in significantly more than minimally engaged (4.6 vs 3.2, p<0.001), recorded approximately 13 more food logs per week (19.4 vs 6.4, p<0.001), and logged food three more days per week (4.6 vs 1.7, p<0.001). Participants losing ≥10% weighed in and logged food significantly more than those losing <5% (4.2 vs 3.6, p<0.001 and 17.1 vs 10.1, p<0.001, respectively).

All participants wore activity trackers 4 days per week on average, achieving an average of 5335 steps daily, with 20 out of 52 weeks in program exceeding 150 active minutes. Highly engaged participants wore their activity tracker nearly 2 days more per week than minimally engaged (5.3 vs 3.2, p<0.001), achieving significantly
Table 1  Demographics summarized using mean (SD) and percentages

<table>
<thead>
<tr>
<th></th>
<th>All participants* n=2037</th>
<th>Highly engaged† n=658</th>
<th>Minimally engaged‡ n=1379</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean (SD)</td>
<td>49.7 (12.0)</td>
<td>54.8 (10.6)</td>
<td>47.3 (11.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Starting weight (kg), mean (SD)</td>
<td>93.9 (21.0)</td>
<td>90.6 (20.1)</td>
<td>95.5 (21.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Starting BMI (kg/m²), mean (SD)</td>
<td>33.3 (6.8)</td>
<td>32.2 (6.4)</td>
<td>33.8 (7.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–44 (%)</td>
<td>32.3</td>
<td>14.7</td>
<td>40.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>45–64 (%)</td>
<td>57.4</td>
<td>67.8</td>
<td>52.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>65+ (%)</td>
<td>10.3</td>
<td>17.5</td>
<td>6.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (%)</td>
<td>5.1</td>
<td>6.5</td>
<td>4.4</td>
<td>0.060</td>
</tr>
<tr>
<td>Overweight (%)</td>
<td>33.1</td>
<td>39.1</td>
<td>30.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Class I obesity (%)</td>
<td>28.8</td>
<td>28.1</td>
<td>29.1</td>
<td>0.650</td>
</tr>
<tr>
<td>Class II obesity (%)</td>
<td>17.5</td>
<td>13.5</td>
<td>19.4</td>
<td>0.001</td>
</tr>
<tr>
<td>Class III obesity (%)</td>
<td>15.6</td>
<td>12.8</td>
<td>16.9</td>
<td>0.010</td>
</tr>
<tr>
<td>College graduate (%)</td>
<td>77.7</td>
<td>81.8</td>
<td>75.8</td>
<td>0.002</td>
</tr>
<tr>
<td>Not a college graduate (%)</td>
<td>22.1</td>
<td>17.6</td>
<td>24.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Education undisclosed (%)</td>
<td>0.2</td>
<td>0.6</td>
<td>0.0</td>
<td>0.050</td>
</tr>
<tr>
<td>Male (%)</td>
<td>26.0</td>
<td>28.9</td>
<td>24.6</td>
<td>0.040</td>
</tr>
<tr>
<td>Risk factor for diabetes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood glucose test (%)</td>
<td>33.8</td>
<td>39.4</td>
<td>31.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gestational diabetes (%)</td>
<td>2.2</td>
<td>3.2</td>
<td>1.7</td>
<td>0.060</td>
</tr>
<tr>
<td>CDC risk test (%)</td>
<td>95.2</td>
<td>96.1</td>
<td>94.9</td>
<td>0.220</td>
</tr>
<tr>
<td>Weight loss at 12 months (%)</td>
<td>5.1</td>
<td>6.6</td>
<td>3.8</td>
<td>0.006</td>
</tr>
</tbody>
</table>

*All participants: any participant enrolled in Livongo DPP who attended lesson 1 and provided a starting weight.
†Highly engaged participants: participants who met the CDC high-engagement criteria by completing nine lessons within months 1–6 of the program and three lessons within months 7–12 of the program with a minimum of 9 months between first and final lessons completed.‡Minimally engaged participants: all participants not meeting the CDC high-engagement criteria.

BMI, body mass index; CDC, Centers for Disease Control and Prevention; DPP, diabetes prevention program.

Participants losing >5% had significantly higher levels of self-monitoring than participants losing <5%.

Participants attended, on average, 17 of the 31 lessons provided during the 12-month program. Coaches initiated interaction with participants two to three times each week, 1–2 days per week, while participants initiated interaction with their expert coach up to one to two times each week, 1 day per week overall. Highly engaged and participants losing ≥7% engaged more in their community than other weight loss categories.

Predictors of weight loss

In a multiple regression analysis using demographics, self-monitoring, and coach-participant interaction measures, significant predictors of weight loss at 12 months for the highly engaged included food logs per week, total number of lessons attended, and percentage of weeks with 150 min of activity. Using standardized coefficient, the number of food logs per week had the highest influence on percent weight loss at 12 months over total lessons attended and percentage of weeks with 150 min of activity.
Table 2  Participant coaching session and lesson attendance at 12 months summarized using mean (SD) and percentages

<table>
<thead>
<tr>
<th>Coach-participant interactions</th>
<th>All participants*</th>
<th>Highly engaged†</th>
<th>Minimally engaged‡</th>
<th>P value</th>
<th>WL &lt;5% to &lt;7%</th>
<th>WL 5% to &lt;10%</th>
<th>WL ≥10%</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1355 (100%)</td>
<td>640 (47%)</td>
<td>715 (53%)</td>
<td>&lt;0.001</td>
<td>152 (47%)</td>
<td>218 (62%)</td>
<td>161 (12%)</td>
<td>276 (20%)</td>
</tr>
<tr>
<td>Lesson attendance</td>
<td>17.1 (9.2)</td>
<td>25.5 (4.4)</td>
<td>9.5 (4.8)</td>
<td>&lt;0.001</td>
<td>18.4 (8.6)</td>
<td>18.4 (8.6)</td>
<td>21.1 (8.5)</td>
<td>22.0 (8.7)</td>
</tr>
<tr>
<td>Coaching session attendance</td>
<td>1.3 (0.5)</td>
<td>1.5 (0.5)</td>
<td>1.2 (0.4)</td>
<td>&lt;0.001</td>
<td>1.3 (0.5)</td>
<td>1.4 (0.5)</td>
<td>1.5 (0.5)</td>
<td>1.4 (0.5)</td>
</tr>
<tr>
<td>Having initial session before week 5</td>
<td>35.2%</td>
<td>36.4%</td>
<td>34.1%</td>
<td>0.001*</td>
<td>34.3%</td>
<td>37.3%</td>
<td>34.7%</td>
<td>37.7%</td>
</tr>
</tbody>
</table>

*All participants: any participant enrolled in Livongo DPP who attended lesson 1 and provided a starting weight.
†Highly engaged participants: participants who met the CDC high-engagement criteria by completing nine lessons within months 1–6 of the program and three lessons within months 7–12 of the program with a minimum of 9 months between first and final lessons completed.‡
‡Minimally engaged participants: all participants not meeting the CDC high-engagement criteria.

CDC, Centers for Disease Control and Prevention; DPP, diabetes prevention program; WL, weight loss.

While coach-participant messages were not shown to be significant predictors of weight loss at 12 months, their presence during the first 6 months of a participant’s program had a higher likelihood of being highly engaged coaching in the form of coach- and participant-initiated messages. Participants with one more coach-participant messages per week (p<0.05) were more likely to post messages to coach (1.8 vs 1.1, p<0.001) and receive more messages (3.0 vs 2.1, p<0.001) and food log feedback (1.4 vs 0.9, p<0.001) from coaches.
### Table 3  Coach feedback and coach–participant messages at 12 months summarized using mean (SD)

<table>
<thead>
<tr>
<th>Coach–participant interactions</th>
<th>All participants*</th>
<th>Highly engaged†</th>
<th>Minimally engaged‡</th>
<th>P value</th>
<th>WL &lt;5%</th>
<th>WL 5% to &lt;7%</th>
<th>WL 7% to &lt;10%</th>
<th>WL ≥10%</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of food log feedback/week</td>
<td>1.1 (0.8)</td>
<td>1.4 (0.9)</td>
<td>0.9 (0.7)</td>
<td>&lt;0.001</td>
<td>1.1 (0.8)</td>
<td>1.2 (0.9)</td>
<td>1.4 (0.9)</td>
<td>1.2 (0.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of food log feedback days/week</td>
<td>0.6 (0.4)</td>
<td>0.8 (0.4)</td>
<td>0.5 (0.3)</td>
<td>&lt;0.001</td>
<td>0.6 (0.4)</td>
<td>0.7 (0.4)</td>
<td>0.8 (0.4)</td>
<td>0.7 (0.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of exercise feedback/week</td>
<td>0.4 (0.3)</td>
<td>0.4 (0.3)</td>
<td>0.3 (0.3)</td>
<td>&lt;0.001</td>
<td>0.3 (0.3)</td>
<td>0.4 (0.3)</td>
<td>0.4 (0.3)</td>
<td>0.4 (0.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of exercise feedback days/week</td>
<td>0.3 (0.2)</td>
<td>0.3 (0.2)</td>
<td>0.2 (0.2)</td>
<td>&lt;0.001</td>
<td>0.3 (0.2)</td>
<td>0.3 (0.2)</td>
<td>0.3 (0.2)</td>
<td>0.3 (0.2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Number of coach message/week</td>
<td>2.5 (1.4)</td>
<td>3.0 (1.4)</td>
<td>2.1 (1.2)</td>
<td>&lt;0.001</td>
<td>2.4 (1.3)</td>
<td>2.8 (1.3)</td>
<td>3.0 (1.4)</td>
<td>2.8 (1.5)</td>
<td>0.013</td>
</tr>
<tr>
<td>Number of coach message days/week</td>
<td>1.4 (0.6)</td>
<td>1.6 (0.9)</td>
<td>1.3 (0.6)</td>
<td>&lt;0.001</td>
<td>1.4 (0.6)</td>
<td>1.6 (0.5)</td>
<td>1.6 (0.5)</td>
<td>1.5 (0.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of participant messages/week</td>
<td>1.4 (1.3)</td>
<td>1.8 (1.6)</td>
<td>1.1 (0.8)</td>
<td>&lt;0.001</td>
<td>1.3 (1.3)</td>
<td>1.5 (1.0)</td>
<td>1.8 (1.4)</td>
<td>1.6 (1.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of participant message days/week</td>
<td>0.9 (0.6)</td>
<td>1.1 (0.7)</td>
<td>0.7 (0.5)</td>
<td>&lt;0.001</td>
<td>0.9 (0.6)</td>
<td>1.0 (0.53)</td>
<td>1.1 (0.6)</td>
<td>1.0 (0.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of participant community messages/week</td>
<td>0.1 (0.1)</td>
<td>0.1 (0.1)</td>
<td>0.0 (0.1)</td>
<td>&lt;0.001</td>
<td>0.1 (0.1)</td>
<td>0.1 (0.1)</td>
<td>0.1 (0.2)</td>
<td>0.1 (0.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*All participants: any participant enrolled in Livongo DPP who attended lesson 1 and provided a starting weight.
†Highly engaged participants: participants who met the CDC high-engagement criteria by completing nine lessons within months 1–6 of the program and three lessons within months 7–12 of the program with a minimum of 9 months between first and final lessons completed.
‡Minimally engaged participants: all participants not meeting the CDC high-engagement criteria.

CDC, Centers for Disease Control and Prevention; DPP, diabetes prevention program; WL, weight loss.

Food logging, lesson attendance, and physical activity have been previously examined as potential predictors of weight loss in DPP participants. Similar to other studies, we showed that a higher adherence to food logging, lesson attendance, and achieving ≥75% of physical activity levels each week is consistently associated with greater weight loss and program engagement. Providing food log feedback has been shown to increase self-monitoring, which is increasing; however, there is currently a lack of literature available around CDC-recognized DPP programs.

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Strengths and limitations
This study has several strengths, including the reporting of real-world weight loss outcomes of a CDC-recognized DPP program, as well as insight into the demographics, self-monitoring behaviors, and coach-participant interactions that drive engagement and weight loss. Participants were not provided with additional incentives to participate in the study beyond the DPP program being provided as a free benefit through their employer’s benefit package. All members who attended lesson 1 and provided a starting weight were included in all participants group and analyzed as the intention-to-treat population.

The study also had some limitations, including the retrospective analysis study design, which does not allow for any causal inferences based on the critical observations. Also, the use of a real-world population does not allow researchers to know if participants were integrating other self-monitoring devices or practices outside of Livongo DPP components and recommendations.

CONCLUSION
In conclusion, Livongo DPP’s highly engaged participants lost >5%, and 25% of these participants lost ≥5% of their body weight. Stronger associations were observed for participants who engaged in the DPP program, as well as insight into the demographics, of real-world weight loss outcomes of a CDC-recognized DPP program: 2-year results of a single-arm longitudinal study.

REFERENCES
[Accessed Apr 2020].


