

Evidence-Based Strategies in Weight-Loss Mobile Apps

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Background: Physicians have limited time for weight-loss counseling, and there is a lack of resources to which they can refer patients for assistance with weight loss. Weight-loss mobile applications (apps) have the potential to be a helpful tool, but the extent to which they include the behavioral strategies included in evidence-based interventions is unknown.

Purpose: The primary aims of the study were to determine the degree to which commercial weight-loss mobile apps include the behavioral strategies included in evidence-based weight-loss interventions, and to identify features that enhance behavioral strategies via technology.

Methods: Thirty weight-loss mobile apps, available on iPhone and/or Android platforms, were coded for whether they included any of 20 behavioral strategies derived from an evidence-based weight-loss program (i.e., Diabetes Prevention Program). Data on available apps were collected in January 2012; data were analyzed in June 2012.

Results: The apps included on average 18.83% (SD=13.24; range=0%–65%) of the 20 strategies. Seven of the strategies were not found in any app. The most common technology-enhanced features were barcode scanners (56.7%) and a social network (46.7%).

Conclusions: Weight-loss mobile apps typically included only a minority of the behavioral strategies found in evidence-based weight-loss interventions. Behavioral strategies that help improve motivation, reduce stress, and assist with problem solving were missing across apps. Inclusion of additional strategies could make apps more helpful to users who have motivational challenges.

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Introduction

Primary care physicians (PCPs) have limited time for weight-loss counseling and would benefit from tools that help patients lose weight. Mobile technology has the potential to develop and deliver such tools, especially given the high prevalence of mobile phone use in the U.S. (285 million subscribers).¹ Weight-loss mobile applications (apps) have been proliferating in the market in recent years.² Given the sheer number of apps and the lack of standards, PCPs have little guidance as to which apps, if any, to recommend to patients. Thus,

mobile apps that have features that are included in evidence-based behavioral weight-loss interventions need to be identified.

Behavioral weight-loss strategies are reflected in evidence-based lifestyle interventions, most notably the Diabetes Prevention Program (DPP), which have been shown to be effective for weight-loss and reduction of risk for cardiovascular disease and diabetes.^{3,4} Evidence-based lifestyle interventions are intensive, involving multiple in-person visits, generally for a period of 6 months to 1 year or more. If effective behavioral strategies could be delivered via mobile technology, a more cost-effective model of care may be possible. In addition to reducing costs, mobile apps may have the capacity to leverage technology in order to reduce some of the burden of behavioral strategies (e.g., nutrition information could be retrieved from packaged foods by barcode scanners) and to enhance behavioral strategies (e.g., by providing in-the-moment context-sensitive intervention).

The extent to which current weight-loss mobile apps are based on the behavioral science of weight loss is unclear. The only existing review of weight-loss mobile

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apps was conducted in 2009 and found that the range of behavioral strategies addressed by apps was quite narrow.⁵ Only 43% of 204 mobile apps reviewed included dietary self-monitoring, a hallmark strategy of evidence-based behavioral weight-loss interventions. A limitation of that review is that the range of strategies evaluated was based on information that was found to be consistent among four government-sponsored websites, not on an evidence-based weight-loss intervention. Also, it included dietary strategies that are not essential to weight loss (e.g., fruit and vegetable intake, water intake) and omitted key strategies common to evidence-based weight-loss protocols (e.g., problem solving and stress management).^{6–8}

The number of apps on the market has continued to proliferate since 2009 as the mobile health (mHealth) movement has gained increasing interest in the healthcare arena.⁹ The aims of the present review were to extend past work by (1) identifying the commercial weight-loss mobile phone apps that include the highest proportion of behavioral strategies represented in evidence-based lifestyle interventions; (2) identify which behavioral strategies have yet to be adapted into a mobile phone app format; (3) identify technology-enhanced features of apps that reduce user burden (e.g., barcode scanners) or provide in-the-moment intervention (e.g., automatic reminders to record food intake); and (4) compare free to paid apps in terms of evidence-based strategies and technology-enhanced features. Findings will inform healthcare providers about the extent to which weight-loss mobile apps approximate evidence-based practices, and mobile technology developers about strategies that have yet to be adapted into the mobile format.

Methods

Inclusion Criteria

The list of all apps available for download, for both iPhone and Android systems, was accessed in January 2012. Apps in the top 100 paid and top 100 free “health and fitness” categories of iTunes and the Android Market were searched. Inclusion in the top 100 is determined by the number of times the app has been downloaded. iTunes lists a total of 400 free and paid apps in “health and fitness,” and the Android Market lists 480.

The description for each app provided by each website marketplace was used in the initial screening process to determine whether weight loss was the stated purpose of the mobile app. For example, a mobile app with a stated purpose of diabetes management would be excluded even if it included a weight-tracking feature. Because self-monitoring has been identified as one of the strongest predictors of weight loss,¹⁰ and was the most common strategy found across mobile apps in the previous review, only weight-loss mobile apps that included weight, diet, and physical activity self-monitoring were included in the present study. A total of 16 of the 100 iPhone apps

met the criteria, and 13 of the 100 Android apps, for a total of 30 apps. All apps were coded in terms of the extent to which they included the 20 other strategies employed in evidence-based behavioral weight-loss interventions (Table 1).

Development of Assessment Criteria

Assessment criteria were developed based on 20 strategies employed in the DPP lifestyle intervention,⁶ which was used in the landmark DPP trial and in numerous efficacy and effectiveness studies that followed.^{8,11} Table 1 lists each strategy, with a brief description, and names the intervention session title in which it is introduced. All 16 sessions included in the 6-month core intervention are represented in the 20 strategies, each of which was coded as either present or absent. After an informal review of the 30 apps, seven technology-enhanced features were identified that are directly relevant to an evidence-based strategy and either reduce burden or provide prompts to engage in the strategy. These features included a barcode scanner; a physical activity tracking device (e.g., accelerometer); an online social network; reminders to eat a meal; tracking of negative thoughts/stress; a calendar; and flags for lapses in dietary goal adherence.

Assessment Phase

All apps that met the initial inclusion criteria were downloaded. As in similar recent studies,^{12,13} each app was reviewed independently by two assessors. After initial ratings were made independently, assessment discrepancies were discussed within coding dyads. When agreement could not be achieved within a dyad, the item was referred to the full assessment team for consensus. Once agreement was achieved, a final assessment sheet was entered into a database. Prior to resolving discrepant ratings, average inter-assessor agreement across all apps was 92%.

Analytic Plan

For each behavioral strategy, the percentage of apps that included it was computed, in order to demonstrate the extent to which each strategy was employed across weight-loss apps. Then, for each app, the percentage of the total number of strategies included was computed. Using ANOVA, paid apps were compared to free apps, on the measure of percentage of total strategies included. Analyses were conducted in June 2012 using SPSS, version 19.

Results

Proportion of Apps That Included Each Behavioral Strategy

The vast majority of apps included goal setting for weight loss (93.3%) and diet (90%; Table 2). Goal setting was typically accomplished by having users select a target goal weight and then providing a calorie-intake goal according to the goal weight. Only 20% of mobile apps gave users a specific physical activity goal in terms of days or minutes per week. The next most common strategy included in the apps was calorie balance; 86.7% of the apps allowed users to view their net calories (i.e., energy consumption minus

Table 1. Evidence-based behavioral weight-loss strategies represented in weight-loss mobile apps

| Strategy | DPP session title ^a | Description | % apps |
|--|--|---|--------|
| Weight-loss goal | Welcome to the Lifestyle Balance Program | Participants are given a goal of 7%, or 1–2 pounds per week. | 93.3 |
| Dietary goal | Getting Started Losing Weight | Participants are given a fat and/or calorie goal that is consistent with weight-loss goal. | 90 |
| Calorie balance | Tip the Calorie Balance | Participants learn how healthy eating and being active are related. | 86.7 |
| Physical activity goal | Getting Started Being Active | Participants are encouraged to get 150 minutes of moderate-intensity physical activity per week. | 20 |
| Exercise safety | Being Active a Way of Life/ Jump Start Your Activity Plan | Participants are instructed on how to measure exertion and avoid injury. | 20 |
| Benefits of healthy diet and physical activity | Welcome to the Lifestyle Balance Program | Participants learn of the health benefits of making lifestyle changes. | 13.3 |
| Food substitutions | Be a Fat Detective | Participants learn healthy substitutions for foods that are high in fat and calories. | 10 |
| Food pyramid | Healthy Eating | Review current food pyramid and its recommendations. | 6.7 |
| Stimulus control | Taking Charge of What's Around You | Participants learn about food and activity cues and ways to change them. | 6.7 |
| Portion control | Be a Fat Detective | Participants learn to use scales, measuring cups, and spoons. | 6.7 |
| Lifestyle activity | Being Active a Way of Life | Participants are encouraged to engage in lifestyle activities (e.g., parking further away). | 6.7 |
| Target heart rate | Jump Start Your Activity Plan | Participants are instructed on how to measure their target heart rate. | 6.7 |
| Problem solving | Problem Solving | Participants learn a five-step process to brainstorm new solutions to problems that inhibit their progress. | 3.3 |
| Stress reduction | You Can Manage Stress | Participants learn how to prevent stress and cope with unavoidable stress. | 0 |
| Relapse prevention | Slippery Slope of Lifestyle Change | Participants learn to identify what causes slips from healthy eating and being active and how to recover from them. | 0 |
| Negative thinking | Talk Back to Negative Thoughts | Participants learn how to identify negative thoughts and talk back to them with positive ones. | 0 |
| Social cues | Make Social Cues Work for You | Participants learn how to identify problem social cues and add helpful ones. | 0 |
| Develop regular pattern of eating | Healthy Eating | Participants are instructed to eat three meals. | 0 |
| Time management | Being Active: A Way of Life | Participants learn strategies for fitting exercise into their schedules. | 0 |
| Nutrition label reading | Be a Fat Detective | Participants learn to read nutrition labels. | 0 |

^aThe DPP Lifestyle Intervention Protocol can be found at www.bsc.gwu.edu/dpp/lifestyle/dpp_part.html.
DPP, Diabetes Prevention Program

energy expenditure). A small proportion of apps included the remaining behavioral strategies. Several behavioral strategies were not used in any of the apps, including stress reduction, relapse prevention, social cues, negative thinking, developing a regular pattern of eating, time management, and instruction on how to read nutrition labels.

Proportion of Behavioral Strategies Represented in Mobile Apps

The mean percentage of behavioral strategies reflected was 18.83% (SD=13.24). The two mobile apps that had the highest percentage of criteria met were MyNetDiary (free) and MyNetDiary Pro (paid), both of which

Table 2. Percentage evidence-based behavioral strategy criteria met by mobile application

| App | Version | Platform | Cost (\$) | % criteria met | % of technology-assisted strategies | Number of stars (of 5) |
|----------------------------------|------------------|----------|-----------|----------------|-------------------------------------|------------------------|
| MyNetDiary PRO | 3.40 | iPhone | 3.99 | 65 | 29 | 5 |
| MyNetDiary | 3.3 | iPhone | Free | 65 | 0 | 5 |
| All-in Fitness | 2.0 | iPhone | 0.99 | 25 | 29 | 3.5 |
| Noom Weight Loss | 2.0 | Android | Free | 25 | 43 | 4.5 |
| Calorie Counter and Diet Tracker | 2.3.1 | Android | Free | 20 | 14 | 4.5 |
| Daily Burn | 1.2.3 | iPhone | Free | 20 | 14 | 3.5 |
| SparkPeople | 2.5 | iPhone | Free | 20 | 0 | 4.5 |
| SparkPeople | 2.1 | Android | Free | 20 | 29 | 3 |
| Absolute Fitness | 2.1.6 | Android | 4.99 | 15 | 0 | 4 |
| Livestrong | 1.2 | Android | 2.99 | 15 | 29 | 3 |
| Calorie Counter Arawella | | iPhone | Free | 15 | 43 | 4 |
| Caloriecount.com | 3.0 | iPhone | Free | 15 | 29 | 4.5 |
| MyFitnessPal | 3.3.1891 | iPhone | Free | 15 | 0 | 5 |
| MyFitnessPal | 2.3.1.007 | Android | Free | 15 | 43 | 5 |
| Calorie Counter by FatSecret | 2.2.6 | Android | Free | 15 | 29 | 4.5 |
| Calorie Counter by FatSecret | | iPhone | Free | 15 | 29 | 4 |
| MyNetDiary | 1.0.5 | Android | 3.99 | 15 | 29 | 4.5 |
| Livestrong | 3.0.2.1201172152 | iPhone | 2.99 | 15 | 0 | 4.5 |
| FitBit | 1.2.3 | iPhone | Free | 15 | 43 | 3 |
| Lose It! | 3.7.2 | iPhone | Free | 15 | 14 | 5 |
| Lose It! | 1.1.9 | Android | Free | 15 | 0 | 4.5 |
| Tap and Track Calorie Counter | 7.2.1 | iPhone | 3.99 | 15 | 0 | 4.5 |
| Ultimate Weight Watcher Diary | 5.2 | Android | 3.99 | 15 | 14 | 3 |
| Weight Watcher Diary | 5.1 | Android | 2.15 | 15 | 14 | 3 |
| Weight Watchers Diary | 4.01 | Android | 3.49 | 15 | 0 | 3 |
| WW Points Plus Diary and Scanner | 21.8 | Android | 1.49 | 15 | 29 | 3.5 |
| P90X | 1.0, Build 94 | iPhone | 4.99 | 10 | 57 | 4 |
| Nutrition Menu | 1.26 | iPhone | 0.99 | 5 | 43 | 4.5 |
| Low-Carb Diet Assistant | NA | iPhone | 2.99 | 5 | 0 | 4 |

NA, not applicable

included 65% of the behavioral strategies (Table 2). The two apps with the next-highest percentage included only 25% of the behavioral strategies coded. Four apps

included 20% of behavioral strategies, 18 included 15%, one included 10%, and the remaining two included only 5%.

Technology-Enhanced Features

The food item barcode scanner was the most common of these strategies, appearing in 56.7% of mobile apps (Table 3). Almost half (46.7%) included a social media component, involving the capability to either connect to other app users or post to an online social network, such as Facebook, Twitter, or one created by the company itself. E-mail reminders were provided by some apps; 20% included reminders when tracking lapsed, and 10% included the capability of setting reminders for meal time. A few (10%) of the apps included a calendar function, which could be used to schedule exercise and other activities. A few (10%) included a function that allowed users to record notes on their thoughts, feelings, or stress, but these did not provide content about how to combat negative thoughts or stress. Only 3.3% included automated physical activity tracking.

Comparison of Paid and Free Mobile Apps

Paid mobile apps, which ranged in price from \$0.99 to \$4.99, were no more likely than free apps to include behavioral strategies, $F(1, 29)=0.22$, $p=0.63$. The examination of individual behavioral strategies showed that paid apps were not significantly more likely than free apps to include any particular behavioral strategy (data not shown). In terms of technology-assisted features, 40% of paid mobile apps included barcode scanners, compared to 73% of free apps, $\chi^2(1)=3.39$, $p=0.06$, and only 27% of paid apps included social networks, compared to 60% of free apps, $\chi^2(1)=3.39$, $p=0.06$. The remaining technology-assisted features were included in $\leq 20\%$ of the apps, a percentage too small to allow for a comparison of paid and free apps.

Discussion

The most common behavioral strategies in 30 popular weight-loss mobile apps were weight-loss goal setting, dietary goal setting, and calorie balance. The majority of

apps included these functions (along with self-monitoring, an inclusion criterion of this review), but few provided other behavioral strategies. Most striking was that seven behavioral strategies were completely missing from the weight-loss mobile apps coded (i.e., stress reduction, relapse prevention, social cues, negative thinking, developing a regular pattern of eating, time management, and instruction on how to read nutrition labels). Some mobile apps do include some of these strategies (e.g., stress reduction, negative thinking), but not in the context of weight loss. This suggests that the technology for a more comprehensive weight-loss app is currently available.

MyNetDiary and MyNetDiary Pro (from the same company) included the greatest number of evidence-based strategies. These included a library, which contained a vast amount of information on a wide variety of topics and was the source of many of the evidence-based strategies. Although other mobile apps linked to websites that included additional information, the use of behavioral strategies on the accompanying websites was not rated because they were not included in the app itself. Paid mobile apps did not include a higher percentage of behavioral strategies or technology-assisted features than free apps, which suggests that price may not be a reflection of content quality or the sophistication of the technology.

Weight-loss mobile apps have technology-assisted features that may provide an advantage over traditional delivery modalities. Some apps not only provide nutrition databases but also automatically calculate calories consumed and burned, and provide visual displays of personal data. Some apps also provide online social networks, which may be a source of social support; calendars to assist in scheduling exercise; a place to record thoughts, mood, and/or stress levels; and e-mail prompts or phone alerts to prevent lapses in self-monitoring. Such features are not typically feasible in a traditionally delivered weight-loss intervention but may enhance adherence, help prevent relapse, and improve outcomes. Research is needed on the acceptability, usability, and efficacy of these features on adherence and outcomes.

If weight-loss mobile apps evolve to incorporate all of the behavioral strategies of evidence-based behavioral weight-loss interventions, research will be needed to determine if users can properly employ the strategies in the absence of a counselor/provider, as occurs in a traditional delivery modality. It remains unclear whether the maximum potential for mobile apps lies in self-guided delivery, delivery with provider oversight, or delivery in conjunction with a formal weight-loss program. Self-guided delivery would seem to have the broadest potential for reach, but perhaps the lowest potential for efficacy, given that it may require a higher

Table 3. Additional technology-assisted strategies

| | % apps |
|----------------------------------|--------|
| Barcode scanner | 56.7 |
| Online social network | 46.7 |
| E-mail reminders to track | 20 |
| E-mail reminders of mealtime | 10 |
| Calendar function | 10 |
| Negative thought/stress tracking | 10 |
| Automatic activity tracking | 3.3 |

level of motivation relative to provider-supervised models. The extent to which technology-enhanced features, such as a food barcode scanner or automated physical activity recorder (i.e., accelerometer), alleviate user burden and facilitate weight loss also requires further study.

The current findings are consistent with those of Breton et al.,⁵ who found that the majority of weight-loss mobile apps in 2009 provided self-monitoring tools, but that the prevalence of other behavioral strategies in mobile apps ranged from 0% to 25%. The present study extends their findings by focusing on strategies excerpted directly from an evidence-based behavioral weight-loss program, examining the next generation of mobile apps, and limiting the examined pool of apps to those that at the very minimum allowed users to track weight, diet, and exercise. The coding criteria used here were broader, including most of Breton and colleagues' as well as other behavioral strategies that are fixtures in behavioral weight-loss interventions (e.g., problem-solving, stress management, negative thinking, time management, and stimulus control). In spite of the fast pace of technology development, the quality of apps in terms of relevance to evidence-based practice has not improved.

Limitations

The current review should be viewed within the context of several limitations. Some of the mobile apps had other features at additional cost that were not evaluated, including contact with a coach, companion websites, DVDs, products, magazines, and books. Weight Watchers has an entire commercial program that could be considered an additional feature. These features were not included here because the goal was to focus exclusively on features accessible via the app, not on an entire multimedia enterprise. Further, apps that did not have dietary and weight self-monitoring features were not included because these two behavioral strategies are the foundation of evidence-based behavioral weight-loss programs and are the most common behavioral strategy included in weight-loss apps.⁵ The purpose here was to determine the prevalence of other behavioral weight-loss strategies.

The included apps were limited to those in the top 100 for Android systems and the iPhone, although many others exist. This limitation prevented an assessment of whether better user ratings are associated with more evidence-based strategies; however, within the narrow range of user ratings (3–5) a nonsignificant trend toward this relationship was observed, $r=0.30$, $p=0.11$. The coding criteria were not based on a pre-existing scheme but rather on a breakdown of the components of the DPP lifestyle intervention. Others may have divided the DPP components differently.

Additionally, whether all of these behavioral strategies are necessary to the efficacy of a lifestyle intervention is

unknown, because the appropriate research to answer that question has not yet been done. The current author team has extensive experience with the DPP lifestyle intervention both clinically and in research.^{14–19} Also, no rating was made of the reliability or validity of nutrition and energy expenditure databases and accelerometry measures included in apps, which all have implications for quality. Future research should evaluate the reliability and validity of the databases utilized in weight-loss mobile apps. Finally, no rating was made of usability in the present study, which could be an important factor in patients' experiences. However, all of the apps reviewed were in the top 100 of the health and fitness category of iTunes and Android systems, which may be a proxy for usability.

Conclusion

Weight-loss mobile apps have proliferated in the marketplace but appear to reflect a narrow range of behavioral strategies. The apps evaluated here ranged from meeting 0%–65% of behavioral strategies included in evidence-based behavioral weight-loss interventions, indicating that the quality varies. Physicians interested in referring patients to weight-loss mobile apps should select apps such as MyNetDiary that are free and include the highest proportion of evidence-based strategies. Research is needed to determine the efficacy of weight-loss mobile apps when they are used in combination with physician advice and monitoring.

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Supplementary data

A podcast created by the authors of this paper can be viewed at www.ajpmonline.org/content/video_podcasts_collection.