

Using self-monitoring technology for nutritional counseling and weight management

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Abstract

Self-monitoring of weight, dietary intake, and physical activity is a key strategy for weight management in adults with obesity. Despite research suggesting consistent associations between more frequent self-monitoring and greater success with weight regulation, adherence is often suboptimal and tends to decrease over time. New technologies such as smartphone applications, e-scales, and wearable devices can help eliminate some of the barriers individuals experience with traditional self-monitoring tools, and research has demonstrated that these tools may improve self-monitoring adherence. To improve the integration of these tools in clinical practice, the current narrative review introduces the various types of self-monitoring technologies, presents current evidence regarding their use for nutrition support and weight management, and provides guidance for optimal implementation. The review ends with a discussion of barriers to the implementation of these technologies and the role that they should optimally play in nutritional counseling and weight management. Although newer self-monitoring technologies may help improve adherence to self-monitoring, these tools should not be viewed as an intervention in and of themselves and are most efficacious when implemented with ongoing clinical support.

Keywords

self-monitoring, wearables, obesity, eHealth

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Self-monitoring of weight, dietary intake, and physical activity is a cornerstone of effective behavioral approaches to weight management for adults with obesity.^{1,2} Daily observation of weight and weight-related behaviors allows individuals to evaluate their progress toward short- and long-term goals, while also heightening the awareness of relationships between specific behaviors and weight, supporting future goal setting.³ Research has demonstrated that individuals who engage in more frequent self-monitoring lose more weight during weight loss programs and regain less weight after program completion.^{4–9}

Despite the importance of self-monitoring for weight regulation, adherence is often suboptimal and decreases over time.^{7,10} Research has identified a host of barriers to regular self-monitoring, including the required effort and time commitment, the need for specialized tools (before the advent of newer technologies, this often involved carrying a paper log and calorie reference book throughout the day), and shame or fear of judgment from others.^{11,12}

Newer self-monitoring technologies offer promise to reduce these barriers; these tools can decrease the time and effort required to self-monitor, many capitalize on devices already carried around throughout the day (e.g. smartphones and/or smartwatches), and their use may be more socially acceptable (e.g. when around others, it may be less stigmatizing to pull out a smartphone to look up nutrition information or log food/drinks consumed compared to use of a traditional paper log and calorie reference book).

Newer self-monitoring technologies also provide immediate feedback on goal progress and reinforcement for goal

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achievement. This real-time feedback may better assist individuals in behavior change efforts, as research has demonstrated that the provision of feedback and reinforcement is more effective when delivered proximally to target behavior.¹³ Real-time feedback may also help increase awareness of eating and exercise behaviors and the impact of these behaviors on goal attainment. For example, the immediate observation of how many calories are in a meal may help an individual learn which foods best promote satiety in relation to dietary intake goals, and immediate feedback on progress toward physical activity goals may help an individual learn which activities best support achievement of these goals.

The primary aim of this narrative review is to provide an overview of self-monitoring technologies and strategies for implementation for researchers, interventionists, and clinicians who wish to integrate these tools into existing interventions or clinical practice. In the following sections, we will first provide an overview of the most popular technology-based tools for the self-monitoring of weight, dietary intake, and physical activity in adults. We will also review the evidence supporting the use of these tools for weight management in adults with obesity and discuss factors that should be considered when selecting tools. We will end with a discussion of emerging technologies, barriers to integration of technology in research and clinical settings, and the optimal role that technology plays in these settings.

Technology for self-monitoring weight

Electronic scales (e-scales) or “smart” scales use wireless internet, cellular networks, or Bluetooth to sync user weight with smartphone applications, websites, and cloud servers.¹⁴ Weights measured by e-scales have been demonstrated to be highly concordant with calibrated clinic scales,^{14,15} demonstrating feasibility for their use to accurately measure weight outside of clinical settings. Since e-scales can directly transfer weight data, without requiring data to be actively recorded by users, they also represent a more accurate measurement for assessing self-weighing frequency.¹⁶

How to select an E-scale

Table 1 provides a list of common, commercially available e-scales by price, connection type, and availability of measurement and data-sharing features. Most e-scales are a one-time purchase and cost approximately \$30–\$150 per unit; however, some scales require additional fees for ongoing data collection. Most e-scales use individuals’ in-home WIFI or sync with a Bluetooth device. Conversely, some e-scales use the cellular network, which can be ideal when working with individuals who do not have access to WIFI or Bluetooth devices. Cellular signal

may be limited for some populations, however, such as those residing in rural or mountainous areas. All scales provide measurements of weight; however, other measurement features vary across scales, with some assessing body fat (e.g. through biometric impedance) or automatically calculating body mass index (BMI). Finally, e-scales differ in whether and how data can be shared, both with external commercial smartphone applications (e.g. MyFitnessPal) and with researcher- or clinician-created applications through an application programming interface (API). Some third-party services, like Fitabase,¹⁷ use these API linkages to power intervention dashboards for research or clinical use.

How to implement E-scales in clinical practice

In order to obtain the most accurate measurement of body weight, participants should be encouraged to weigh themselves first thing in the morning, after voiding but before eating or drinking.¹⁴ Although initial recommendations in evidence-based weight management programs were for individuals to weigh themselves once each week,¹⁸ evidence suggests that more frequent self-monitoring of weight can improve weight loss outcomes without affecting mental health outcomes.^{19,20} Thus, many programs now encourage participants to weigh themselves once each day. Despite early concerns that daily self-monitoring of weight might lead to negative psychological consequences, research has shown no statistically significant detrimental effects of daily self-weighing on depressive symptoms or disordered eating behaviors.^{21–23} When encouraging daily self-monitoring of weight, it is important to provide education about the normality of within day and day-to-day weight fluctuations and the importance of considering overall patterns of weight change (e.g. whether weight is trending up or down over several days) rather than focusing on swings up or down between days.²⁴

Technology for self-monitoring dietary intake

Dietary intake can be self-monitored using websites and smartphone applications that allow individuals to log foods and beverages consumed throughout the day. These technologies have eliminated the need to carry around paper records or a food reference book, making it easier for individuals to self-monitor dietary intake discreetly in social situations. These tools can also improve workflow for clinicians, as they can be sent to a healthcare provider synchronously, and they eliminate the need to decipher handwriting or correct mathematical errors from hand calculations.

Although all self-report methods of assessing dietary intake have challenges related to accuracy,²⁵ the use of smartphone applications to track dietary intake has been shown to have acceptable validity in comparison to

Table 1. E-Scale comparison.

Scale name	Cost	Type	Body fat	BMI	Phone app	Sync w/ other apps	Clinician access	API access
BodyTrace	\$80*	Cellular	-	-	-	-	X	X
Arboleaf	\$29.99	Bluetooth	X	X	X	X	-	-
Fitbit Aria Air	\$49.95	Bluetooth	-	X	X	-	-	X
Eufy Smart Scale P1	\$44.99	Bluetooth	X	X	X	X	-	-
Renpho Body Fat Scale	\$29.99	Bluetooth	X	X	X	X	-	X
Garmin Index	\$149.99	Wifi	X	X	X	-	-	-
Greater Goods Smart Scale	\$49.95	Wifi	X	X	X	X	-	-
Withings Body +	\$99.95	Wifi	X	-	X	X	-	X

X: Has feature; -: Does not have feature; *: \$80 for scale and first year of monitoring; API: Application programming interface; BMI: Body mass index.

doubly labeled water, objective measures of energy expenditure, and more-burdensome 24-h recalls.^{26,27} Compared to traditional paper-and-pencil records, self-monitoring of dietary intake via technology may be more accurate, as it is easier for participants to track meals in real time, which leads to more accurate records than waiting until the end of the day.²⁸ Research has demonstrated that the timing and frequency of self-monitoring dietary intake are significantly related to weight outcomes, such that recording intake closer to the time of ingestion and more frequent monitoring are associated with greater weight loss.²⁹⁻³¹

How to select technology for self-monitoring dietary intake

Table 2 provides an overview of common commercial websites and smartphone applications, listing price (of general use and for premium features), and overall feature availability. All applications in this table allow users to track their kilocalorie and macronutrient intake; however, the availability of other features (e.g. whether an individual can set specific goals, plan meals, or track micronutrients) and cost of these features (if they are available to all users, free-of-charge, or only at additional cost as part of “premium” user plans) vary between applications.

All but one of the applications listed in Table 2 allow users to set a calorie goal in the free version. Goal setting is considered an integral part of the self-regulation process³² and is a core behavioral change strategy employed in evidence-based behavioral weight management programs.³³ All applications in Table 2 also allow users to track macronutrients, but only one allows users to set a macronutrient goal for free, which may be an important consideration when working with individuals

that need to track key macronutrients (e.g. individuals with diabetes who wish to monitor carbohydrates). Lastly, similar to e-scales, the ability of clinicians or researchers to access user data varies widely between applications. Only two applications listed in Table 2 allow clinicians to access user data for free; however, all but one either have the ability to provide API access or report that they will soon.

How to implement technology to self-monitor dietary intake in clinical practice

As previously discussed, encouraging users to track food and drink consumption throughout the day, rather than waiting until the end of the day, promotes the accuracy of self-monitoring records. When reviewing dietary intake records, it is important to recognize that accuracy can be influenced by a multitude of factors, including the accuracy of the type and portion size of the food/drink selected and the accuracy of the application’s nutritional information.⁸ To self-monitor dietary intake using these technologies, users select foods/drinks from the application’s database (which typically starts with the USDA Nutrient Database for Standard Reference³⁴ with periodic updates to reflect restaurant or product changes and to manage user-added foods).³⁵ Many of these databases are comprehensive, but they often do not include every brand of food and cannot provide information on foods/drinks from local restaurants or from meals cooked at home, unless entered ingredient-by-ingredient into the application by users themselves. As a result, there are times when users must make an educated guess from the various options, selecting the option that most closely resembles the food/drink they consumed. These databases also often include options that vary

Table 2. Dietary intake application comparison.

App name	Cost	Cal track	Cal goal	Macro track	Macro goal	Micro track	Meal planning	Recipe builder	Clinician access	API access
Calorie Counter-MyNetDiary	Free, \$8.99/mo or \$59.99/yr	X	X	X	\$	\$	X	X	\$	-
FatSecret	Free, \$6.49/mo or \$38.99/yr	X	X	X	X	X	X	X	X	X
Fitbit	Free	X	X	X	-	X	X	-	-	X
Loselt	Free, \$39.99/yr	X	\$	X	\$	\$	\$	X	\$	In Progress
MyFitnessPal	Free, \$9.99/mo or \$49.99/yr	X	X	X	\$	X	X	X	X	Approved Developers

X: Has feature; -: Does not have feature; \$: Has feature in paid/premium version; API: Application programming interface; Cal: Calorie; Macro: macronutrient; Micro: micronutrient.

Table 3. Physical activity application and wearable device comparison.

Monitor name	Cost	Steps	Step goal	Heart rate	PA mins	PA goal	EE (kcal)	EE goal	Move reminders	Clinician access	API access
Apple Phone (Health App)	Free	X	-	-	-	-	-	-	-	X	X
Apple Smartwatch	\$399.99	X	-	X	X	X	X	X	X	X	X
Android Phone (Google Fit)	Free	X	X	-	-	-	X	X	-	-	X
Fitbit Charge 4	\$149.95	X	X	X	X	X	X	X	X	\$	X
Fitbit Inspire 2	\$99.95	X	X	X	X	X	X	X	X	\$	X
Fitbit Versa 2	\$179.95	X	X	X	X	X	X	X	X	\$	X
Garmin Vivosmart 4	\$129.99	X	X	X	X	X	X	X	-	-	X
Garmin Vivofit 4	\$79.99	X	X	-	X	X	X	X	X	-	X

X: Has feature; -: Does not have feature; \$: Has feature in paid/premium version; API: Application programming interface; EE: energy expenditure; PA: physical activity.

widely in portion size or preparation method used, and incorrect selections can result in an inaccurate representation of the foods/drinks consumed. Furthermore, many databases include user-generated food and drink entries that may include inaccurate nutritional information.

Despite the importance of accuracy for assessing an individual's true dietary intake, research suggests that the

frequency and consistency of self-monitoring may be more important than the comprehensiveness or accuracy of the records.⁸ Clinically, we have observed that the quest for "perfect" records may lead some individuals to self-monitor less frequently or give up completely when a high level of accuracy cannot be maintained. Additionally, partial self-monitoring has been shown to

result in weight loss.³⁶ Thus, it can be important to emphasize that, although accuracy and completeness are important, partial self-monitoring is better than none at all.

Technology for self-monitoring physical activity

Technologies to self-monitor physical activity include smartphone applications (e.g. those that measure steps walked using the accelerometer commonly built into smartphone devices, or those that allow individuals to self-report minutes of activity) and wearable devices (e.g. Bluetooth-enabled pedometers or wrist-worn devices such as smartwatches which track activity through accelerometry and/or heart rate measurements). When compared with research-grade accelerometers, there is mixed evidence regarding the ability of smartphone applications that use built-in accelerometers to accurately measure steps, with most studies showing that smartphones underestimate step counts.^{37,38} Some studies have shown that the device placement matters, such that devices carried in the hand or worn on the wrist are less accurate than those worn on the hip or placed in a pocket.³⁹ In addition, when examining other physical activity variables, wearable devices such as Fitbit and Garmin smartwatches have been shown to have low to moderate validity for measuring minutes of moderate to vigorous physical activity.^{40–42} Even though smartphones and wearables have low to moderate validity for assessing steps and active minutes against research-grade actigraphy, these tools can be useful for monitoring within-person changes (i.e. tracking how an individual is making changes in their activity) and can provide information necessary for future physical activity goal setting.⁴²

How to select technology for self-monitoring physical activity

Table 3 provides an overview of the listing price, available features, and data access capabilities of commercial applications and wearable devices for tracking physical activity. When selecting self-monitoring technology for physical activity, one of the most important factors to consider is the type of activity that will be tracked. Most smartphone applications can use passive sensing (i.e. tracking activity without additional input from the user) to track steps and distance during activities such as walking or running, but cannot track other activities without direct input from the user (e.g. by selecting an activity and the number of minutes for the activity as part of a manual-entry activity log). Smartwatches, on the other hand, use passive sensing and/or heart rate to track not only walking and running but also activities such as swimming, cycling, or exercising on an elliptical. Most smartwatches can also provide data on variables such as heart rate levels, sleep, minutes of activity, and energy expenditure.

If selecting a smartwatch, other factors to take into consideration are whether the monitor needs to be waterproof (i.e. to assess swimming) or have GPS capabilities. If wanting to pull data for clinician review, all of the smartphone applications and wearable devices highlighted in Table 3 provide API access, but fewer provide direct clinician access.

How to implement technology to self-monitor physical activity in clinical practice

The 2018 Physical Activity Guidelines state that adults should get 150 min of moderate to vigorous intensity physical activity for substantial health benefits, but that 300 min or more are needed for weight management.⁴³ Therefore, traditional behavioral weight management programs typically prescribe goals of 200–300 min per week for weight management benefits.⁴⁴ When helping individuals meet these goals, it is important to encourage a gradual increase in activity (e.g. starting off at 50 min per week and working up to 200) and to focus on moderate-intensity activities (e.g. brisk walking) at first to reduce the risk for injury.⁴³ Although most wearables and smartphone applications provide information on steps, many evidence-based weight management programs now use minutes of exercise as the primary goal for physical activity because step measurement does not take activity intensity into account. In other words, striving for the widely accepted step goal of 10,000 steps may increase overall physical activity; however, if these steps are taken at a light intensity, this movement may not offer the same cardiometabolic benefits as moderate- to vigorous-intensity exercise.⁴³ Lastly, even though many of the smartwatches estimate energy expenditure (e.g. kilocalories “burned” through physical activity), it is important to discourage overreliance on these device-calculated estimates, as they have been shown to have low validity.^{42,45}

Emerging technologies

New technologies, such as bite counters and photo-based dietary tracking systems, are emerging as potentially efficacious tools for reducing the burden of self-monitoring in weight management programs. Wrist worn bite counters have been associated with lower caloric intake^{46,47} and weight loss⁴⁷ in the context of weight management interventions. Photo-based diet tracking systems are improving in their ability to accurately determine the calorie amount of meals,⁴⁸ which would further reduce the time necessary for individuals to self-monitor dietary intake. Although these emerging technologies demonstrate promise for further reducing the burden of self-monitoring, additional research needs to be conducted to assess their impact on dietary intake and longer-term weight loss outcomes.

Barriers to use of self-monitoring technology

Although self-monitoring technology addresses many barriers to self-monitoring, there are also potential barriers to the use of these tools. First, the price of e-scales and wearables can be a prohibitive factor, as costs can range from \$30 to \$400. Smartphone applications for self-monitoring dietary intake and/or physical activity, on the other hand, often have a free version and can be accessed via the Internet (e.g. on a computer or tablet) or downloaded to an individual's smartphone. As of April 2021, Pew Research Center⁴⁹ estimated that 85% of American adults own a smartphone, with no differences between race/ethnicity; thus, these applications have potential for wide reach. Smartphone-based self-monitoring applications still require a data plan or access to WiFi, which may be a limiting factor for individuals with lower socioeconomic status or those living in rural areas. Second, an individual's language preference can impact both their preferred method for obtaining health information (face-to-face vs. technology)^{50,51} and the quality of the health information. For example, a recent study demonstrated that the content quality of weight loss information was lower when accessed in Spanish instead of English.⁵² Third, some individuals may have difficulty using technology (e.g. older adults or individuals with low health literacy),^{53,54} hindering their success with these tools. Therefore, providing additional hands-on training may be necessary for individuals less familiar with the use of smartphones and wearable technologies. Finally, some individuals may be hesitant to share self-monitoring data with researchers or clinicians due to privacy concerns. For these participants, it can be important for the researcher or clinician to clearly understand data transfer protocols (e.g. if encryption and other privacy measures are appropriately used) in order to explain how exactly individuals' data will be collected, transmitted, stored, and used.

Impact of self-monitoring technology on intervention outcome

Overall, research suggests that individuals consider newer self-monitoring technologies acceptable, easy to use, and helpful.^{55–57} There is also evidence that the inclusion of these tools within broader weight management programs can increase adherence to self-monitoring^{10,58,59} and promote greater weight loss.⁶⁰ Less benefit is observed when these tools are implemented alone, without additional intervention. One recent review found that, when offered without additional intervention (e.g. coaching or feedback provided by an interventionist or dietician), the provision of self-monitoring technology did not consistently improve weight loss outcomes.⁶¹ This pattern of results has led to calls for these technologies to be viewed as facilitators, but not drivers, of behavior change.^{61,62}

As early as 2011, Mohr and colleagues⁶³ argued that human support may be critical to sustaining engagement in digital health interventions. In particular, they described the importance of “supportive accountability,” which is the idea that interventionists can improve engagement with and outcomes of digital health programs by providing accountability (e.g. from individuals knowing that someone else is checking to see if they self-monitored or not) coupled with nonjudgmental feedback and assistance with overcoming barriers to health behavior change. One study that provided individuals with newer self-monitoring tools, either with or without additional interventionist support (delivered remotely via brief telephone calls), found that participants randomized to receive additional interventionist support reported greater perceptions of supportive accountability. In addition, greater perceptions of supportive accountability were associated with higher adherence to weight-management behaviors.⁶⁴ Related specifically to accountability, it may be particularly important that interventionists and clinicians actually review the data collected by self-monitoring tools. Another study found that participants whose interventionists had access to the data collected via technology-based self-monitoring tools regained significantly less weight in a weight maintenance program compared to participants who used the same tools but whose interventionists did not have access to review their self-monitoring data.⁶⁵ In order to drive clinically meaningful changes in dietary intake, physical activity, and weight, it may be necessary to implement these tools within a broader intervention, involving additional feedback and support from a trained interventionist (e.g. a registered dietician, health psychologist, or other individual trained in behavioral health counseling).

Conclusion

Newer self-monitoring technologies offer promise to overcome many of the barriers of traditional, paper-and-pencil self-monitoring tools. Given the vast number of tools currently available, this narrative review provides an overview of tools currently available on the commercial market and discusses guidelines for the implementation of these tools in intervention and clinical practice. Digital tools can capture data in real time and provide immediate feedback but have important barriers to consider, including access (related to cost and language), individual comfort with technology use, and privacy concerns. Research has demonstrated that these tools, when used in the context of a weight management intervention or ongoing clinical relationship, can improve self-monitoring adherence and weight loss outcomes compared to traditional self-monitoring tools. In contrast, the provision of the technology alone, without additional counseling, is unlikely to produce clinically meaningful change.^{62,63} Thus, these technologies are optimally implemented in the context of

a larger intervention (e.g. a behavioral weight management program or counseling provided by a registered dietician), versus being provided to individuals without further guidance.

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