An Evaluation of a Personal Electronic Device to Enhance
Self-Monitoring Adherence in a Pediatric Weight Management
Program using a Multiple Baseline Design

Christopher C. Cushing, MS, Chad D. Jensen, MA, and Ric G. Steele, PhD, ABPP
University of Kansas

All correspondence concerning this article should be addressed to Ric G. Steele, PhD, Clinical Child
Psychology Program, University of Kansas, 2011 Dole Human Development Center, 1000 Sunnyside Avenue,
Lawrence, KS, 66045-7555, USA. E-mail: rsteele@ku.edu

Received April 15, 2010; revisions received July 19, 2010; accepted July 22, 2010

Objective To examine the effectiveness of a personal electronic device (PED) in order to improve adherence
to self-monitoring of dietary intake and physical activity. Method The impact of a PED on adherence
to self-monitoring goals was examined in a multiple baseline design across three overweight adolescents.
During baseline, a traditional paper-and-pencil method of self-monitoring was utilized. The subsequent study
phase introduced a PED for self-monitoring. Percent self-monitoring goal attainment was the outcome of
interest. Results During baseline, attainment of self-monitoring goals was low for all three participants
(3–4%). Each subject’s percent attainment of self-monitoring goal increased upon the introduction of the
PED. For two of the three subjects this increase was stable (~75 and 100%) post-intervention. For the third
subject the increase in percent attainment of self-monitoring goal was more variable but remained above
baseline levels. Conclusion PEDs have potential for improving self-monitoring in the context of behavioral
weight management treatment for adolescents.

Key words adolescent, obesity, personal electronic device, self-monitoring.

Self-monitoring is a common component of treatments
for a wide variety of pediatric health conditions, including
diabetes (Saudek, Derr, & Kalyani, 2003), asthma (Teach,
Crain, Quint, Hylan, & Joseph, 2006), cystic fibrosis
(Hains, Davies, Quintero, & Biller, 2009), and cancer
(Gesundheit, Greenberg, Or, & Koren, 2007). Commonly
defined as the systematic observation and recording of
target behaviors (Wilde & Garvin, 2007), self-monitoring
has been shown to enhance health behavior and lead to
measurable changes in health-related outcomes.

In the context of weight management programs,
self-monitoring has been referred to as the “cornerstone”
of behavioral interventions (Wadden & Sarwer, 1999).
In child and adolescent weight management programs,
self-monitoring interventions typically include recording
target behaviors such as dietary behavior and physical
activity. Many of these programs employ simplified food
categorization systems for dietary monitoring such as the
traffic light diet (for examples see, Epstein, Paluch,
Kilanowski, & Raynor, 2004; Herrera, Johnston, &
Steele, 2004). Consistency of monitoring has frequently
shown to correlate with initial weight loss
(Kirschenbaum, Germain, & Rich, 2005; Salaens &
McGrath, 2003) and continued treatment success many
months post-treatment for adolescents (Germann,
Kirschenbaum, & Rich, 2007). Furthermore, several exper-
imental studies have demonstrated that increases in
consistency of self-monitoring yield improvements in
weight control (e.g., Boutelle & Kirschenbaum, 1998).

Although the effectiveness of self-monitoring in
behavioral weight management programs has been demon-
strated, individuals’ acceptance of and adherence to
self-monitoring procedures varies widely. Salaens and
McGrath (2003) reported that only 20% of participants
in a weight management program monitored diet and phys-
ical activity on 75% of treatment days. Also problematic, a
number of reports exist documenting declining self-monitoring over the course of treatment. Kirschenbaum and colleagues (2005) reported self-monitoring adherence of nearly 50% (monitoring 3.5 days/week) at the end of 1 month of treatment, while only 25% of participants continued to monitor on most days of the week after 6 months of treatment. Perhaps not surprisingly, participants often report having completed their self-monitoring homework while objective measures of self-monitoring contradict these self-reports (Burke et al., 2008).

One method that has the potential to improve adherence to self-monitoring in some patient populations is the use of a personal electronic device (PED). Insufficient empirical evidence currently exists to draw strong conclusions about the relative impact of PEDs over paper-and-pencil methods of self-monitoring in weight loss programs; only one randomized clinical trial is underway with adults (Burke et al., 2009), and no studies have examined the use of PEDs for self-monitoring in the context of pediatric weight management programs. However, some preliminary evidence from the adult literature provides encouragement for the further exploration of PEDs as a tool to improve self-monitoring in this population. For example, a brief pilot study of 33 women demonstrated improved self-reported adherence to self-monitoring over baseline practices when PEDs were used as a method of capturing dietary behavior (Glanz, Murphy, Moylan, Evensen & Curb, 2006). Additionally, participants in a 24-week behavioral weight loss program demonstrated equivalent self-monitoring practices using paper-and-pencil methods or PEDs, and higher rates of self-monitoring were correlated with greater weight loss, leading the authors to conclude that weight loss consumers should be matched to the method of behavioral record keeping that fits their lifestyle (Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007).

Adolescents appear to be a population whose lifestyle is particularly amenable to PED intervention. It is estimated that 85% of adolescents own at least one personal media device that could serve as a PED (Lenhart, Madden, & Hitlin, 2005). In addition to the wide availability of PEDs among adolescents, PEDs also have the advantage of being a novel strategy of recording health data for most adolescents. Moreover, PEDs provide immediate feedback based on information provided by the user, a characteristic which may increase adolescent engagement in self-monitoring. Similarly, PEDs may have more salience for adolescents because self-monitoring is integrated into a device that serves multiple daily functions (e.g., music player, daily planner). Given the dearth of literature concerning the utility of PEDs for dietary and physical activity self-monitoring among adolescents and the widespread availability of PEDs to adolescent consumers, there is value in conducting preliminary trials designed to determine the power of PEDs in improving self-monitoring adherence among adolescent populations.

The current study was designed to evaluate the impact of the use of PEDs on adolescents’ self-monitoring adherence in the context of a family-based behavioral intervention for pediatric obesity. The application of PEDs for tracking diet and physical activity information served as an experimental manipulation targeting self-monitoring adherence following a baseline period of paper-and-pencil self-monitoring. Based on studies in the adult literature (e.g., Glanz et al., 2006) and the belief that PEDs would be a more preferred method of self-monitoring than paper-and-pencil methods for adolescents, it was hypothesized that adherence to self-monitoring using PEDs would be superior to baseline paper-and-pencil self-monitoring adherence. The current study also provided the opportunity to interview participants concerning their preferences for each method of self-monitoring.

Methods

Participants

The first three consecutive eligible families presenting to a university-based weight management specialty clinic after institutional review board approval were enrolled. All participants were female and above the 85th body mass index (BMI) percentile for age and sex [based on Centers for Disease Control and Prevention (CDC) normative data; Kuczmarski et al., 2002]. H.R. was a 14-year-old Caucasian female at the 91st percentile of BMI for sex and age at the beginning of treatment. H.R. and her family attended six out of nine scheduled sessions over a 10-week period in the summer. H.R. was absent 4 weeks during the summer and chose to terminate her participation after 10 weeks and, consequently, received only six of the nine treatment sessions. The second participant, T.L., was a 16-year-old Caucasian female at the 98th percentile of BMI for sex and age. T.L. and her family attended nine out of nine scheduled sessions over a 10-week period in the summer. Although T.L. received the full program, she was absent for 1 week during the summer causing the 9-week treatment to include 10 weeks of data. Finally, C.M. was an 18-year-old Caucasian female at the 99th percentile of BMI for sex and age. C.M. and her family attended nine out of nine scheduled sessions over a 12-week period in the summer. C.M. was unable to attend treatment sessions on several weeks, requiring that the 9-week program be delivered over the course of 12 weeks.
Measures

Self-Monitoring Adherence

Self-monitoring adherence was assessed by recording each participant’s stated goal for self-monitoring frequency and calculating the percent goal attainment for each week of the program. H.R.’s and T.L.’s goals were to monitor diet and physical activity three times a day, while C.M.’s goal was to monitor once a day. For each scheduled self-monitoring occasion, participants received a score of 1 if they met their goal and a 0 if they did not. The number of successful self-monitoring occasions in each week was summed. This value was then divided by the number of scheduled occasions for that week based on the participant’s self-monitoring goal. Therefore, since H.R. and T.L. could receive a score ranging from 0 to 3 for each day of monitoring over a 7-day period, their denominator was 21. Likewise, with daily scores of 0 or 1 over a 7-day period, C.M.’s denominator was 7. Because H.R. and T.L. provided self-monitoring records on multiple occasions per day, records occurring 4 hr apart were considered discrete monitoring events. This was determined using self-reported times when self-monitoring occurred in the baseline condition and by a time stamp provided by the PED program in the intervention condition.

Exit Interview for Baseline

A semi-structured exit interview, designed for use at the conclusion of the initial paper-and-pencil recording phase, was developed for the current study with the intent of assessing difficulties experienced by participants during the baseline phase. Participants were asked to report how helpful they believed recording their diet and physical activity to be, including the relative ease of self-monitoring using the paper-and-pencil diary. Finally, participants were asked to provide suggestions to improve the acceptability of the self-monitoring homework.

Exit Interview for Intervention

Semi-structured interviews of each participant were conducted at the conclusion of the final study session. Participants were asked to compare and contrast their experience in the baseline and intervention conditions. Each participant was asked to report on their intention to use self-monitoring strategies in the future as a strategy for weight loss.

Procedure

The current study utilized 9 weekly family treatment sessions comprised of nutrition/physical activity education, behaviorally based family therapy, and a goal-setting period with each session lasting ~90 min (Steele et al., n.d.). Because adherence to self-monitoring was the variable of interest in the current investigation, participants were instructed about the benefits of the self-monitoring technique and were asked to set a goal for self-monitoring each week. Weekly percent goal attainment was recorded. In the baseline phase, participants were given a 3 × 5 notebook to record food and drink consumption and physical activity performed during the week. Self-monitoring records were transferred to a dry-erase board during treatment sessions and discussed in terms of energy expenditure for the week. During the baseline phase, participants were unaware that they would later receive a PED for self-monitoring.

In the intervention phase, participants were given a PED pre-loaded with commercially available software to record their food intake and physical activity information. Participants were instructed to use the PED to record all of the information previously collected in notebooks during the baseline phase. Consistent with the baseline condition, during the intervention phase of the study self-monitoring records from the PEDs were reviewed and discussed during treatment sessions.

In the intervention phase, the commercially available Apple iPod Touch™ was loaded with the mobile version of http://www.livestrong.com, an application that allows users to wirelessly track their dietary intake and physical activity. The application also provides real-time feedback by graphing the number of calories consumed or expended by the participant in a given serving, meal, and day. The alarm function on the iPod Touch™ was used to prompt participants to self-monitor at regular intervals. The tracking software provided a time stamp for each record.

Participant T.L. began the PED protocol after her paper-and-pencil self monitoring was within 10% of the previous week’s data. Participants H.R. and C.M. began the PED protocol during the first session after an effect of intervention had been established for the participant immediately preceding them in the randomly determined order. Due to the nonconcurrent design, participants did not receive the same treatment session on the same week. Additionally, participants were not required to complete one session per week. However, when families were absent from treatment, participants were asked to keep the materials necessary to self-monitor with them (i.e., PED or notebook) and provide self-monitoring data at the next attended session. All procedures were approved by the institutional review board of the authors’ institution.

Results

As illustrated in Figure 1, during the baseline phase of paper-and-pencil monitoring, percent adherence to
self-monitoring goals began at 62.5% for H.R. but decreased to 10% by Week 4. For T.L. and C.M., percent adherence was near 0 and did not improve as a function of time. Improvements in percent adherence to self-monitoring were noted for all participants upon introduction of the PED. For T.L. and C.M. the increase in self-monitoring was stable, averaging ~75 and 100% post-intervention, respectively. H.R.’s post-intervention adherence fluctuated, but on average ($M = 55.1\%$), remained above her average baseline level ($M = 25.3\%$).

At the end of baseline (i.e., when she was scheduled to receive a study PED), C.M. elected to use her own PED which was the same model as the one to be assigned as part of the study. Her personal PED malfunctioned and she was unable to use it during Weeks 7–9 and was instructed to continue using the paper-and-pencil method.

Figure 1. Comparison of baseline and intervention percent goal attainment. Dashed lines indicate the transition from the baseline to intervention phase of treatment. Diamonds represent weeks where a treatment session occurred while squares indicate a missed session.
of self-monitoring because she planned to be absent until Week 10. When C.M. returned to treatment she was assigned a working PED for the remaining weeks of the study.

At the end of the baseline phase, H.R. reported a belief that self-monitoring was helpful with program adherence, but reported difficulties completing the tasks (e.g., problems remembering to record, difficulty carrying her notebook with her). During the interview, she was unable to generate solutions to these difficulties. At termination, H.R. reported that she found the PED to be helpful, but that she did not plan to continue using it for self-monitoring.

At the end of the baseline phase, T.L. reported a belief that self-monitoring was helpful for improving adherence to the nutritional and physical activity recommendations. However, she too reported difficulties with paper-and-pencil self-monitoring (e.g., did not like to keep it with her, difficulty remembering food intake). During the interview at the end of the baseline period, she spontaneously recommended that she use her iPod™ because she “always” had it with her. At the end of the intervention T.L. reported preferring the PED to her notebook for self-monitoring and found a different application that she continued to use following completion of the intervention.

At the end of baseline, C.M. reported being particularly dissatisfied with the requirement to self-monitor using the notebook. When asked what could be done to make the task easier, C.M. reported that recording in something other than a notebook would help because she was unhappy about carrying it with her. At the end of the intervention C.M. reported that the change in method of self-monitoring was critical to her success. She also reported a belief that the flexibility to record on her own time with an alarm reminder made the task easier.

**Discussion**

The current study examined the impact of PEDs on self-monitoring goal attainment in the context of an adolescent weight management program. Using a multiple baseline or other small-n design can be critical to evaluating interventions in a clinical setting due to the flexibility to choose independent variables that are costly to evaluate on a larger scale and to identify individual differences in response to an intervention (Rapoff & Stark, 2008). An additional strength of employing a multiple baseline design is the ability to establish the effect of the PEDs on self-monitoring at different points in treatment for each participant. This lends credibility to the conclusion that PEDs produce improvements in self-monitoring adherence independent of time spent in treatment or a particular session (Barlow, Nock, & Hersen, 2009). Understanding individual differences early in the development of a protocol can help to tailor interventions to the anticipated needs of the population and to plan for mediational and moderator analyses in larger more costly trials.

The results of this investigation support the further examination of PEDs as a method of improving self-monitoring in weight management interventions for pediatric populations. Participants all increased the frequency of self-monitoring over baseline and more closely approximated their goals in the intervention phase. Participants reported that PEDs were easier to use, and two of the three participants reported intent to continue using the PED after completion of the program.

Several explanations are reasonable for the observed findings. First, it is likely that the alarm reminded the participants to self-monitor their nutrition and physical activity for the reporting period. Palermo, Valenzuela, and Stork (2004) demonstrated similarly improved adherence with pain diaries using PEDs with alarms set to alert children to record in their diary. Additionally, participants were visually reminded to self-monitor every time they turned on the device by the Livestrong™ icon on the home screen. Accompanying this increased prompting (i.e., alarms and visual cue), we might anticipate that more immediate reporting may have reduced the burdens associated with retrospective reports on their diet and exercise behavior, thus improving accuracy (Rapoff, 2010). Unfortunately, our results cannot speak to the accuracy of the adolescents’ self-monitoring in this study, or the potential impact of PEDs on accuracy. This remains a fruitful direction for future studies in pediatric weight management.

Additionally, the device used in the current study offers a flexible platform for entertainment, organization, web-browsing, and data collection that may have been more attractive than PEDs used in other studies (e.g., Yon et al., 2007). The Apple iPod Touch™ has the capacity to serve multiple daily functions (e.g., daily planner, media player) and may serve as a convenience rather than a burden. These characteristics may have had some stimulus value to the participants outside of the research study, which may have caused participants to keep the device with them, resulting in more frequent self-monitoring. From a behavioral standpoint, this decreased response effort may have led to superior monitoring when using PEDs. It is also possible that features of the Livestrong™ software such as immediate feedback were reinforcing for...
participants. Finally, it is plausible that adolescents have a stronger preference for technology than adults, perhaps resulting in an increase in adherence with electronic monitoring in this population.

Obviously, the addition of technology does not solve all adherence issues. Participant H.R., for example, failed to comply with her own behavioral goal on several weeks. However, her specific lapses in self-monitoring occurred on weeks when she was relatively active (i.e., a week hiking in Colorado and a week at volleyball camp). She may have seen the PED as a supportive, but optional, adjunct rather than as an active component in treatment. This speculation is partially supported by the finding that H.R.’s mean level of self-monitoring increased during the PED intervention phase.

The current study allowed an initial assessment of an intervention for self-monitoring that would be expensive to implement on a larger scale. Perhaps the most noteworthy innovation in the current study is the introduction of a popular PED into the intervention framework rather than relying on technologies that are convenient for researchers but burdensome to participants. By using a commercially available product, the current study capitalized on the popularity of a method of storing data rather than convincing participants to comply with a less-convenient method of self-monitoring. Although large-scale distribution of PEDs in clinical settings is likely cost-prohibitive, our results suggest that clinicians might be well advised to inquire as to the availability of PEDs among families/adolescents in treatment for obesity. Given the ubiquity of the technology (Lenhart et al., 2005) and the promising results of this study, it is likely that at least some clients will find PEDs a useful tool to assist with their self-monitoring goals.

The current investigation is limited in the generalizability of its findings. The use of a nonconcurrent multiple baseline design means that the results are more susceptible to a history confound that cannot be isolated and removed (Barlow et al., 2009). The use of a homogeneous sample of adolescents also limits the generalizability. All participants were Caucasian females, and other studies examining the use of PEDs for self-monitoring have found differences across gender (Palermo et al., 2004). As can be observed in Figure 1, participant H.R. had a trend moving in the hypothesized direction prior to the implementation of the intervention condition. This limits the conclusions that can be drawn from participant H.R. compared to the other two participants. Furthermore, the expense attendant to using the Apple iPod Touch™ or other electronic devices may represent a barrier to using this method of self-monitoring in adolescent weight management programs, particularly those serving families with lower incomes. Finally, we are unable to control for any potential impact of the technical error encountered with C.M.’s PED.

Given the positive findings of this initial study, clinicians and researchers should consider using PEDs in future weight management interventions to facilitate self-monitoring in larger randomized interventions. For example, Agras, Taylor, Feldman, Losch, and Burnett (1990) programmed PEDs to cue adult participants to enter dietary and physical activity information and then provide feedback and suggestions for appropriate behavior. In this context the device can serve as both a two-pronged intervention (i.e., self-monitoring and feedback) and as a method of assessment. Future interventions may be able to maximize the contact with the client by combining self-monitoring and individualized feedback delivered by PEDs.

Acknowledgments
The authors gratefully acknowledge Dr Michael A. Rapoff for his helpful comments on an earlier draft of this manuscript.

Conflicts of interest: None declared.

References


