ABSTRACT

**Objective:** To examine acceptability, attrition, adherence, and preliminary efficacy of mobile phone short message service (SMS; text messaging) for monitoring healthful behaviors in children.

**Design:** All randomized children received a brief psychoeducational intervention. They then either monitored target behaviors via SMS with feedback or via paper diaries (PD) or participated in a no-monitoring control (C) for 8 weeks.

**Setting:** University of North Carolina at Chapel Hill.

**Participants:** Fifty-eight children (age 5-13) and parents participated; 31 completed (SMS: 13/18, PD: 7/18, C: 11/22).

**Intervention:** Children and parents participated in a total of 3 group education sessions (1 session weekly for 3 weeks) to encourage increasing physical activity and decreasing screen time and sugar-sweetened beverage consumption.

**Main Outcome Measures:** Treatment acceptability, attrition, and adherence to self-monitoring.

**Analysis:** Descriptive statistics and nonparametric tests were used to analyze differences across time and group.

**Results:** Children in SMS had somewhat lower attrition (28%) than both PD (61%) and C (50%), and significantly greater adherence to self-monitoring than PD (43% vs 19%, P < .02).

**Conclusions and Implications:** Short message service may be a useful tool for self-monitoring healthful behaviors in children, although the efficacy of this approach needs further study. Implications suggest that novel technologies may play a role in improving health.

**Key Words:** children, diet, physical activity, technology, monitoring (J Nutr Educ Behav. 2008;40:385-391)

INTRODUCTION

Approximately 19% of youth aged 6 to 11 and 17% of adolescents age 12 to 19 were overweight in 2003 and 2004.\(^1\) With 80% of overweight adolescents becoming obese adults,\(^2\) early intervention is critical. Although several treatment tools exist, promising interventions for weight control in youth focus on improving nutrition (decreasing dietary fat, increasing fruit and vegetable intake),\(^3,5\) reducing sugar-sweetened beverages (SSB),\(^6\) decreasing screen time (television, computers, video games),\(^7\) and increasing physical activity.\(^8,10\) Further, self-monitoring of intake, expenditure, and weight are the hallmarks of long-term weight control.\(^11\)

Despite the robust literature on the importance of monitoring for weight loss success, both adults and children often do not adhere.\(^12-15\) In the first month of a weight control intervention for morbidly overweight children, 44% self-monitored at least 3.5 days per week\(^14,15\); however, only 25% continued at 6 months.\(^14\) Thus, approaches are needed to enhance adherence to self-monitoring. Modern information technology provides one such tool. Elec-
Electronic diaries increase adherence by providing immediate feedback and time stamps. In one study, personal digital assistants increased patient adherence from 11% to 94%.17

Children use electronic devices regularly; 45% of US teenagers ages 12 to 17 own a mobile phone, and 33% use the short message service (SMS; text messaging).18 Grounded in behavioral theory of practice and reinforcement, SMS may be especially useful for self-monitoring because of the potential for providing both support and immediate feedback based on a patient’s specific goals. According to cognitive social learning theory, health behavior will change when goals are set, and when cueing, support, and positive reinforcement are provided.19 Short message service has been shown to be acceptable for providing support, effecting behavior change, and/or maintaining treatment gains in diabetes,20,21 asthma,22 smoking cessation,23,24 and bulimia nervosa.25,26 Although to the authors’ knowledge no study has investigated SMS in young children, previous studies have used somewhat older children and adolescents. Compared to conventional treatment, automatic daily SMS (providing support, tips, and information) combined with weekly SMS reminders about personal goals resulted in increased self-efficacy and adherence to diabetes management in children aged 8-18 with type 1 diabetes.27 Similarly, compared to a control group, in participants over age 16 in a smoking research study, SMS messages offering support and advice resulted in more participants who quit smoking after 6 weeks.23 Finally, weekly SMS self-monitoring of bulimic symptoms with automatic SMS feedback resulted in good monitoring adherence and acceptability in women aged 16 to 44 post-discharge from inpatient treatment.25 Given these observations, SMS may be promising for self-monitoring behaviors critical to childhood weight control. The investigators examined acceptability, attrition, and adherence to SMS self-monitoring relative to paper diaries (PD) or a no-monitoring control (C) over 8 weeks. The hypothesis was that SMS would be more acceptable to children and show less attrition than both PD and C and would result in better adherence to self-monitoring relative to PD. The investigators also explored the preliminary efficacy of SMS in effecting behavior change in children.

**DESCRIPTION OF THE PROCEDURE**

Children were recruited through letters sent to pediatricians, letters sent home from school with children, media advertisements, and university listservs for a study of healthful behaviors. Included were children of any weight; with no major metabolic problems associated with obesity; aged 5 to 13 years (as specified by funding mechanism); with anticipated parent participation (same parent must attend each session as parents were used both as a means to help children and to acquire accurate data); and with fluency in English. Although children in this wide age range may have differences in development, cognition, and abilities, the SMS system was developed to be performed with a parent such that younger children would receive assistance from their parents. Families were screened and completed questionnaires pertaining to eating and activity. Fifty-eight eligible families were randomized on a 1:1:1 basis (SMS: 18, PD: 18, C: 22) using the uniform random number generator.
Chapel Hill.

The study was approved by the Biomedical Institutional Review Board at the University of North Carolina at Chapel Hill.

**DESCRIPTION OF THE EVALUATION**

Frequency of monitoring was measured by dividing the total number of required monitoring days by the number of days the participant monitored. Owing to slight variations in the exact number of days that different waves of the study were expected to monitor, a more accurate comparison is percentage of total monitoring days rather than actual number of days monitored. Families in SMS and PD completed daily responses to 3 questions: (1) what was the number on your pedometer today? (2) how many SSB did you drink today? and (3) how many minutes of screen time did you have today? Means from weeks 1 and 8 constituted baseline and post-treatment. All families also responded to the following questions at both baseline and post-treatment: “On average over the past week, for each day: (1) how many minutes did you spend exercising? (2) how many SSB did you consume? and (3) how many minutes of TV did you watch?” Parents answered the questions for themselves, and parent and child together answered for the child. Although not validated, these questions were used to explore the preliminary efficacy of SMS in promoting behavior change. Parents and children completed treatment acceptability questions at post-treatment (Table 2). Height and weight were assessed without shoes using a digital physician’s scale and stadiometer. Body mass index (BMI; kg/m²) was calculated for parents, and BMI for age was calculated for children according to the Centers for Disease Control and Prevention guidelines. All analyses were conducted with SAS (SAS, Version 8, Cary, NC, 1999). Descriptive statistics and frequencies were used for many of the outcome measures. Given the small
sample size and non-normal distributions, nonparametric tests were used; thus, P values should be interpreted with caution.

**Preliminary Results**

**Treatment acceptability.** Prior to randomization, 100% of children hoped that they would be randomized to SMS. However, no significant differences emerged in most treatment acceptability measures across any of the groups (Table 2). The only difference was in parental reports of likelihood of participating in such a study again, with parents in the control condition being more likely to participate again.

**Attrition.** Completers were defined as participants who completed the 8-week post assessment and who attended at least 2 of the 3 educational sessions. The numbers of families who attended the weekly sessions were 39, 30, and 24 for the first, second, and third weeks, respectively. A total of 31 completed the study (SMS: 13/18, PD: 7/18, C: 11/22). Differences in attrition were analyzed using the Fisher exact P value. Although not statistically significant (P < .15) owing to the small sample size, the number of dropouts was substantially lower in SMS (n = 5, 27.8%) than in PD (n = 11, 61.1%) or C (n = 11, 50.0%). Attrition typically occurred during the first few weeks (ie, during the intervention sessions). For SMS, anecdotal reasons for attrition included:

- time conflict (n = 2);
- child did not want to use pedometer (n = 1);
- no mobile phone coverage (n = 1); and
- did not report (n = 1).

For PD, the reasons were:

- time conflict (n = 5);
- illness (n = 2);
- distance to travel (n = 1); and
- child did not want to participate (n = 1) and did not report (n = 1).

For C, the reasons given were:

- time conflict (n = 4);
- illness (n = 2);
- child did not want to participate (n = 2);
- family making changes on own (n = 1); and
- did not report (n = 2).

<table>
<thead>
<tr>
<th>Likert-scale Item</th>
<th>SMS Mean (SD) Range (n = 13)</th>
<th>PD Mean (SD) Range (n = 8)</th>
<th>C Mean (SD) Range (n = 11)</th>
<th>K-W X²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARENT</td>
<td></td>
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</tr>
<tr>
<td>1. How much did the program meet your expectations?</td>
<td>7.5 (1.4) 6.0–10.0</td>
<td>7.6 (2.2) 4.0–10.0</td>
<td>7.0 (2.1) 4.0–10.0</td>
<td>0.5</td>
<td>.77</td>
</tr>
<tr>
<td>2. How likely would you be to recommend this program to a friend and his or her child?</td>
<td>8.00 (1.6) 5.0–10.0</td>
<td>8.1 (2.0) 5.0–10.0</td>
<td>8.09 (2.5) 4.0–10.0</td>
<td>0.3</td>
<td>.85</td>
</tr>
<tr>
<td>3. How likely would you be to participate in this program again if necessary?</td>
<td>7.4 (2.1) 3.0–10.0</td>
<td>6.9 (3.5) 2.0–10.0</td>
<td>9.2 (1.8) 4.0–10.0</td>
<td>6.0</td>
<td>0.05</td>
</tr>
<tr>
<td>CHILD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. How much fun did you have doing this program with your parent?</td>
<td>3.3 (0.7) 2.0–4.0</td>
<td>3.4 (0.8) 2.0–4.0</td>
<td>2.9 (1.2) 0.0–4.0</td>
<td>1.1</td>
<td>.59</td>
</tr>
<tr>
<td>2. How much would you tell a friend to try this with mom or dad?</td>
<td>3.0 (0.9) 2.0–4.0</td>
<td>2.7 (1.0) 1.0–4.0</td>
<td>2.6 (1.6) 0.0–4.0</td>
<td>0.3</td>
<td>.86</td>
</tr>
<tr>
<td>3. How much would you like to do this program again?</td>
<td>3.1 (0.9) 2.0–4.0</td>
<td>2.6 (1.3) 1.0–4.0</td>
<td>2.5 (1.4) 1.0–4.0</td>
<td>1.6</td>
<td>.45</td>
</tr>
</tbody>
</table>

Note: P values are from a Kruskal-Wallis (K-W) nonparametric 1-way analysis of variance. Anchors for parent: 0 = not at all; 10 = extremely. Anchors for child: Question 1. 0 = I hated it, not fun at all; 1 = I didn’t really like it; 2 = it wasn’t fun but I didn’t hate it; 3 = it was a little bit fun; 4 = lots of fun! Question 2. 0 = No way. I wouldn’t tell any of my friends; 1 = I probably wouldn’t tell my friends to do the program; 2 = I would tell them it was okay; 3 = I would tell them it was fun; 4 = I would say, “You have to do this with your mom or dad—it was great!” Question 3. 0 = I wouldn’t really want to do this again; 2 = I might do it again—I’m not sure; 3 = I would do this again; 4 = I would definitely do this again!

SMS indicates short message service; K-W, Kruskal-Wallis nonparametric 1-way analysis of variance; PD, paper diaries; C, control; SD, standard deviation.
Adherence to self-monitoring. Adherence to self-monitoring was analyzed by the Wilcoxon rank-sum tests. There was a significant difference in self-monitoring with 43.0% versus 19.0% adherence to total monitoring days in children and adults in the SMS and PD conditions, respectively (2-sided z approximation: $P < .02$). Although the authors did not require that both parent and child submit their SMS together, there was never a day in which the child submitted data without the parent (or vice versa).

Preliminary efficacy. Preliminary efficacy was assessed in completers through self-monitoring data in SMS and PD groups and through recall of targeted behaviors for all groups (Table 3). In terms of self-monitoring data (SMS and PD), there were no within- or between-group differences on any targeted behavior for the children. In terms of self-reported recall, SMS was the only group that showed a significant reduction in minutes of screen time in children compared to PD or C. There were no significant between- or within-group differences in exercise or SSB. There were also no differences between groups in percentage of children who met each of the 3 recommended goals (SSB: 12 [39%]; screen time: 15 [48%]; physical activity: 25 [81%]).

DISCUSSION

This feasibility study examined SMS for self-monitoring of 3 target behaviors relevant to childhood weight control. Randomization to SMS was desirable to the children. In SMS, 72% completed the study versus 39% and 50% in PD and C. Although this difference was not statistically significant (most likely a result of the small sample size; to detect a difference between 39% and 50% with 80% power would have required a total sample size of 338 subjects), it is substantial improvement both clinically and for completion of a research study. Families in SMS completed 43% of requested self-monitoring versus only 19% in PD. Thus, children appear to prefer a technological, tailored, interactive program versus a more traditional paper diary program and when enrolled, those using SMS may have greater adherence and higher completion rates. These results are similar to previous studies using SMS for providing support and effecting behavior change, suggesting that SMS is a feasible and acceptable method for communicating with individuals.

Table 3. Comparison of Participants in the Conditions on Preliminary Efficacy in Reducing Sugar-sweetened Beverages and Screen Time and Increasing Activity

<table>
<thead>
<tr>
<th>Self-Monitoring</th>
<th>Steps (pedometer steps/d)</th>
<th>SSB (servings/d)</th>
<th>Screen Time (min/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M ± SD)</td>
<td>(M ± SD)</td>
<td>(M ± SD)</td>
</tr>
<tr>
<td><strong>SMS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>7803.9 ± 4273.3</td>
<td>1.5 ± 1.2</td>
<td>99.5 ± 91.5</td>
</tr>
<tr>
<td>Post</td>
<td>8187.0 ± 4536.1</td>
<td>0.4 ± 0.4</td>
<td>110.7 ± 125.5</td>
</tr>
<tr>
<td><strong>PD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>8589.6 ± 4224.3</td>
<td>2.0 ± 1.2</td>
<td>141.0 ± 110.6</td>
</tr>
<tr>
<td>Post</td>
<td>10927.4 ± 336.8</td>
<td>0.7 ± 0.9</td>
<td>48.4 ± 21.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-Reported Recall</th>
<th>Exercise (min/d)</th>
<th>SSB (servings/d)</th>
<th>Screen Time (min/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M ± SD)</td>
<td>(M ± SD)</td>
<td>(M ± SD)</td>
</tr>
<tr>
<td><strong>SMS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>102.9 ± 48.5</td>
<td>1.8 ± 1.6</td>
<td>149.3 ± 90.0</td>
</tr>
<tr>
<td>Post</td>
<td>137.3 ± 187.7</td>
<td>0.9 ± 0.6</td>
<td>80.6 ± 47.1†</td>
</tr>
<tr>
<td><strong>PD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>106.4 ± 76.0</td>
<td>2.0 ± 1.8</td>
<td>200.5 ± 158.8</td>
</tr>
<tr>
<td>Post</td>
<td>137.1 ± 94.6</td>
<td>0.6 ± 0.8</td>
<td>102.9 ± 45.4</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>129.2 ± 126.3</td>
<td>1.5 ± 1.2</td>
<td>188.6 ± 197.1</td>
</tr>
<tr>
<td>Post</td>
<td>114.1 ± 105.4</td>
<td>0.6 ± 0.7</td>
<td>111.8 ± 87.7</td>
</tr>
</tbody>
</table>

SSB indicates sugar-sweetened beverages; SMS, short message service; PD, paper diaries; C, control; d, day; M, mean; SD, standard deviation.

† = Within-group change over time: signed rank = 26.5, $P < .00$. 

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families and intermittent difficulties with using SMS (eg, phone companies merged, plans discontinued, coverage areas), which could influence generalizability.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Results suggest that one potentially effective way of increasing self-monitoring adherence in children is to use a novel device. This method could be used by both clinicians and researchers to obtain greater adherence to treatment. In particular, children of this era use technology both for education and socially and are likely to do so more than their parents, teachers, and thus researchers. Therefore, in order for researchers and practitioners to reach children (and even many adults), they will have to enhance their protocols to accommodate more modern methods of communication. A next step is to investigate children who already have a mobile phone to control for this novelty. Future studies should also control for frequency of provider contact, as in this study those in SMS had daily, albeit automated, contact, whereas those in PD had weekly verbal contact. Future planned studies include mixed methods models in which the investigators will employ qualitative approaches to understand the advantages to and barriers to using SMS as a self-monitoring tool. Moreover, future studies should use a validation loop (eg, observations recorded by a research assistant) to make sure the pedometer readings, SSB servings, and reported screen time are indeed accurate. Cost-effectiveness of traditional therapy, telephone, e-mail, or SMS should also be examined. Short message service may prove to be a cost-effective method for increasing adherence and effecting behavior change. Further, larger samples with wider recruitment are needed; a large portion of this sample came from listserv recruitment, which poses selection bias. Given that preliminary studies are finding acceptability with SMS for use with various populations, 

ACKNOWLEDGMENTS

Support for this research project was provided by the Ambulatory Pediatric Association Young Investigator Award; an unrestricted gift from the Gatorade Company for the Get Kids in Action Partnership with the University of North Carolina at Chapel Hill; National Institutes of Health grants 5T32MH19111-15 and DK56350; and an Alexander von Humboldt Stiftung German-American Trans-Coop grant. We greatly appreciate Abby Scheer for assistance with data entry and Sue Googe, Lutfi Arikan, and Mahmut Arikan for technical support.

REFERENCES


