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INTERNET-BASED CONTINGENCY MANAGEMENT TO IMPROVE ADHERENCE WITH BLOOD GLUCOSE TESTING RECOMMENDATIONS FOR TEENS WITH TYPE 1 DIABETES

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The current study used Internet-based contingency management (CM) to increase adherence with blood glucose testing to at least 4 times daily. Four teens diagnosed with Type 1 diabetes earned vouchers for submitting blood glucose testing videos over a Web site. Participants submitted a mean of 1.7 and 3.1 blood glucose tests per day during the 2 baseline conditions, respectively, compared to 5.7 tests per day during the intervention. Participants and their guardians rated the program favorably on a number of dimensions. The results suggest that Internet-based CM is feasible, acceptable, and effective to increase self-monitoring of blood glucose in teens.

Key words: adherence, adolescents, blood glucose, contingency management, diabetes, Internet

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Intensive glycemic control in individuals diagnosed with Type 1 diabetes can lead to a reduction or postponement in diabetes-related health complications. In the seminal Diabetes Control and Complications Trial (1994), conventional and intensive treatment groups of adolescents and adults were followed for 6.5 years. One critical component for the intensive group was self-monitoring blood glucose (SMBG) at least four times per day. Blood glucose monitoring provides information about glucose levels, which is critical for making decisions about diabetes management: what can be eaten, how much insulin to take, and how much to exercise. Adolescents and adults in the intensive group were found to be at a greatly reduced risk of developing or progressing to later stages of several diabetes-related illnesses (e.g., retinopathy) than individuals in the conventional group. Thus, glycemic control has long-lasting beneficial effects, underscoring the importance of intensive glycemic control during adolescence.

Although adolescents with Type 1 diabetes are told to perform SMBG at least four times per day and aim for target glucose levels of around 90 to 150 mg/dl (Silverstein et al., 2005), adherence with testing tends to decline as children transition to adolescence. Adolescent self-reports show as few as 25% adhering to the guidelines (Anderson et al., 2009; Kyngas, 2000).

Contingency management (CM) is a procedure that has been used to increase adherence and involves delivering consequences (e.g., money) contingent on meeting the requirements of the medical regimen. We recently developed an Internet-based CM procedure to monitor carbon monoxide (CO) via Web-camera videos and to reinforce targeted CO levels in adult and adolescent smokers who were trying to quit (Dallery & Glenn, 2005; Dallery, Glenn, & Raiff, 2007; Reynolds, Dallery,

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Shroff, Patak, & Leraas, 2008). The Internet program was effective and broadened the reach of the intervention by making it available to anyone with Internet access.

The current study tested the feasibility and acceptability of extending Internet-based CM to blood glucose testing in adolescents diagnosed with Type 1 diabetes. Use of a secure Web site (Mōtiv[8]) allowed participants to submit Web-camera videos showing SMBG, which resulted in vouchers stating monetary earnings. To our knowledge, this is the first study to use Internet-based CM for blood glucose testing.

METHOD

Participants

Participants and one guardian were screened for inclusion during an appointment at the diabetes clinic or over the phone. Four participants qualified and provided informed consent with the assistance of a guardian. Participants had to be between 12 and 18 years of age, do SMBG less than four times per day, and have Internet access in the home. (Girls were given a pregnancy test and would have been disqualified if pregnant due to the need for additional medical attention.) Participants were three girls (Talia, white, 17 years old; Bonita, black, 15 years old; and Andrea, Hispanic, 16 years old), and one boy (Edward, white, 12 years old).

Materials

Participants were lent a Web camera and an UltraMini glucose meter (LifeScan, Inc.), were given 50 test strips and lancets to use during the intervention, and were given diabetes management education (*Simple Start + Insulin* by LifeScan, Inc.). Two participants were lent an Asus EeePC because they had an Internet service provider but no functional computer. The UltraMini can store 500 test results and digitally displays the blood glucose value (in milligrams per deciliter), as well as the date and time of the test.

Procedure

The researcher collected the previous 5 days of glucose tests from the participant's personal glucometer. Next, the researcher installed the Web camera and explained the rules of the intervention to the participant, which stated,

> You will earn a $1 voucher for every glucose testing video that you post, but you will only be able to keep the money that you earn if you post at least four videos. When you submit your fourth video, you will also earn a $3 bonus, and you will get to keep everything you earned up to that point. You can post a maximum of eight videos per day, as long as you space your glucose tests by a minimum of 1 hr. Thus, you can earn up to $11 per day for posting videos. If you test your glucose at a time when Internet access is not available, you can post a video showing the stored value when you regain Internet access.

Participants completed a quiz to ensure that they understood the rules and practiced posting a SMBG video. First, the participant logged onto the secure Web site using a unique user name and password, which took the participant to his or her home page. The home page contained a graph showing glucose values over consecutive video submissions. Below the graph was a box containing voucher earnings and a "post video" button. Pushing the button prompted the participant to turn on the video camera and begin recording. Participants were instructed to show (a) the glucose meter screen after inserting the test strip, (b) puncturing the finger with a lancing device, (c) applying a small drop of blood to the test strip, and (d) the final glucose reading. Next, the participant manually entered the glucose value in a text box and posted the video. The program thanked the participant for posting a video and, after returning to the home page, he or she could see an updated graph with the newest glucose value.

In some cases it was impossible for the participant to test glucose in front of the camera (e.g., due to school attendance), in which case he or she could post videos of stored tests when Internet access was available. For stored tests,

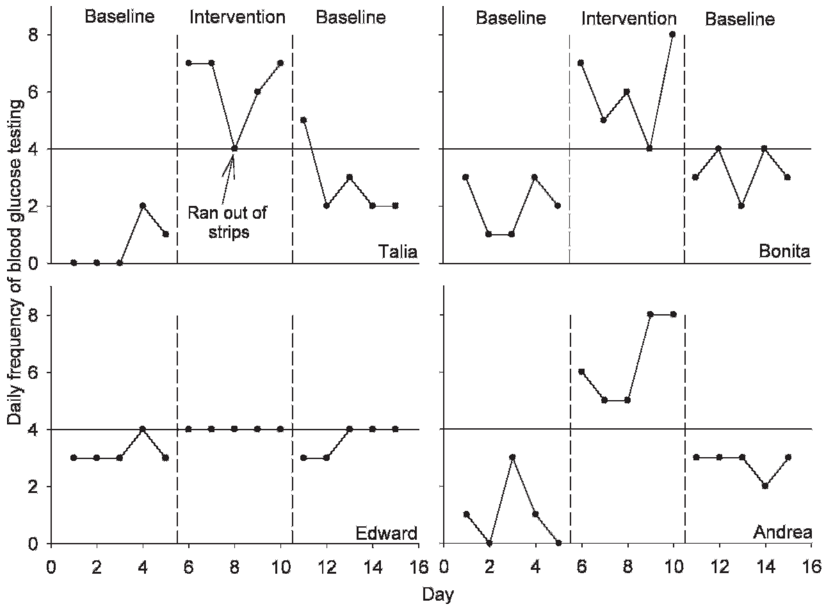

Figure 1. The daily frequency of blood glucose tests for each participant during baseline (left), intervention (middle), and return to baseline (right). The dashed vertical lines indicate condition changes, and the solid horizontal line represents the goal of four blood glucose tests per day.

the participant held the glucose meter up to the camera to display the glucose value, the date, and the time. The participant recorded a separate video for each stored test. Due to lighting, it was difficult to see the date and time for Talia, so she wrote the information on a piece of paper and held it up to the camera, which was later verified by checking glucose meter memory. The experimenters reviewed videos each day and entered voucher earnings manually.

Experimental conditions. An A-B-A reversal design was used, with all conditions lasting 5 days. Blood glucose tests for the initial baseline were collected from the participant's personal glucose meter memory. The B condition was Internet-based CM. The researcher told each participant that at the end of 5 days he or she would no longer post videos but to continue testing as the doctor recommended; this served as return to baseline.

After the last day of the return to baseline, a meeting was scheduled in which the participant and a guardian separately completed a treatment acceptability questionnaire, using a 100-mm visual analogue scale (higher numbers were more favorable) to rate ease of use, enjoyment, convenience, helpfulness, and effectiveness. The researcher recorded the data from the glucose meter for the return to baseline and collected the equipment. All participants purchased gift cards with their vouchers, with the approval of a guardian.

RESULTS AND DISCUSSION

Figure 1 shows the daily frequency of blood glucose testing. During baseline, participants did not meet the minimum of four tests per day. When the intervention was introduced, an increase in the frequency of testing occurred. During the intervention, Talia, Edward, Bonita, and Andrea earned \$46, \$35, \$45, and \$48 in vouchers, respectively. Removing the intervention resulted in a decrease in the frequency of testing, although there were some carryover effects.

More than half of the videos (64%) depicted the entire SMBG process. The majority of stored tests (87%) were accounted for by Talia

(27 tests). Bonita, Edward, and Andrea submitted 10 (33%), 2 (6%), and 2 (6%) stored tests, respectively. Only about 17% of the blood glucose values fell within the target range of 90 to 150 mg/dl (19 of 113) during the intervention. Mean blood glucose values during the intervention were 265 (range, 85 to 508), 146 (range, 48 to 256), 162 (range, 56 to 501), and 161 (range, 55 to 344) mg/dl for Talia, Edward, Bonita, and Andrea, respectively. Reaching target glucose levels was not a goal of the current intervention. Future studies could investigate arranging contingencies to target blood glucose levels (e.g., bonus vouchers for test values within range). It is important to note that increasing SMBG is critical, regardless of the values, because it can be used to inform treatment.

Participants rated the program as easy to use (M = 87, range, 77 to 96), helpful (M = 80, range, 71 to 98), and effective (M = 86, range, 75 to 97), and they reported that earning vouchers was enjoyable (M = 93, range, 86 to 98). These high ratings suggest that the intervention was acceptable. Participants rated the UltraMini (M = 47, range, 2 to 98) and the intervention convenience less favorably (M = 54, range, 22 to 84); however, despite these lower ratings, every participant submitted the minimum number of tests while the intervention was active. Furthermore, three of the participants lived in locations far away from clinics (33, 82, and 121 km). An intervention as intensive as CM would not have been possible if in-person appointments had been required. However, it might be possible to make the intervention more convenient by requiring all tests to be submitted at the end of the day rather than as they are conducted throughout the day, or cell phones could be used to record and submit videos.

User acceptability was also rated by the guardians. Their ratings suggest that the program was helpful to their teens (M = 93, range, 80 to 99), increased their teen's independence with diabetes management (independence before: M = 54, range, 22 to 95; independence during: M = 89, range, 77 to 100), and was enjoyable for their teen to use (M = 92, range, 85 to 100). A number of studies have shown that conflicts arise between parents and their children as the children move toward independent diabetes management (e.g., Anderson et al., 2009). If Internet-based CM interventions are acceptable, effective, and enjoyable for parents and teens, then it has the potential to overcome a number of family conflicts.

There are a few limitations that should be considered when interpreting these results. First, the intervention phase was brief, but the demand for SMBG testing is ongoing. Future studies should be aimed at identifying ways to maintain SMBG over longer periods. Second, it is possible that posting videos of SMBG testing alone or being accountable for testing on a daily basis by a third party would have increased testing in the absence of vouchers (i.e., reactivity). Third, Internet access is required for this intervention. Although an estimated 98% of individuals in the United States between 8 and 18 years old have experience going on-line, only about 70% live in a home with Internet access (Rideout, Roberts, & Foehr, 2005). Future research should explore increasing access by using even more widely available technologies, such as cell phones. Finally, although the cost of supplying vouchers may raise some concerns, it should be noted that the costs incurred by medical complications from poorly managed diabetes are considerable (American Diabetes Association, 2008). Nevertheless, strategies could be explored to decrease treatment costs, such as using intermittent schedules or nonmonetary incentives.

The current study was the first to use Internet-based CM to improve adherence with blood glucose testing in adolescents diagnosed with Type 1 diabetes. The results demonstrated that this procedure is feasible, acceptable, and effective. Helping adolescents develop diabetes management practices can result in long-term benefits to their overall health, as well as minimize the economic burden associated with future complications. Internet-based interventions may be an excellent medium to use with this population, and many possibilities exist for making it more accessible, efficacious, and cost effective.

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