BRIEF REPORT

Engagement with a Text-Messaging Intervention Improves Adherence in Adolescents with Type 1 Diabetes: Brief Report

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Abstract

Adherence to diabetes management is a challenge for adolescents with type 1 diabetes (T1D). Positive psychology interventions have improved adherence to treatment recommendations in adults with chronic health conditions but have not been widely tested in pediatric populations. We hypothesized that higher engagement with a text-messaging intervention to promote positive affect would increase the effects on diabetes management among adolescents with T1D. Adolescents with T1D ($n=48$) and their caregivers were randomized to either an attention control condition or a novel positive psychology intervention delivered through personalized automated text messaging. We examined rates of engagement (percent response to text messages) in relation to demographic factors, and we explored the effect of engagement in relation to adherence and glycemic control. Adolescent engagement was good (mean response rate of 76%) over the 8-week intervention. Engagement was related to adolescents' gender, race, baseline glycemic control, and blood glucose monitoring, but not to treatment type (pump vs. injection), diabetes duration, age, or household income. There was a significant effect of level of engagement on better caregiver-reported adherence, but adolescents' engagement was not related to self-reported adherence or glycemic control. These results indicate feasibility and initial efficacy of using automated text-messaging to deliver an intervention aimed at promoting adherence in adolescents with T1D.

Keywords: Type 1 diabetes mellitus, mHealth, Adolescents, Adherence.

Background

ONLY A FRACTION of adolescents with type 1 diabetes (T1D) meet goals for glycemic control, and adolescents have the lowest frequency of blood glucose monitoring (BGM) among youth with T1D.¹ Interventions are needed to improve outcomes in this high-risk population, and more recently, mHealth interventions have been developed and tested to improve adherence and glycemic control in adolescents. A review of text-messaging interventions for children and adolescents with T1D found that such mHealth interventions were feasible among youth, but the results for acceptability and efficacy were mixed.² For example, the SMART project tested a 6-week text-messaging program to provide self-management reminders and education to adolescents with T1D ($n=23$).³ The authors reported good response to the messages (78%), with higher rates among girls, adolescents

who texted more frequently, and adolescents with lower mean blood glucose levels.³ However, this study had a small sample size, it did not measure impact on diabetes management, and it did not include caregivers. A larger trial ($n=90$) conducted with older adolescents and young adults tested a text-messaging program that sent motivational messages focused on lifestyle issues to participants over 1 month.⁴ In this study, 71% of participants responded to at least half of the messages that elicited a response, but the authors did not report associations between demographic or clinical characteristics with engagement.⁴ Using a guiding behavioral theory and including caregivers in a text-messaging intervention may increase participant engagement,² but there is still a need to determine how best to promote engagement with mHealth interventions in adolescents with T1D to optimize outcomes.

We tested a novel approach to improve adherence in adolescents by focusing on promoting positive affect (PA)

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(e.g., feeling happy, content, and interested) as a way to improve motivation for self-care.^{5,6} Clinical trials have demonstrated the efficacy of similar interventions to promote adherence to treatment recommendations among adults with chronic health conditions,^{7,8} but these have not been widely tested in pediatric populations, and the interventions with adults were delivered through telephone. Given that text messaging has been shown to be an effective way to reach difficult-to-engage patients, including adolescents with T1D,² we developed tailored, automated text messages to induce PA. In this study, we investigated adolescents' engagement with the text-messaging intervention. We hypothesized that higher levels of intervention engagement would yield better diabetes management, and we explored whether caregiver engagement or other demographic factors were associated with adolescents' levels of engagement.

Methods

We conducted a randomized pilot study investigating the effects of a positive psychology intervention on diabetes outcomes with 48 adolescents and their caregivers. Adolescents were eligible if they were 13–17 years old, diagnosed with T1D >12 months, and HbA1c 7.5%–12.0% (59–108 mmol/mol). Adolescents and their caregivers were recruited during regularly scheduled diabetes clinic visits at an academic medical center. After providing informed consent/assent, participants were randomized to an attention control (Education, $n=24$) or text-message PA intervention ($n=24$). The protocol was approved by the Institutional Review Board and the study was registered as a Clinical Trial (NCT 02984709). Adolescents who did not own a mobile phone were provided a basic cell phone and service for the study period ($n=4$). The percent of eligible adolescents who participated was 53%; the most common reason for refusal was lack of time or interest.

Adolescents in the PA group received 4–5 text messages/week over the 8-week intervention period. Based on preliminary work, we developed separate message banks for girls and boys with the highest ranked Mood Booster messages (jokes and inspirational quotes), which were sent 2–3 times/week. In addition, adolescents received 1 weekly personalized Important Value message (“You mentioned that [your relationship with friends] is important to you...”), and 1 weekly Gratitude message (“Last week you said that [hugs] made you happy... Take a moment to notice things that make you happy this week.”). These messages were personalized by piping in adolescents' responses to the questions obtained during the baseline study visit. Caregivers in the PA group were sent weekly reminders to give positive messages to their adolescents. Participants were asked to respond to indicate that they had received messages. Adolescents in the Education group received printed educational materials based on information from the American Diabetes Association website (diabetes.org) on topics such as understanding A1C, sports and exercise, and driving. Education content was not delivered by text message.

Adherence was measured objectively by downloading glucometer data to obtain the frequency of BGM (average number of checks/day over the previous 30 days). In addition, adolescents and caregivers completed the self-care inventory (SCI),⁹ a measure of adherence to the T1D treatment regimen. In our sample, reliability was 0.70 for adolescents' reports and

0.80 for caregivers' reports. Glycemic control was measured with point-of-care HbA1c, collected as part of the clinic visits. Caregivers provided demographic data, including race/ethnicity, and household income. Data were collected at baseline (enrollment clinic visit) and postintervention (~3 months after enrollment or 1 month after the intervention ended, during a clinic visit). Engagement was defined as the percent of messages to which the participant responded, categorized as high ($\geq 90\%$), good ($\geq 70\%$ – $<90\%$), and low ($<70\%$) engagement levels. At the end of each group of messages (i.e., mood booster, important value, or gratitude), the participant was prompted to verify that they received the messages (e.g., “Did you receive your mood booster?”).

To identify potential factors that influenced adolescent engagement, we conducted bivariate correlations and compared means across demographic and clinical variables. In addition, we conducted repeated-measures analyses of variance to examine engagement level as a moderator of the intervention's effect on diabetes outcomes (time $\times$ engagement interaction). All statistical analyses were performed using SPSS version 24.

Results

Table 1 presents the demographic and clinical characteristics of the sample. We observed no significant differences between groups on demographic or clinical variables at baseline. Retention rates were excellent; 98% of adolescents completed follow-up data.

Overall, adolescents demonstrated good levels of engagement; the mean response rate was 75.7% overall. Although the responses waned over the 8-week period, from 87% in week 1 to 81% in week 5 and 62% in week 8, the mean response rate remained above 50% over the 8-week intervention period. We observed equal numbers of participants in each category of engagement: 33.33% were in the high engagement group, 33.33% were in the good engagement group, and 33.33% were in the low engagement group. Higher levels of HbA1c ($r=0.30$, $P=0.016$) and less frequent BGM ($r=-0.37$, $P=0.010$) at baseline were moderately associated with higher levels of engagement. Engagement was not associated with treatment type (pump vs. injection), household income, adolescent age, or diabetes duration. However, adolescent sex was significantly related to engagement ($t=2.42$, $P=0.024$); boys demonstrated higher response rates (88%) than girls (67%). Race/ethnicity was also significantly related to engagement ($t=3.48$, $P=0.041$), with white, non-Hispanic youth responding to more messages (80%) than minority youth (45%). Caregiver engagement (response to text message reminders for positive messages) was also good (76% overall), but caregiver engagement was not significantly related to adolescent engagement ($r=0.07$, $P=0.756$).

There were no significant effects of the intervention (PA vs. Education) on HbA1c, BGM, or adherence.¹⁰ We conducted repeated-measures analyses to examine engagement level as a moderator of the effects of the intervention on diabetes outcomes. We found a significant main effect for time ($F=8.75$, $P=0.008$) and a time $\times$ engagement interaction ($F=3.63$, $P=0.040$) on the caregiver SCI, such that the highest engagement level was associated with the greatest improvement in caregiver-reported adherence over 3 months (Fig. 1). However, the main effects for time and the

TABLE 1. DEMOGRAPHIC AND BASELINE CLINICAL CHARACTERISTICS (N=48)

Variable	Range	PA Group		Education Group		Combined	
		Mean (SD)	n (%)	Mean (SD)	n (%)	Mean (SD)	n (%)
Adolescent age (years)	13–17	15.0 (1.3)	—	14.4 (1.2)	—	14.7 (1.3)	—
Duration of diabetes (years)	1–14	6.08 (3.4)	—	5.58 (3.35)	—	5.83 (3.4)	—
Baseline A1c (%)	7.5–11.5	8.57 (0.9)	—	9.00 (1.1)	—	8.8 (0.99)	—
Baseline BGM	—	3.45 (1.4)	—	2.96 (1.5)	—	3.21 (1.44)	—
Baseline P-SCI	—	3.59 (0.7)	—	3.57 (0.7)	—	3.58 (0.69)	—
Baseline C-SCI	—	3.53 (0.8)	—	3.56 (0.7)	—	3.55 (0.74)	—
Sex							
Male	—	—	10 (41.7)	—	13 (54.2)	—	23 (47.9)
Female	—	—	14 (58.3)	—	11 (45.8)	—	25 (52.1)
Race/Ethnicity							
White, Non-Hispanic	—	—	21 (87.5)	—	18 (75)	—	39 (81.2)
Other	—	—	3 (12.5)	—	6 (25)	—	9 (18.8)
Annual income (USD)							
<39,000	—	—	3 (12.5)	—	7 (29.2)	—	10 (20.8)
40,000–79,000	—	—	10 (41.7)	—	8 (33.3)	—	18 (37.5)
>80,000	—	—	11 (45.8)	—	9 (37.5)	—	20 (41.7)
Treatment type							
Injection	—	—	9 (37.5)	—	9 (37.5)	—	18 (37.5)
Insulin pump	—	—	15 (62.5)	—	15 (62.5)	—	30 (62.5)

BGM, blood glucose monitoring; PA, positive affect; SCI, self care inventory.

time $\times$ engagement interaction on adolescents' self-reported adherence (SCI) were not significant ($F=2.28$, $P=0.147$; $F=1.04$, $P=0.372$, respectively). There was an improvement in BGM over time, but it was not statistically significant ($F=1.91$, $P=0.185$). Finally, we did not find a significant effect for time or time $\times$ engagement level on HbA1c.

Discussion

mHealth researchers emphasize the need to evaluate engagement with behavioral interventions, to determine which factors influence engagement, and to examine engagement as a moderator of the intervention effects.¹¹ In this study, we observed good levels of engagement with a text-messaging

FIG. 1. Time $\times$ engagement interaction effect on caregiver-reported adherence. Repeated-measures analysis of time $\times$ group (high, good, or low engagement level, or control group) on caregiver-reported adherence, measured by SCI. Engagement was defined as the percent of messages to which the participant responded, categorized as high ($\geq 90\%$), good ($\geq 70\%$ – $<90\%$), and low ($<70\%$) engagement levels. Time was categorized as baseline (enrollment clinic visit) and post-intervention (~ 3 months after enrollment). SCI, self-care inventory.

intervention for adolescents with T1D, and the level of engagement moderated the intervention's impact on caregiver-reported adherence; high engagement was related to greater improvement in caregiver-reported adherence. When examining factors that may influence engagement, we found that adolescents' race/ethnicity and sex were the only demographic factors significantly related to engagement. The finding that boys had higher engagement than girls in our sample was surprising, since females typically demonstrate higher levels of engagement with mHealth interventions,¹¹ and a similar text-messaging program for adolescents with T1D found higher engagement among girls.³ It is possible that tailoring our messages by sending different Mood Boosters to girls and boys increased the appeal. In addition, while race/ethnicity influenced the level of adolescent engagement, the limited diversity of the sample ($n=21$ white, non-Hispanic vs. $n=3$ non-white in the PA group) prohibits drawing conclusions.

This study was limited by the small sample size and some missing/inaccurate glucometer data. In addition, the lack of findings related to glycemic control is likely due to the timing of our follow-up data collection, which may not have been long enough to show a change in HbA1c. While pilot study results must be interpreted with caution,¹² the use of a randomized design with an attention control group is a strength of the study. Furthermore, the good rates of engagement observed in this pilot study support that text messaging may be a feasible and acceptable method of delivery for a positive psychology intervention for a high-risk population, adolescents with suboptimal glycemic control. In line with previous findings,^{2,3} our results support the use of text messaging as a component of behavioral interventions for adolescents, who have high rates of cell phone ownership across racial/ethnic and socioeconomic groups and are most likely to use their phones for texting.¹³ Furthermore, in investigating adolescent engagement, this brief report contributes to the limited research currently available toward using text-messaging as a tool for management delivery in healthcare.¹¹

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Authors' Contributions

S.Z. conducted data analyses and wrote the article; E.H. edited the article and contributed to the Discussion; S.K. conducted data analyses; M.L. edited the article and created the table; R.W. edited the article and created the figure; S.J. designed the study and wrote the article.

Author Disclosure Statement

No competing financial interests exist.

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