Randomized Trial of a Positive Psychology Intervention for Adolescents With Type 1 Diabetes

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Abstract

Objective To evaluate the effects of a positive psychology intervention for adolescents with type 1 diabetes (T1D) on adherence, glycemic control, and quality of life. **Methods** Adolescents with T1D ($n=120$) and their caregivers were randomized to either an Education (EDU) ($n=60$) or Positive Affect (PA) intervention ($n=60$). Adolescents in the PA group received the intervention reminders (gratitude, self-affirmation, parental affirmation, and small gifts) via text messages or phone calls over 8 weeks. Questionnaires were completed by adolescents and caregivers and clinical data (glucometer and HbA1c) were collected at baseline 3 and 6 months. Data were analyzed using generalized linear modeling. **Results** After adjusting for covariates, adolescents in the PA group demonstrated significant improvement in quality of life at 3 months, compared to the EDU group, but this was not sustained at 6 months. Similarly, the PA group showed a significant decrease in disengagement coping at 3 months but not at 6 months. There was no significant intervention effect on blood glucose monitoring, but the odds of clinically significant improvement (checking at least one more time/day) were about twice as high in the PA group as the EDU group. No significant effects were found for glycemic control. **Conclusions** A positive psychology intervention had initial significant, positive effects on coping and quality of life in adolescents with T1D. A more intensive or longer-lasting intervention may be needed to sustain these effects and to improve adherence and glycemic control.

Key words: adherence; coping skills and adjustment; diabetes; intervention outcome; quality of life.

Type 1 diabetes (T1D) is one of the most common chronic childhood health conditions, affecting 1 in 400 youth (Hamman et al., 2014). To prevent acute and long-term complications, the recommended treatment regimen for people with T1D is intensive, including checking blood glucose at least four times per day, monitoring carbohydrate intake and activity levels, and administering insulin several times a day (American Diabetes Association, 2018). Adolescents with T1D struggle with adherence to this demanding

treatment regimen (Borus & Laffel, 2010), and in a recent study of a national sample, only 17% of youth age 13–17 were meeting glycemic targets recommended by the American Diabetes Association (Miller et al., 2015). Further, the intensive level of responsibility required to adhere to treatment recommendations is likely to increase stress (Anderson et al., 2002) and negatively impact quality of life in adolescents (DCCT Research Group, 1996). While previous behavioral interventions have had modest effects on adherence

and glycemic control (Hood, Rohan, Peterson, & Drotar, 2010), many were time-intensive and required the expertise of highly trained mental health professionals, and few have focused on a resilience, or strengths-based, approach in this population (Hilliard, Powell, & Anderson, 2016). Thus, novel approaches are needed to improve outcomes in this high-risk population.

Positive Affect (PA), defined as feelings that reflect pleasurable engagement with the environment, may help people to cope with diabetes-related stress or challenges by providing respite from stress and increasing motivation (Fredrickson & Branigan, 2005). Increased PA is thought to “broaden and build” people’s coping strategies, enhancing the use of more complex and adaptive strategies, while reducing the use of avoidant/disengagement strategies (Fredrickson & Joiner, 2002). The use of PA has been linked to favorable health outcomes, such as reduced symptoms and pain (Pressman & Cohen, 2005) and was related to greater competence for diabetes management in adolescents with T1D (Fortenberry et al., 2009). In a recent study of adolescents with T1D, self-reported and observed PA was associated with better glycemic control and quality of life in adolescents with T1D, and higher levels of PA predicted improvements in glycemic control over 6 months (Lord, Rumburg, & Jaser, 2015). Thus, interventions aimed at increasing PA have the potential to improve adherence and other health outcomes in adolescents with T1D.

Charlson and colleagues (2007) have conducted a series of randomized clinical trials of positive psychology interventions aimed at improving adherence in adults with chronic illness by inducing PA. In these studies, adults with hypertension (Ogedegbe et al., 2012) and cardiovascular disease (Peterson et al., 2012) who received the PA intervention had significantly higher levels of adherence over 12 months than those who received patient education only. The study protocols included monthly phone calls to remind participants to notice small things that made them happy (gratitude), reflect on things that they were proud of (self-affirmation), and small gifts in the mail (unexpected pleasures). These PA interventions have not been widely tested in pediatric populations, however, and it is not known whether modifications are needed to make them more developmentally appropriate. Our research team conducted a small pilot study (Jaser, Patel, Rothman, Choi, & Whittemore, 2014) to demonstrate the feasibility and acceptability of a similar intervention in adolescents with T1D, but findings suggested that the format was not ideally suited to adolescents. Specifically, adolescents were not always available for phone calls, and biweekly contact did not seem to be frequent enough to remind adolescents to use the PA exercises. In addition, the inclusion of family members may be essential for pediatric populations. We used findings from qualitative exit

interviews conducted with participants in the initial pilot study, as well as national trends in teen technology use (Duggan, 2013), to guide the changes to the protocol. In addition, feedback was obtained from adolescents with T1D on specific aspects of the study protocol (e.g., options for small gifts, topics for diabetes education) prior to the start of the current trial. The current protocol was adapted to increase contact with adolescents from biweekly to weekly, caregivers were sent weekly reminders to provide affirmations to their adolescent children, and we piloted delivering the PA intervention reminders using an automated text-messaging system versus phone calls.

Current Study

We conducted a randomized trial to evaluate the effects of a positive psychology intervention on glycemic control, adherence, and quality of life. The study is based on the premise that, by increasing PA, we would enhance adolescents’ use of adaptive coping strategies, which, in turn, would increase adherence behaviors and improve glycemic control. The primary outcome was glycemic control. The intervention was aimed at increasing adolescents’ frequency of blood glucose monitoring (BGM), which may be the best proxy for adherence, as it is strongly related to glycemic control (Haller, Stalvey, & Silverstein, 2004; Miller et al., 2013). Further, frequency of BGM has been shown to decrease with age in adolescents (Ingerski, Anderson, Dolan, & Hood, 2010). We hypothesized that adolescents who received the positive psychology intervention would demonstrate better glycemic control, adherence, and quality of life over time than those who received the attention control (education) intervention. We also examined the effects of the intervention on coping and PA. Finally, we explored differences in response rate and outcomes between participants who received the intervention by phone versus automated text messages.

Methods

The current study was a parallel randomized controlled trial of a positive psychology intervention for adolescents with T1D (NCT02746627). Recruitment occurred from January, 2014 to May, 2015 during regularly scheduled diabetes outpatient clinic visits at a large academic medical center in the Southeast that serves a catchment area of five states, including urban, suburban, and rural communities. Adolescents age 13–17 were eligible if they had been diagnosed with T1D for at least 6 months,¹ spoke and read English, and had glycosylated hemoglobin (HbA1c) levels between 8%–12%. The HbA1c range was chosen to

¹ Only one participant had been diagnosed less than 12 months.

Table I. Demographics and Baseline Clinical Characteristics by Treatment Group

Characteristic	EDU (<i>n</i> = 60)	PA (<i>n</i> = 60)	Total sample (<i>n</i> = 120)	<i>t</i> -test/chi-square
Adolescent Age, <i>M</i> (<i>SD</i>)	14.88 (1.42)	14.78 (1.47)	14.83 (1.44)	0.38 (<i>p</i> = .705)
Duration of Diabetes, <i>M</i> (<i>SD</i>)	6.22 (3.60)	5.47 (3.67)	5.84 (3.64)	1.13 (<i>p</i> = .261)
A1C, <i>M</i> (<i>SD</i>)	9.17 (0.84)	9.15 (0.96)	9.16 (0.90)	0.18 (<i>p</i> = .856)
Sex				
Male, <i>n</i> (%)	25 (42)	32 (53)	57 (47)	1.64 (<i>p</i> = .201)
Female, <i>n</i> (%)	35 (58)	28 (47)	63 (53)	
Race/Ethnicity				
White, Non-Hispanic, <i>n</i> (%)	53 (88)	52 (87)	105 (88)	0.01 (<i>p</i> = .973)
Other, <i>n</i> (%)	7 (12)	7 (12)	14 (12)	
Unknown, <i>n</i> (%)	0	1 (1)	1 (0)	
Annual Income (USD)				
<39,000, <i>n</i> (%)	19 (32)	13 (22)	32 (27)	2.24 (<i>p</i> = .327)
40,000–79,000, <i>n</i> (%)	19 (32)	26 (43)	45 (38)	
>80,000, <i>n</i> (%)	22 (36)	21 (35)	43 (36)	
Treatment Type				0.30 (<i>p</i> = .584)
Insulin Pump, <i>n</i> (%)	29 (48)	32 (52)	61 (51)	
Injection, <i>n</i> (%)	31 (52)	28 (48)	59 (49)	

include those who were not meeting treatment goals (American Diabetes Association recommendation at the time the study began was <8% for adolescents) but who were not in extremely poor glycemic control (>12%), for whom a low-intensity intervention may not be effective. Adolescents who had other serious medical issues that may interfere with diabetes management were not eligible for the study. Caregivers were eligible if they could read and speak English, and if they lived with the child at least 50% of the time, to ensure that they would be available to provide parental affirmations. These eligibility criteria were determined based on the medical record and caregiver responses.

In line with the protocol approved by the University Institutional Review Board (IRB #131384), research staff described the study to interested families, and caregivers and adolescents provided informed consent/assent (see Table I for demographic and clinical characteristics of the final sample). Adolescents and their parents completed psychosocial questionnaires electronically on REDCap, a HIPAA-protected secure site (Harris et al., 2009) at baseline and 3 and 6 months after baseline, corresponding with regularly scheduled clinic visits. Surveys were typically completed in the clinic before or after visits, but some participants completed follow-up surveys from home (e.g., if they missed their clinic appointment). Follow-up data collection occurred from April, 2014 to December, 2015. Glucometers were downloaded and HbA1c was obtained as part of regular care at each corresponding clinic visit. After collecting baseline survey data, adolescents were randomly assigned to an intervention condition. The randomization scheme was generated by the study biostatistician using a computer program in which block sizes were randomly chosen from 2, 4, 6, and 8, to ensure equal numbers of participants in the PA and EDU groups (60 each), and equal numbers of participants in the

PA-Phone Reminder and PA-Text Reminder groups (30 each). The research assistant assigned participants to a study condition based on the randomization scheme and informed participants of their intervention condition.

As seen in the CONSORT diagram (Figure 1), participation was fairly high: 65% of eligible adolescents enrolled in the study (*n* = 120). There were no significant differences between those who did or did not participate on mean HbA1c, age, sex, or race/ethnicity. Retention was also quite high: 91% of participants completed questionnaire data at 3 months, and 91% completed data at 6 months. Clinical data collection (HbA1c) was 98% at 6 months. Only three participants withdrew from the study (one from the EDU group and two from the PA group). One participant (EDU group) withdrew after completing the 3-month data to participate in another study, one participant (PA-Phone Reminder group) withdrew after the intervention due to a family member's health problems, and one participant (PA-Text Reminder group) withdrew after completing baseline data, due to the time commitment. No study-related adverse events occurred.

Interventions

EDU Intervention

Adolescents randomized to the EDU intervention (*n* = 60) received educational materials in the mail every 2 weeks for 8 weeks. These three-page packets included information available on the American Diabetes Association website (www.diabetes.org) in simple language on topics such as Hypoglycemia, HbA1c, and Driving with Diabetes. Similar to the protocol established by Charlson and colleagues (2012), adolescents in the EDU group also completed a health behavior contract, in which they identified a goal for increasing frequency of BGM. The health behavior

Figure 1. CONSORT diagram.

contact focused the participant on the goal for adherence, to ensure that we were evaluating the effects of the PA intervention, rather than differences in knowledge or attention to adherence.

PA Intervention

Adolescents randomized to the PA intervention ($n = 60$) received the same materials as those in the EDU group for 8 weeks, as well as several components

intended to induce PA. At the time of enrollment, adolescents met with trained research assistants to complete a brief PA interview, in which adolescents identified sources of gratitude (“What’s something that makes you happy, even for a moment?”) and self-affirmation (“What’s something you are proud of?”). To guide this interview, the adolescent was given a worksheet with examples of each. In addition, parents were instructed to provide affirmations to their

adolescents on a weekly basis (e.g., “Nice job on your math test.”) and reminders for parent affirmations were sent weekly by phone or text message (based on parental preference). Study staff were trained by the Principal Investigator (PI) on how to administer the health behavior contract and the PA interview, including mock sessions. Further, study staff attended 8 hr of diabetes education, in addition to required training in human subjects research. The Research Assistants (RAs) followed a guided script and used a detailed worksheet to guide the PA interview. These worksheets were reviewed for fidelity by the PI. Adolescents in the PA group also received small gifts as a way to boost PA, in line with the initial protocol developed and tested by [Charlson and colleagues \(2007\)](#). These small gifts were not intended to reinforce specific behaviors; rather, they were a way to boost PA.

PA-Text Reminders Condition

Adolescents randomized to the PA text condition ($n = 30$) received weekly PA reminders, via automated, standardized text messages for 8 weeks. In these messages, they were asked to report whether they had noticed something that made them happy that week (gratitude). They were also reminded to think of something that made them proud when it was difficult to test their blood sugar (self-affirmation). Adolescents indicated preferred times to receive text messages, and messages were not sent during school hours. To measure engagement with the text messages, each series of messages started with the statement, “Reply to this message with any text.” In addition, every two weeks, adolescents were sent an Amazon gift card code worth \$5.00. Parents were sent weekly text messages to remind them to provide affirmations to their adolescents.

PA-Phone Reminders Condition

Adolescents randomized to the PA phone condition ($n = 30$) received weekly PA phone calls from a trained research assistant for 8 weeks. The wording of the phone call script and text messages was identical (e.g., “The last time we spoke you told me some things that made you feel good. Have you noticed those things this week? Is there anything new that has made you feel good this week? If yes, what has made you feel good?”). Adolescents indicated preferred times to receive phone calls, and calls were not made during school hours. In addition, every 2 weeks, adolescents were mailed a small gift worth approximately \$5.00 (e.g., phone charger, lanyard).

Measures

Glycemic control was determined by the point-of-care HbA1c test conducted as part of the clinic visit.

HbA1c is an average of blood glucose levels over the prior 8–12 weeks. Analyses were performed using the Bayer Diagnostics DCA2000[®] machine (normal range = 4.2–6.3%).

The mean frequency of BGM was used as an objective measure of adherence ([Haller et al., 2004](#)). Mean BGM (average checks per day over the previous 30 days) was obtained by downloading the adolescent’s glucometer at the time of enrollment, 3 month, and 6 month follow-up visits.

As an additional measure of adherence, the Self Care Inventory (SCI) was used to assess adolescents’ and parents’ perceptions of how well adolescents followed diabetes treatment recommendations ([La Greca, 2004](#)). The scale consists of 14 items, and mean scores range from 1 (Never do it) to 5 (Always do this as recommended without fail). In the current study, internal consistency was 0.78 for adolescents’ self-report at baseline, 0.82 at 3 months, and 0.75 at 6 months. Internal consistency was 0.77 for parent report at baseline, 0.78 at 3 months, and 0.79 at 6 months.

The Positive and Negative Affect Scale for Children was used to measure adolescents’ affect ([Laurent et al., 1999](#)). The measure consists of 27 items: a PA scale made up of 15 items (e.g., interested, excited, proud) and a negative affect scale made up of 12 items (e.g., upset, guilty, scared). Participants were asked to rate to what extent they experienced each emotion over the past 2 weeks, on a scale of 1 (very slightly or not at all) to 5 (extremely); higher scores indicate higher levels of affect. In the current study, internal consistency was $\alpha = 0.90$ for PA at baseline, 0.91 at 3 months, and 0.94 at 6 months.

The Pediatric Quality of Life Inventory Type 1 Diabetes Module (PedsQL) was completed by adolescents to assess their quality of life ([Varni et al., 2003](#)). It consists of 28 items, with a standardized score ranging from 0 to 100. Higher scores indicate better quality of life. In the current study, internal consistency was $\alpha = 0.87$ for adolescents at baseline, 0.87 at 3 months, and 0.90 at 6 months.

The Responses to Stress Questionnaire (RSQ) was used to measure adolescents’ coping with diabetes-related stress ([Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000](#)). The scale consists of 57 items, and confirmatory factor analyses support three separate coping factors on the RSQ ([Compas et al., 2006](#); [Connor-Smith et al., 2000](#)): primary control engagement coping (problem solving, emotional modulation, emotional expression) ($\alpha = 0.78$ at baseline, 0.79 at 3 months, and 0.81 at 6 months); secondary control engagement coping (positive thinking, cognitive restructuring, acceptance, distraction) ($\alpha = 0.75$ at baseline, 0.81 at 3 months, and 0.82 at 6 months); and disengagement coping (avoidance, denial, wishful

thinking) ($\alpha = 0.82$ at baseline, 0.86 at 3 months, and 0.84 at 6 months). To control for individual differences in rates of endorsing items, proportion scores were used in analyses (Vitaliano, Maiuro, Russo, & Becker, 1987).

Because adolescent depression could have a confounding effect on participation or response to the intervention, the Patient Health Questionnaire (PHQ-9; Richardson et al., 2010) was used to measure adolescents' depressive symptoms at baseline. The PHQ-9 consists of 9 items, with scores ranging from 0 to 27, and higher scores indicate higher levels of depression. If adolescents scored ≥ 20 , indicating severe symptoms of depression, or endorsed suicidal ideation (item 9), we followed a self-harm protocol to ensure their safety. The PI (a licensed clinical psychologist) followed up with the adolescent and his/her parents and referred for treatment if needed. In the current study, internal consistency was $\alpha = 0.79$ at baseline.

Demographic information, including family income, caregivers' marital status, and the caregiver's and child's race/ethnicity was provided by caregivers.

We conducted exit interviews and obtained satisfaction data from study participants to assess acceptability (reported in Bergner et al., 2018).

Data Analysis

Data were graphically examined to check for outliers as well as distribution for continuous outcomes. Identified outliers were manually checked in the REDCap database and corrected if needed. As a sensitivity analysis, we performed multiple imputations and determined that results were not sensitive to missing data ($<10\%$ of data); the models presented in this paper were based on a complete case analysis. Sample size was based on power calculations for to detect clinically meaningful differences in BGM. With a sample size of 120, we had power of 0.19 to detect small effects, power of 0.78 to detect moderate effects, and power of 0.99 to detect large intervention effects.

Baseline differences in demographic and clinical variables between the EDU and PA groups were compared using Chi-square test for categorical variables and Wilcoxon rank sum test for continuous variables. The primary analyses were performed using multiple linear regressions with adjustment of covariates and PA group as the main effect. The following *a priori* selected covariates were adjusted in each analysis: age, sex, race/ethnicity, income, baseline depressive symptoms, pump use, and baseline measurement for each outcome, for a total of 18 analyses. As secondary outcomes, clinically meaningful changes from the baseline were *a priori* defined for glycemic control ($\geq 0.5\%$ decrease of HbA1c, Nathan et al., 2009) BGM (≥ 1.0 increase, Miller et al., 2013) and quality of life (≥ 5.27

increase, Hilliard et al., 2013) as a reference point for researchers and clinicians. The analyses for secondary outcomes were performed using logistic regressions with adjustment of the same covariates except baseline measurement for each outcome. Finally, we conducted exploratory analyses using multiple linear regressions with adjustment of covariates and baseline measurement for each outcome to determine whether there were variations (estimated mean differences) in outcomes related to the type of PA reminders (phone vs. text message). All analyses were performed using the programming language R version 3.3.0 (R Core Team, 2016).

Results

Primary Analyses

The PA and EDU groups were not significantly different for demographic and clinical variables at baseline (see Table I).

3-Month Follow-Up

Overall, as seen in Table II, the PA intervention significantly improved quality of life (mean difference = 3.88, 95% Confidence Interval (CI) = 0.58 to 7.18, $p = .022$). There were no significant intervention effects on frequency of BGM or glycemic control (mean difference = 0.00, 95% CI = -0.52 to 0.52, $p = .996$ for BGM; mean difference = 0.03, 95% CI = -0.34 to 0.41, $p = .860$ for HbA1c). In addition, there were no significant intervention effects on parent-reported adherence on the SCI (mean difference = 0.46, 95% CI = -0.91 to 1.83, $p = .506$) or adolescent-reported adherence (mean difference = 0.04, 95% CI = -1.80 to 1.88, $p = .964$).

Regarding effects on coping, the PA intervention significantly decreased disengagement coping (mean difference = -0.01, 95% CI = -0.02 to 0.00, $p = .018$), but there were no significant intervention effects for primary control coping (mean difference = 0.01, 95% CI = -0.01 to 0.02, $p = .481$). Compared to the EDU group, there was not a significant effect on secondary control coping for the PA group (mean difference = 0.01, 95% CI = 0.00 to 0.03, $p = .168$). No significant intervention effect on PA was observed (mean difference = 1.0, 95% CI = -1.69 to 3.65, $p = .469$).

6-Month Follow-up

As seen in Table II, there was no significant intervention effect on quality of life (mean difference = 1.28, 95% CI = -3.13 to 5.70, $p = .569$) at six months. Similarly, there were no significant intervention effects on BGM or glycemic control (mean difference = 0.21, 95% CI = -0.31 to 0.73, $p = .434$ for BGM; mean difference = -0.12, 95% CI = -0.53 to 0.29, $p = .557$

Table II. Summary of Diabetes and Psychosocial Outcomes at Each Time Point by Intervention Group

Variable	Baseline (M + SD)	3 months (M + SD)	Effect Size (d)	6 months (M + SD)	Effect Size (d)
PedsQL					
PA	71.3 ± 11.9	74.2 ± 11.5	0.34	76.0 ± 11.8	0.29
Education	70.2 ± 11.9	70.1 ± 12.4		72.4 ± 13.4	
BGM					
PA	3.6 ± 1.9	3.3 ± 2.1	0.16	3.3 ± 1.9	0.18
Education	3.2 ± 1.8	3.0 ± 1.5		3.0 ± 1.3	
HbA1c					
PA	9.2 ± 0.97	9.0 ± 1.1	0.00	9.0 ± 1.2	0.15
Education	9.2 ± 0.84	9.0 ± 1.4		9.2 ± 1.4	
SCI (teen)					
PA	25.9 ± 4.9	26.6 ± 5.9	0.31	26.6 ± 4.9	0.36
Education	21.0–28.0	24.8 ± 5.8		24.7 ± 5.5	
SCI (parent)					
PA	25.3 ± 4.9	25.3 ± 4.7	0.20	25.8 ± 4.5	0.38
Education	25.0 ± 5.3	24.3 ± 5.2		23.9 ± 5.5	
Primary Control Coping					
PA	0.17 ± 0.02	0.18 ± 0.04	0.28	0.19 ± 0.04	0.25
Education	0.18 ± 0.03	0.17 ± 0.03		0.18 ± 0.04	
Secondary Control Coping					
PA	0.19 ± 0.03	0.28 ± 0.06	0.36	0.27 ± 0.06	0.18
Education	0.20 ± 0.03	0.26 ± 0.05		0.26 ± 0.05	
Disengagement Coping					
PA	0.16 ± 0.02	0.14 ± 0.03	0.33	0.14 ± 0.03	0.00
Education	0.16 ± 0.02	0.15 ± 0.03		0.14 ± 0.03	
Positive Affect					
PA	27.2 ± 6.7	40.6 ± 9.2	0.23	39.0 ± 10.0	0.29
Education	25.7 ± 4.9	38.6 ± 8.3		36.0 ± 11.0	

Note. PA = Positive Affect; PedsQL = Pediatric Quality of Life; BGM = average daily blood glucose monitoring; SCI = Self Care Inventory; d = Cohen's d.

for HbA1c) at 6 months. In addition, there were no significant intervention effects on adolescent-reported adherence on the SCI (mean difference = 0.20, 95% CI = -1.60 to 2.01, $p = .825$) or parent-reported adherence on the SCI at 6 months (mean difference = 1.21, 95% CI = -0.37 to 2.79, $p = .132$).

No significant intervention effects were found for any coping factors at 6 months: for primary control coping, mean difference = 0.00, 95% CI = -0.01 to 0.02, $p = .668$; for secondary control coping, mean difference = 0.01, 95% CI = -0.01 to 0.03, $p = .328$; and for disengagement coping, mean difference = -0.01, 95% CI = -0.02 to 0.01, $p = .290$. Finally, no significant change PA was observed at 6 months (mean difference = 3.59, 95% CI = -1.40 to 8.57, $p = .156$).

Secondary Analyses

The odds of clinically significantly improvement in quality of life (at least 5.27 increase of PedsQL) were about 2.8 times higher in the PA group than in the EDU group at 3 months (Odds Ratio (OR) = 2.8, 95% CI = 1.01 to 7.66, $p = .049$), but the intervention effect was not retained at 6 months. In terms of BGM, for those in the PA group, the odds of clinically significantly improvement (checking at least one more time/day) were about twice as high as for those in the EDU

group at 3 months, but this was not statistically significant (OR = 1.9, 95% CI = 0.51 to 7.13, $p = .337$). No intervention effects were found for clinically significant improvements in glycemic control at 3 or 6 months.

Exploratory Analyses of PA Subgroups

We examined feasibility and acceptability of the PA-phone reminders and PA-text reminders subgroups (Bergner et al., 2018). In terms of engagement, 16% of adolescents in the PA-Phone Reminder group responded to calls, while 66% of adolescents in the PA-Text Reminder group responded to text messages.

We also explored differences in outcomes between the two subgroups. In terms of quality of life, a significant improvement was observed for those in the PA phone group at 3 months (mean difference = 4.07, 95% CI = 0.09 to 8.04, $p = .045$), while the improvement was marginal for those in the text group (mean difference = 3.64, 95% CI = -0.67 to 7.95, $p = .097$). There was no significant difference in quality of life at 6 months in either subgroup. Regarding effects on coping, there was a significant decrease in disengagement coping in the PA phone group at 3 months (mean difference = -0.02, 95% CI = -0.03 to 0.00, $p = .030$), but not in the PA text group (mean difference = -0.01, 95% CI = -0.03 to 0.00,

$p = .108$). A significant increase in secondary control coping was also observed in the PA phone group at 3 months (mean difference = 0.02, 95% CI = 0.00 to 0.04, $p = .022$) but not in the PA text group (mean difference = -0.00, 95% CI = -0.02 to 0.02, $p = .834$). No significant effects were observed for primary control coping or PA at 3 months, and there were no significant differences in coping or PA at 6 months for either subgroup. There were no significant intervention effects for either subgroup on glycemic control or adherence (frequency of BGM or SCI) at 3 months or 6 months.

Conclusions

In this randomized trial, a positive psychology intervention did not have the expected effects on glycemic control or adherence in adolescents with T1D, but we did observe significant, positive effects in quality of life initially. Further, adolescents who received the positive psychology intervention reported decreased use of disengagement coping strategies (e.g., avoidance, withdrawal) over 3 months. A more intensive or longer-lasting intervention may be needed to sustain these effects and to improve adherence and glycemic control.

The initial impact of the intervention on quality of life was significant and clinically meaningful, which is noteworthy for a relatively low-intensity intervention. Further, the significant effect on disengagement coping is in line with the broaden-and-build hypothesis (Fredrickson & Joiner, 2002), suggesting that increased PA broadens the range of coping strategies used. It is important to note that the coping variables are ratio scores, and therefore these findings reflect a shift from less adaptive coping strategies (e.g., avoidance, withdrawal), to more adaptive strategies, such as acceptance. In other studies of coping in adolescents with T1D, greater use of primary and secondary control coping has been found to mediate the effects of diabetes-related stress on quality of life (Jaser, Patel, Xu, Tamborlane, & Grey, 2017). Thus, the shift away from using disengagement coping strategies observed in the PA group may be related to the improvements in quality of life.

Although we did not find a significant intervention effect on glycemic control or adherence at 3 months or 6 months, we did find that the odds of clinically significant improvement in BGM (checking at least one more time/day) were about twice as high in the PA group as compared to those in the EDU group at 3 months. These results suggest that the intervention had some impact on adherence behaviors, but that a more intensive or longer-lasting intervention may be needed to sustain these effects and to improve glycemic control. Given the mixed findings of the current

trial, we believe that a higher-intensity intervention may be needed to observe significant changes in health behaviors. It is possible that this strengths-based intervention had a stronger effect on quality of life, via increased use of adaptive coping strategies, than on the downstream factors of adherence and glycemic control. Further, given that adolescents in this age group are at such high risk for not meeting glycemic targets and problems with adherence (Miller et al., 2015), it may be that this intervention was preventing deterioration of glycemic control, rather than improving it. Finally, although a change in PA was anticipated in participants who received the PA intervention, we did not find significant effects on PA in our analyses. It is possible that the timing of the measurement did not allow us to detect these changes, and that we were observing the downstream effects of PA on coping and quality of life. Our findings are similar to a trial with adults testing a PA intervention, in which no significant difference in PA was observed (Boutin-Foster et al., 2016).

Translating a positive psychology intervention from adults to adolescents requires attention to developmental perspective. For example, while weekly contact may be sufficient, or even perceived as burdensome for adults (Nelson, Coston, Cherrington, & Osborn, 2016), it may not have been frequent enough for adolescents, who send/receive up to hundreds of text messages a week (Duggan, 2013). Based on our exploratory data, text messages appear to be preferable to phone for intervention delivery. Similar to another recent study using text messages to improve self-management in adolescents with T1D (Herbert, Mehta, Monaghan, Cogen, & Streisand, 2014), we found a response rate of 66% to text messages, as compared to only 16% response rate to phone calls. However, automated text messages increase the risk for system errors (Herbert, Owen, Pascarella, & Streisand, 2013). The low response rate to the phone calls indicates that this was not a feasible method to provide reminders to use PA exercises. Adolescents in the phone reminder condition still received the same PA intervention at baseline as those in the text condition, and our results suggest that the initial PA interview had some impact on the adolescents, even if they did not receive the reminder calls. Differences in outcomes between the phone and text subgroups were minor. More details regarding feasibility and acceptability of the current study are presented elsewhere (Bergner et al., 2018).

Limitations of the current study must be noted. The sample had a relatively few racial/ethnic minority participants; however, it is important to note that T1D is most common in White, non-Hispanic youth (Hamman et al., 2014), and our sample included a range of income levels and geographic regions (urban

and rural), which was representative of the clinic population. Participants agreed to participate in a randomized trial and therefore may have been more motivated to improve adherence behaviors than adolescents in the general population. Further, the eligibility criteria related to HbA1c may impact the generalizability of these findings; it is possible that adolescents with an initial HbA1c >12% may benefit more or less from the intervention than those within our eligible range. Finally, the study was not powered to detect significant differences between the phone and text delivery of PA reminders.

The current study demonstrated the potential for a positive psychology intervention to improve quality of life in adolescents with T1D, but the results did not support the hypothesized effects on adherence or glycemic control. Thus, findings from the current study suggest that the current intervention may be useful as an adjunct to a larger combination intervention, or that more work into key components of the intervention, with feedback from stakeholders, is needed to make the intervention more effective. For example, the PA reminders could be delivered with text messages only (no phone condition), increased contact may strengthen the effects of the intervention, and parents may need more detailed instructions for providing positive messages to their adolescents (e.g., praise specific behaviors, avoid comments on diabetes care). Findings suggest that adolescents may benefit from health care providers taking a positive psychology approach (focusing on gratitude, self-affirmations, and parental affirmations) as a way to improve quality of life. Further studies are needed to determine whether this approach has clinical implications for adherence to treatment and glycemic control. In conclusion, the current study provides initial support for a positive psychology intervention to improve quality of life and coping in adolescents with T1D, but more work is needed to increase and sustain the impact of the intervention.

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