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Effects of Stress Management and Relaxation Training on the Relationship between Diabetes Symptoms and Affect among Latinos

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Abstract

Objective: Stress management and relaxation (SMR) interventions can reduce symptoms of chronic disease and associated distress. However, there is little evidence that such interventions disrupt associations between symptoms and affect. This study examined whether SMR dampened the link between symptoms of hyperglycemia and proximal levels of affect. We predicted that during periods of increased hyperglycemia, individuals receiving SMR training, relative to controls, would demonstrate smaller increases in negative affect.

Design: Fifty-five adult Latinos with type 2 diabetes were randomized to either one group session of diabetes education (DE-only; N = 23) or diabetes education plus eight group sessions of SMR (DE+SMR; N = 32). After treatment, participants reported five diabetes symptoms and four affective states twice-daily for seven days using a bilingual telephonic system.

Results: Mean age = 57.8 years, mean A1c = 8.4%, and ¾ was female with less than a high school education. Individuals receiving DE+SMR, compared to DE-only, showed a weaker positive within-person association between daily diabetes symptoms and nervous affect. Groups also differed on the association between symptoms and enthusiasm. Age moderated these associations in most models with older individuals showing less affect reactivity to symptoms.

Conclusions: Findings provide partial support for theorized mechanisms of SMR.

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Keywords

Daily process; affect-reactivity; diabetes symptoms; stress management; Latinos

Hyperglycemia is the hallmark of diabetes. Living with type 2 diabetes entails experiencing transient, or sometimes chronic, symptoms of hyperglycemia and its complications. Presence and severity of symptoms of hyperglycemia are associated with increased levels of negative affect, including symptoms of panic (Ludman et al., 2006), anxiety and depression (Paddison et al., 2011). Living with type 2 diabetes also entails difficulties including a complex routine of self-management behaviors, disruption of daily routine, potentially uncomfortable social situations, aversive healthcare interactions, and navigating an often confusing healthcare environment. Moreover, individuals most at risk for diabetes, i.e., racial and ethnic minorities and those from low socio-economic backgrounds, face experiences that may increase risk for psychological distress. Thus, psychological distress is common in persons with diabetes but remains only partially understood.

There is evidence that interventions aimed at stress-management and relaxation (SMR) are efficacious for reducing overall levels of distress associated with chronic conditions and their symptoms (e.g., Hall et al., 2017; van Son et al., 2013; Duncan et al., 2012). However, little research has directly examined whether such interventions dampen concurrent emotional reactions to spikes in symptom levels in everyday life, i.e., one of the implied mechanisms underlying such techniques.

In the present study, we examined how within-person daily changes in affective states covaried with temporally proximal diabetes symptoms and whether this association was attenuated for individuals receiving SMR training compared to individuals in a control condition. We examined this in a sample of Latinos with type 2 diabetes. Latinos are an appropriate and important group for this research question. Compared to non-Latino Whites, Latinos are almost twice as likely to have diabetes, with the highest prevalence among Puerto Ricans (Melnik et al., 2004). Compared to their non-Latino White counterparts with diabetes, Latinos also have higher rates of diagnosed anxiety disorders (Li et al., 2008) and diabetes-related emotional distress (Peyrot et al., 2014).

Evaluating daily processes in clinical interventions

Over the last several decades, there has been increased attention among clinical researchers on modeling the associations among dynamically changing thoughts, affective states and physical symptoms associated with chronic disorders. This line of research has been facilitated by the increasing use of micro-longitudinal (daily process) research designs (Mehl & Connor, 2012; Reis, Gable, & Maniaci, 2014) and data-analytic techniques such as multilevel modeling (e.g., Raudenbush & Bryk, 2002). Research questions in this area usually involve “when-then” sequences such as how individuals’ thoughts and emotions change *when* potential triggers occur (e.g., physical symptoms, stressors, etc.). Intensive repeated assessment (e.g., daily, multiple times per day) of such variables in or close to real time allows for modeling contingencies at the appropriate level of analysis and reduces numerous self-report errors and biases associated with recall of such phenomena over long

periods of time (Shiffman, 2000; Tennen, Affleck, Armeli, & Carney, 2000). Analytically, these within-person dynamic processes are modeled as regression slopes derived from the repeated assessments of the predictor (e.g., trigger) and outcome (e.g., affect). Researchers then attempt to explain variation in these slopes – commonly referred to as individual differences in “reactivity” – by predicting them from relevant person-level variables such as personality traits (e.g., (Bolger & Zuckerman, 1995), genetic dispositions (e.g., (Gunthert et al., 2007), or clinical symptoms and disorders (e.g., O’Hara, Armeli, Boynton, & Tennen, 2014).

Relatively few studies, however, have examined daily process-derived reactivity slopes as outcomes in clinical interventions. Such an approach would be useful for validating mechanisms underlying successful interventions such as showing how mean level differences in symptoms and distress correspond to changes in symptom-related reactivity. In addition, this approach could shed light on unintended effects of treatment, which in some cases, might help explain why such interventions failed to produce mean level differences in the outcomes of interest. For example, Davis, Zautra, Wolf, Tennen, and Yeung (2015) used a pre-post micro-longitudinal design to compare the effects of various treatment modalities – i.e., mindfulness meditation (MM), cognitive-behavioral therapy (CBT) and arthritis education – on pain-related appraisals and affect among arthritis patients. Results showed that although CBT outperformed MM in terms of pain control, MM resulted in greater reductions in daily reactivity, i.e., weaker positive within-person associations between daily pain and catastrophizing appraisals and fatigue. Similarly, Parrish et al. (2009) found that patients receiving CBT for depression showed decreased mean depression levels and dampened (less positive) within-person daily associations between the number of daily stressors and sadness from pre- to post-intervention. Interestingly, Parrish et al. also found that the within-person association between negative thoughts related to daily stressors and sadness became stronger (more positive) pre- to post-treatment (i.e., increased negative thought-reactivity). They posited that therapy’s instruction to attend closely to such thoughts might have exacerbated its effect on negative affect, at least in the short term. More generally, findings from these intervention studies highlight the benefit of examining within-person daily processes (slopes) in addition to mean levels of outcomes of interest. Whereas some behavioral interventions for type 2 diabetes have been shown to decrease the number and severity of diabetes symptoms (Garcia, Brown, Horner, Zuniga, & Arheart 2015), and others have been shown to reduce psychological distress and improve well-being (Tavote et al., 2014; Safren et al., 2014; van Son et al., 2014; Ebert et al., 2017), to our knowledge, none have reported daily symptom-affect reactivity slopes as outcomes.

The present study

This study examined whether SMR training dampens the association between the day-to-day ebb and flow of diabetes symptoms and negative affect. The core aim of SMR interventions is to provide patients with techniques to reduce negative affect when noxious stimuli occur, which in turn, is posited to aid in decreasing overall levels of distress. The present study examined this question in a sample of Latinos with type 2 diabetes who were randomized to SMR plus diabetes education (DE+SMR) or DE-only conditions. The sample in the present study – which is a subset of the larger study – completed a week of twice-daily (morning

and evening) interactive voice response (IVR) in which they reported their affective states and diabetes symptoms. We previously reported that compared to DE-only, individuals receiving DE+SMR showed reduced mean levels of symptoms of depression and anxiety and improved self-reported health using traditional one-time retrospective reports (Wagner et al., 2016). The present study employed a randomized two-group post-test only design to examine the following questions. First, we wanted to replicate findings from Wagner et al. (2016) showing that individuals receiving DE+SMR training, compared to DE-only, reported lower mean levels of post-intervention mean negative affect (assessed daily using IVR). Of greater interest was to examine whether DE+SMR training, compared to DE-only, weakened the link between changes in diabetes symptoms and negative affect (i.e., diabetes symptoms affect-reactivity). Thus, our central hypothesis was that individuals receiving SMR+DE training, compared to individuals receiving DE-only training, would show weaker positive associations between relative increases in daily symptoms of hyperglycemia and negative affect.

As a comparison, we also examined symptom reactivity for positive affective states. More generally, we selected affective states that represent different quadrants on the affect circumplex model (Larsen & Diener, 1985) derived from the activation (arousal) and valence (pleasantness) axes to examine possible differential effects. Specifically, we assessed sad (low activation/negative valence), enthusiastic (high activation/positive valence) and calm (low activation/positive valence) affect.

Finally, in a more exploratory fashion, we also examined whether daily symptom reactivity was stronger among individuals with higher overall levels of diabetes symptoms. The common strategy for examining affect-reactivity is to examine how deviations from individuals' mean levels of stressors (i.e., diabetes symptoms in our case) relates to temporally proximal affect levels (e.g., Bolger & Zuckerman, 1995; Gunthert et al., 2007). Although this approach allows us to focus on within-person effects, i.e., how does affect change when individuals experience changes in diabetes symptoms, it does not take into account individual differences in the diabetes symptoms. One possibility is that higher mean levels of diabetes symptoms results in greater strain on emotion regulation resources (Baumeister, Vohs, & Tice, 2007), which in turn results in greater spikes in negative affect (or decreases in positive affect) as a function of relative increases in diabetes symptom levels.

Methods

Participants and Procedure

The Community Health Workers Assisting Latinos Manage Stress and Diabetes (CALMS-D) trial (Wagner et al., 2015; Wagner et al., 2016) employed community health workers (CHWs) to deliver group diabetes education and a group stress management and relaxation interventions designed for Latinos with type 2 diabetes. A subsample of participants were enrolled in this sub-study upon their completion of the main CALMS-D trial between 2012 and 2014. The UConn Health Institutional Review Board approved all procedures and participants provided written informed consent for the trial and then separately for the sub-study. Participants of the parent study were recruited from a Hartford Hospital outpatient

community clinic that serves primarily Latino and low-income patients. Inclusion criteria were: adult resident of Hartford, self-identified Latino or Hispanic, Spanish-speaking, ambulatory, with type 2 diabetes 6 months, and most recent past-year HbA1c >7.0%. Exclusion criteria included: medical instability or intensive medical treatment (e.g., dialysis), bipolar disorder or thought disorder, suicide attempt or psychiatric hospitalization in the past 2 years, alcohol problems as indicated by an elevated score on the CAGE questionnaire (Ewing, 1984), or enrollment in another research study.

CHWs who had already worked with participants in the parent study recruited them into the sub-study over the phone. Exclusion criteria for the sub-study included not being able to read or write or not knowing numbers ($N = 3$), problematic scheduling or loss to follow up in the parent study ($N = 12$), hearing loss that would interfere with IVR phone calls ($N = 3$), medical conditions other than diabetes that would make the protocol unduly burdensome ($N = 19$), shiftwork ($N = 6$), and one participant had died. The remainder ($N = 4$) were eligible but declined participation.

Of the 107 participants who completed the parent study, 58 were enrolled in the sub-study and $N = 3$ withdrew or did not follow the protocol, leaving 55 for analysis. There were no differences between our sample and remaining participants ($N = 52$) from the larger study in terms of sex, $\chi^2(1) = .16, p = .69$, marital status, $\chi^2(1) = .38, p = .54$, education, $\chi^2(1) = .03, p = .86$, employment status, $\chi^2(1) = .32, p = .57$, use of insulin, $\chi^2(1) = .12, p = .73$, Spanish-only speaking, $\chi^2(1) = 3.30, p = .07$, A1c levels, $t(104) = .69, p = .49$, and baseline assessments of anxiety $t(103) = -.33, p = .74$, and depression $t(102) = -1.19, p = .24$ (described below). However, there was a significant age difference, $t(105) = 2.41, p = .02$, with individuals in our sub-study ($M = 57.75, SD = 11.50$) being younger than excluded individuals ($M = 63.04, SD = 11.23$).

The sub-study sample was predominately female (75%) and single (71%) and had less than a high school education (75%); the mean age was 57.8 years ($SD = 11.5$). The vast majority (86%) were born in Puerto Rico, 5% in the mainland US, and 9% other countries (Peru, Mexico, Honduras, Dominican Republic). About a third (36%) spoke only Spanish and modal monthly household income was \$501-\$1000. Mean A1c = 8.4% ($SD = 1.6\%$) and 56% used insulin. Among the sub-study participants, 32 were in the DE+SMR intervention, and 23 were in DE-only. Treatment condition was unrelated to sex, $\chi^2(1) = .29, p = .59$, marital status, $\chi^2(1) = .17, p = .68$, education, $\chi^2(1) = .29, p = .59$, employment status, $\chi^2(1) = .20, p = .66$, use of insulin, $\chi^2(1) = 1.17, p = .28$, Spanish-only speaking, $\chi^2(1) = .13, p = .72$, and A1c levels, $t(53) = .24, p = .81$. However, there was a significant condition difference for age, $t(53) = 2.17, p = .04$, with individuals in the SMR condition ($M = 60.5, SD = 10.2$) being older than individuals in the DE-only ($M = 53.9, SD = 12.3$); thus, we controlled for age in tests of the key hypotheses.

Treatment

All participants received the standard care offered by the clinic from which they were recruited, which has been described elsewhere (Pérez-Escamilla et al., 2015). The same CHW delivered all sessions to avoid interventionist effects. Findings for excellent treatment fidelity have been previously reported (Wagner et al., 2015). All participants attended a 2.5-

hour group diabetes education (DE) session delivered by the study CHW in Spanish. The session covered basic information about diabetes self-management including nutrition, medication, physical activity and self-monitoring of blood glucose. Participants were provided resources for healthy eating, a glucose meter and strips, and a portable CD player with an audio CD promoting physical activity from the National Diabetes Education Program. After completing DE, participants were randomized to DE-only or DE+SMR. Expecting that attrition would be higher in DE+SMR (8 sessions) than DE-only (1 session), so block randomization used greater assignment to DE+SMR than DE-only. Blocks ranged from 9 to 16 participants who were assigned to study group using a binary allocation procedure. As previously reported (Wagner et al., 2015), diabetes knowledge significantly increased from pre- to post.

The SMR intervention (previously described in Wagner et al., 2015) was a manualized, culturally based intervention comprised of 8 group sessions spread across 8–10 weeks that included psychoeducational skills training and physical relaxation training. General concepts included modifying appraisals, problem-solving, and effective coping strategies for common stressors. Specific topics included the link between stress and health, identifying and modifying automatic thoughts, problem solving, seeking social support, communication skills, and emotion regulation.

Each session employed a culturally relevant analogy or story to introduce its learning objectives and was accompanied by a mindful awareness exercise. Examples of stressors used in the curriculum were always related to diabetes, for example, experiencing diabetes symptoms, co-morbid medical conditions, side effects of medications, transitioning from oral agents to injectables, problematic communication with healthcare providers, interference of family members with food choices, unavailability of safe options for physical activity, difficulty accessing linguistically appropriate health-related services, worry about long-term complications, and diabetes self-management ‘burnout.’ For each teaching point, participants were encouraged to nominate stressors from their own lives as examples. These were often diabetes-related, but also often reflected the socioeconomic context of their lives, such as incarceration of family members, household food insecurity, and financial strain.

The intervention also sequenced relaxation techniques; 1) active and passive progressive muscle relaxation exercises, some with autogenics, 2) thermal biofeedback of finger temperature with handheld thermometers, and, 3) guided meditation with visualization of relaxing scenes. In addition to relaxation practice during every intervention session, participants were given a portable CD player and a CD of the relaxation exercises to use for home practice between sessions, and a log to document the frequency of their home practice. Participants were encouraged to practice all techniques, but were allowed to focus on those that they preferred. The exercises were culturally tailored and recorded both in Spanish and English. As previously reported (Wagner et al., 2015), in-vivo relaxation exercises produced within-session increases in positive affect and decreases in negative affect. Group cohesion and therapeutic alliance with the CHW were excellent, as was participant satisfaction with the program.

IVR Procedures

After completion of treatment sessions, participants meeting eligibility criteria for the sub-study were invited to participate and provided written informed consent. CHWs then made a home visit to train participants how to use the IVR system. The IVR survey was offered in English or Spanish. The English was translated into Spanish and back-translated by independent bilingual personnel familiar with the goals of the study and any discrepancies were resolved through consensus with bilingual speakers from north, central, and south America. CHWs reviewed each question with participants who then practiced answering. To facilitate hands-free keypad responding, all participants were provided headsets. CHWs called the participants to promote IVR adherence and participants could contact the CHW in case of any questions or concerns.

Two daily assessments, approximately 10 minutes each, were conducted 8–10 AM and 8–10 PM. This schedule balanced density of data collection and participant burden. Specific reporting windows were chosen as times when this population would likely not be otherwise occupied with daily tasks. The morning window allowed us to capture experiences from early morning and from the previous night when symptoms of nocturnal hyperglycemia might occur. The evening window allowed us to capture experiences when individuals would be awake and symptoms and affect would be most salient. The IVR system called participants at random times during these 2-hour windows. If the call was unanswered, the system continued calling regularly within the time-window. If the participant could not complete the IVR survey at that time (e.g., if engaged in childcare) the participant could use a keypad response requesting that the system call back in 15 minutes. If the survey was unanswered by the end of the reporting window, the report was coded as missing. If a call was disconnected, the system called back to resume the survey. IVR data were monitored daily to detect protocol non-adherence. After 7 days of IVR data collection, the CHW returned to the participant's home for debriefing and to deliver compensation. A graduated incentive system was used: participants were compensated \$4 for each IVR survey, with a \$2 bonus for responding to both in a given day, for a total possible of \$10 per day across 7 days, for a total possible of \$70. In a few cases, participants reported beyond 7 days, thus to maximize power, we used all available daily reports.¹ Adherence level was high (89%; based on first seven days of reporting). There were 738 daily reports available for analysis, an average of 13.4 reports ($SD = 2.2$) per participant. Reports were approximately evenly distributed across windows (i.e., 51% morning and 49% evening). Adherence rate did not differ significantly across treatment conditions, $t(53) = 1.79$, $p = .08$.

IVR self-report measures

Participants could choose whether to hear the IVR questions in English (16%) or Spanish (84%). The IVR survey was pilot tested for face and content validity among 10 Latinos (in Spanish ($n=5$) and English ($n=5$) with type 2 diabetes. Items were piloted for response

¹Only 56 out of the 738 daily observations were beyond the planned seven reporting days (7.5% of the daily reports). The majority of these observations (86%) was reported on the 8th day and the remainder on the following day. The majority of the sample (78%) did report beyond the 7th day and there were no associations between having reporting extra-reporting days and any of the study variables, i.e., age, baseline anxiety and depression, treatment condition or any of the aggregate daily variables. Finally, exclusion of the extra reporting intervals did not alter any of the findings.

variability, meaning, task difficulty, and respondent interest and attention. We also checked for flow, order, skip patterns, timing, and overall respondent burden.

Affect.—The IVR system asked participants how they felt regarding various affective states “since [clock time of last reporting window]”. We chose states that represented differential levels of activation and valence (pleasant/unpleasant) as indicated according to the circumplex model of affect (Larsen & Diener, 1985). Specifically, we examined reports of feeling *nervous* (high activation/negative valence), *sad* (low activation/negative valence), *enthusiastic* (high activation/positive valence) and *calm* (low activation/positive valence). Responses were made using a 3-point scale (1= “not at all”, 2 = “a little”, and 3 = “a lot”).

Diabetes symptoms.—A brief diabetes symptom scale was adapted from the Diabetes Symptom Checklist (Grootenhuis, Snoek, Heine, & Bouter, 1994). Symptoms of hyperglycemia and its complications were chosen that would be expected to vary in occurrence or intensity over the course of hours-to-days according to glucose fluctuations. Our diabetes symptoms tapped hyperglycemia specifically since episodes of hypoglycemia are far less frequent among most patients with type 2. The IVR system asked, “*Now I’m going to ask whether you had some physical symptoms of diabetes since* [clock time of previous reporting window].” Participants were asked if the following diabetes symptoms occurred since the previous IVR assessment (“*Did you have pain, numbness, or tingling in your hands, legs or feet?*,” “*Did you feel exhausted?*,” “*Did you have vision problems even when wearing glasses?*,” “*Did you have frequent need to urinate?*” and “*Did you have dry mouth or were you very thirsty?*”). Response options were on a 3-point scale (1= “not at all”, 2 = “a little”, and 3 = “a lot”). We averaged the five items to compute a composite symptom scale, the reliability (alpha) of which was 0.82.

Baseline retrospective self-report measures

Depressive symptoms.—The Spanish version of the Personal Health Questionnaire (PHQ8; the PHQ9 without the suicidality item, (Wulsin, Somoza, & Heck, 2002) measures depressive symptoms over the past 2 weeks with higher scores indicating greater depressive symptoms. The suicidality item was omitted to avoid the potential for CHWs needing to respond to suicidality. The observed internal consistency was acceptable, alpha = 0.79.

Anxiety symptoms.—The Spanish version of the PROMIS Emotional distress/anxiety scale (Short Form 8a; (Cella et al., 2010) assesses anxiety symptoms over the past 7 days. The 8-item scale has response options from 1 = “never” to 5 = “always” with higher scores indicating more anxiety symptoms. The observed alpha = 0.91.

Data management and analysis

Given the non-independent nature of the repeated measures, we used multilevel regression models (Raudenbush & Bryk, 2002) to test the main hypotheses. Specifically, we estimated 3-level linear multilevel models with morning and evening IVR reports (level 1) nested within days (level 2) nested within persons (level 3). In the level 1 portion of the model, we specified affective states occurring in that reporting period as the dependent variable (in separate models) predicted by diabetes symptoms occurring in that reporting period. We

refer to this specification as the concurrent-time model. Diabetes symptoms were person mean-centered, i.e., each person's mean level was subtracted from each report; thus, level 1 slopes correspond to within-person associations. We also included a dummy code for time of day (0 = AM, 1 = PM) in the level 1 portion of the model. Finally, we included a treatment dummy code (0 = DE-only, 1 = DE+SMR) in the level 3 portion of the model along with overall mean levels diabetes symptoms, age and baseline anxiety (both grand mean-centered). We first included these person level variables as predictors of the level 1 intercepts, then in a second step, as predictors of the level 1 slopes for the daily diabetes symptoms-affect associations, except for mean daily diabetes symptoms, which we examined in an exploratory fashion in a third step. We included random effects for the level 1 intercepts at levels 2 and 3 and for the level 1 slopes at level 3. To facilitate model convergence, we removed the random slope if not significant.

Results

Descriptive statistics

Table 1 shows the descriptive statistics and correlations among the baseline and aggregate daily variables (below diagonal) and the bivariate within-person correlations among the daily variables (above the diagonal); the significance values for the within-person association were derived using the multilevel regression approach described above. At the between-person level of analysis, several of the affect dimensions were highly correlated (e.g., nervous-sad and calm-enthusiastic). In contrast, these associations were considerably weaker at the within-person level of analysis. Across both levels of analysis, nervous affect showed the strongest association with diabetes symptoms.

Also shown in Table 1, treatment condition was also unrelated to any of the aggregate IVR variables and baseline depression scores. However, treatment condition was related to baseline anxiety scores. Thus, in subsequent multi-level regression models we controlled for baseline anxiety and, as previously noted, age.

Finally, we calculated intraclass correlations using Raudenbush and Bryk's (2002) formulas, for each of the IVR variables to ascertain the proportion of variance at the three levels of analysis, i.e., within-day, daily, and person levels of analysis (see bottom of Table 1). For the affect variables, the largest amount of variance was at the within-day level of analysis, followed closely by person-level variance. In contrast, the majority of the variance in diabetes symptoms was between-person. Day-level variance was the smallest component of the total variance and was negligible for calm affect and diabetes symptoms.

Treatment effects on symptom-affect reactivity

Table 2 shows the results from the multilevel models. We first examined the additive effects of the predictors, and then in a second step, we included the interaction effects. In step 1 we found no effect of treatment condition on any of the affect (mean) levels. However, mean level of diabetes symptoms were positively associated with mean levels of nervous and sad affect. Similarly, higher levels of baseline anxiety levels were associated with higher mean levels of sadness and lower mean levels of calm affect. Finally, at the within-day interval

(morning, evening) level of analysis, diabetes symptoms were positively related to nervous affect; specifically, within-day intervals characterized by relatively higher levels of diabetes symptoms were associated with higher levels of nervous affect.

Regarding interaction effects (see Step 2), we found a treatment $\times$ daily diabetes symptom interaction, i.e., treatment predicting symptom reactivity, in the predicted direction for nervous affect (see Figure 1). Specifically, the positive association between relative interval levels of diabetes symptoms and nervous affect was stronger for individuals in the control (DE-only) condition compared with individuals in the DE+SMR condition. Stated in other words, individuals in the DE+SMR condition had weaker anxiety-related diabetes symptom-reactivity. Simple slopes analyses indicated that the positive associations were significant in both the DE+SMR condition ($B = .33$, $SE = .11$, $p = .004$) and the DE-only condition ($B = .67$, $SE = .08$, $p < .001$). We also found a significant treatment $\times$ daily diabetes symptom interactions in predicting enthusiasm (see Figure 2). Specifically, individuals in the DE-only condition showed a significant positive association between relative interval levels of diabetes symptoms and enthusiasm ($B = .49$, $SE = .18$, $p = .006$), whereas individuals in the SMR+DE condition showed a negative association ($B = -.72$, $SE = .19$, $p < .001$). Although we made no specific predictions about the effects of the intervention on positive affect reactivity to diabetes symptoms, this finding does seem contradictory to the results for anxiety.

Age also moderated the within-day symptom-affect associations in all models except for sad affect. The form of these effects indicated that older individuals showed weaker positive associations between relative changes in diabetes symptoms on nervous affect and weaker negative associations between relative changes in diabetes symptoms and both enthusiasm and calm affect. Finally, we included mean diabetes symptoms as a predictor of the level 1 diabetes symptom-affect slopes. Only one interaction reached significance (see Step 3 in table 2), with individuals with higher mean levels of diabetes symptoms showing stronger positive associations between relative levels of diabetes symptoms and sad mood. Inclusion of mean diabetes symptoms as a predictor of the level 1 slopes did not alter any of the existing interaction effects. We should note that for all of the models, controlling for language of assessment did not change the pattern of significance for any findings.

Discussion

Our main finding was that following treatment, participants in the DE+SMR condition, compared to individuals in the DE-only condition, showed weaker positive associations between relative levels of diabetes symptoms and nervous affect. Interestingly, this occurred in the absence of overall mean differences in daily affect across the treatment groups. Treatment condition also predicted the association between relative levels of diabetes symptoms and enthusiasm; participants in the DE+SMR condition, compared to individuals in the DE-only condition, showed a weaker positive association between relative levels of diabetes symptoms and enthusiasm. However, the direction of this effect was not specifically predicted. Treatment condition was not associated with symptom reactivity associated with sad or calm affect.

Treatment effects on symptom-affect reactivity

The finding that individuals receiving DE+SMR training, compared to DE-only, showed weaker anxiety-related diabetes symptom-reactivity provides some support for one of the core aims of SMR training, i.e., providing individuals with efficacious techniques to down-regulate negative affect when noxious stimuli occur – in this case, symptoms of hyperglycemia and its complications. It is important to note that whereas *hypoglycemia* can induce anxiety via adrenergic effects of counter-regulatory hormones (hormones that oppose insulin), there is no biological mechanism for a direct physiological effect of *hyperglycemia* on anxiety. Our diabetes symptoms tapped into hyperglycemia specifically. Therefore, any differences in hyperglycemia symptom-related anxiety would not be biologically based. In the absence of a direct biological effect, the anxiety reported concurrent with symptoms of hyperglycemia is presumably mediated by cognitive appraisals of, and/or coping strategies in response to, the symptoms of hyperglycemia, i.e., some of the skills specifically targeted in the SMR intervention.

Our results showing specificity of SMR training to high arousal negative affect (nervousness), rather than low arousal negative affect (sadness) may be related to the relaxation component of the intervention. SMR participants were also taught relaxation techniques as a secondary coping strategy. Relaxation exercises were designed to disrupt the physiological stress response and promote a physiological relaxation response. Participants practiced relaxation exercises during each treatment session and were given tools and encouraged to practice them at home between sessions. The focus on relaxation may have dampened arousal rather than decreasing negative affect (or increasing positive affect) per se. Stress management and similar behavioral interventions for medical populations (e.g., Shao, Gao, & Cao, 2016) or non-medical populations (e.g., Kitozaki et al., 2014; Sallon, Katz-Eisner, Yaffe, & Bdolah-Abram, 2017), even those that employ daily measures of affect (e.g., Davis & Zautra, 2013), typically report outcomes for positive and negative affect, but have not examined affective arousal or dampening per se.

We also found that when experiencing relatively high levels of diabetes symptoms, individuals receiving SMR showed reduced enthusiasm whereas individuals in the DE-only condition displayed increased enthusiasm. Although not specifically predicted and in need of replication, these findings again suggest SMR training's general effect on decreasing high arousal states (i.e., enthusiasm and nervous affect, but not sad and calm affect) when symptoms spike. Stated in other words, in addition to decreasing negative-valenced arousal states when diabetes symptoms spiked, SMR training also might have the unintended consequence of dampening enthusiasm in such situations. This finding might help explain the null group mean differences in affect, at least in the current sub-study using IVR assessment (cf., (Wagner et al., 2016). One possibility is that treatment might have had countervailing effects on distress: a beneficial effect via decreased anxiety-related symptom reactivity and a deleterious effect, at least in the short-term, via dampened symptom-related enthusiasm. Reduced enthusiasm when symptoms spiked also might have limited the opportunity of positive mood “buffering” effects of such states in such situations (e.g., (Fredrickson, Mancuso, Branigan, & Tugade, 2000). Whereas observational data are consistent with positive affect buffering of the symptom-negative affect relationship (e.g.,

Thong, Tan, & Jensen 2017), we are not aware of any data in the context of intervention outcomes. Although not tested here, reduced enthusiasm might also decrease the likelihood of engaging in the diabetes self-care activities that would be indicated to reduce the underlying hyperglycemia giving rise to symptoms. If replicated, this finding could inform future SMR protocols to highlight the need to maintain positive-valenced high arousal states while reducing negatively-valenced high arousal states when problems arise.

As mentioned earlier, our treatment effects on symptom affect-reactivity occurred in the absence of mean level differences in affect – contrary to what was found by Wagner et al. (2016). In addition to reduced sample size, these differential findings also might be due to the fact that the retrospective posttests utilized in Wagner et al. were administered prior to the daily assessment period (i.e., more proximal to the treatment phase). Thus, the treatment effect on overall levels of negative affect might have dissipated more quickly than the effects on symptom affect-reactivity. More importantly, it should be noted that our design limited the conclusions that we can make about treatment effects of symptom-affect reactivity. Specifically we did not have a pre-intervention daily assessment phase (e.g., Davis, Zautra, Wolf, Tennen, & Yeung, 2015; Parrish et al., 2009), thus, we could not evaluate whether reactivity decreased from pre- to post-intervention. Future studies employing such designs are needed to further test our interpretations.

We also found that individuals with high mean levels of diabetes symptoms demonstrated stronger sadness-related symptom reactivity. That is, among individuals with chronically higher levels of symptoms, relative increases in diabetes symptoms were associated with greater increases in sad mood, but not other affective states. Chronic hyperglycemia may be linked to greater increases in sad mood by biological mechanisms such as inflammation (Doyle, et al., 2013). Another possibility is that chronically higher symptom levels place a greater strain on individuals emotion regulation abilities (e.g., (Baumeister, Vohs, & Tice, 2007), thus resulting in greater reactivity. The specificity to sad affect could be a result of low control appraisals arising from repeatedly dealing with chronic symptoms; such appraisals are commonly found to be related to depressive symptoms (Smith, Peck, & Ward, 1990).

Finally, we found that age moderated several symptom-affect associations. Older individuals showed less of an exacerbating effect of symptoms on nervous affect and less of a dampening of symptoms on enthusiasm and calm affect – stated in other words, relative symptom levels had less of an impact on affect states among older individuals. These findings are generally consistent with previous research showing that unlike many cognitive abilities, emotional functioning might improve with age (Carstensen & Mikels, 2005) and that older individuals might be better equipped to deal with minor variations in symptom levels, at least with respect to their affective states. Although in need of replication, these findings could suggest that SMR interventions might be best targeted at younger individuals.

These findings may have clinical implications. Diabetes symptoms may have particular importance for Latinos. Latino patients have reported relying on their physical symptoms to estimate their glucose levels (Garcia 2005) and to inform diabetes self-care behaviors (Brown, Upchurch, Garcia, Barton, & Hanis, 1998). Whereas patients from other ethnic

groups almost certainly do the same, the practice may be more prevalent among Latinos due to a culturally-based somatic focus and/or, more likely, barriers to glucose monitoring equipment and supplies and appropriate diabetes education. Efforts to promote self-monitoring of blood glucose, and to increase engagement with self-management behaviors when symptoms or glucose levels are problematic, are warranted.

Limitations

Our major limitation was our small sample size. Not only might our observed effects overestimate any true effects that might exist, we also did not have a sufficient sample size to examine moderators of treatment effects (e.g., by Latino sub-ethnicity). In addition, we were not able to collect reliable information regarding diabetes duration, which could influence the observed associations. As mentioned above, the lack of a pre-intervention daily process assessment phase limits our conclusions about the effects of our intervention. In addition, we could not evaluate the duration of our intervention effect because we did not include a follow up daily diary phase (i.e., an additional daily reporting phase beyond what we examined). Future studies of these processes should include pre-intervention daily diary reporting along with multiple follow up daily assessment periods to evaluate change trajectories in these processes, though doing so may pose feasibility challenges regarding time, resources and participant burden for many intervention trials.

Another limitation was that our models were cross-sectional at the interval level of analysis. We did not examine morning-evening lag-time models, because these relatively long intervals (i.e., approximately 10 hours between morning and evening IVR assessments) would not adequately map on to the fast-moving process of interest that might unfold in minutes, i.e., anxiety being elicited from symptom spikes. Future studies using more fine-grained real-time assessment techniques are needed to help tease out fast moving lead-lag associations. We utilized single item indicators of affect, the reliability of which might have been less than optimal; however, such brief assessment methods are commonly used in daily studies to offset participant burden associated with multi-item measures. Finally, our symptom measure focused entirely on physical symptoms of hyperglycemia and did not include other aspects of living with diabetes such as self-management fatigue, disruption of daily routine, or frustration with not meeting treatment goals. Inclusion of these other aspects of diabetes-related issues might have produced stronger symptom-affect associations.

These limitations notwithstanding, our findings highlight the usefulness of embedding daily process methods within clinical intervention research. Our results partially support posited processes underlying SMR and highlight promising approaches for improving or modifying such techniques. Our findings also have implications for intervention delivery for the underserved. Mental health interventions for Spanish-speaking medical populations are seriously lacking. The demonstrated ability of CHWs to deliver a SMR intervention that successfully weakened the association between diabetes symptoms and associated distress, suggests that CHWs may be effective psychoeducation interventionists and, therefore, that dissemination of such interventions is plausible.

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Figure 1. Nervous affect as a function of study condition and relative levels diabetes symptoms.
Note. DE = Diabetes education, SMR= stress-management/relaxation.

Figure 2.
Enthusiasm as a function of study condition and relative levels diabetes symptoms
Note. DE = Diabetes education, SMR= stress-management/relaxation.

Table 1.

Descriptive statistics and correlations

	M	SD	1	2	3	4	5	6	7	8
Correlations										
1. Study condition (0= DE, 1 = DE+SMR)	--	--								
2. Baseline Anxiety	14.45	6.68	-.28 [*]							
3. Baseline Depression	6.04	5.32	-.11	.70 [*]						
4. Nervous ^a	1.20	.29	.05	.25	.48 [*]		.24 [*]	.03	-.08	.30 [*]
5. Sad ^a	1.28	.38	-.08	.42 [*]	.56 [*]	.70 [*]	-.03	-.15 [*]	.17 [*]	
6. Enthusiastic ^a	1.87	.55	.17	-.19	-.15	.02	.11		.19 [*]	-.08
7. Calm ^a	2.27	.52	.22	-.32 [*]	-.27 [*]	-.10	-.22	.60 [*]		-.05
8. Diabetes Symptoms ^a	1.41	.45	-.05	.22	.39 [*]	.68 [*]	.62 [*]	.03	-.08	
Within-day level variance						49.6%	48.9%	48.9%	53.1%	23.5%
Day-level variance						12.9%	9.4%	9.4%	1.8%	0.1%
Person-level variance						37.4%	41.7%	41.7%	45.2%	76.4%

Note. Values below the diagonal are between-person associations; above diagonal are within-person associations.

^a Aggregate (mean) daily values. DE = Diabetes education, SMR = Stress management and relaxation training. Multilevel regressions used for significance tests for within-person correlations.

* $p < .05$

Table 2.

Multilevel regression results

Step		Nervous			Sad			Enthusiastic			Calm		
		b	SE	p	b	SE	p	b	SE	p	b	SE	p
1													
	Mean Diabetes Symptoms (DS)	.418	.084	<.001	.543	.099	<.001	.114	.148	.447	-.024	.120	.840
	Treatment group	.082	.057	.153	.053	.082	.518	-.008	.159	.960	.164	.139	.244
	Age	-.002	.002	.291	-.005	.003	.083	.008	.006	.169	-.002	.007	.763
	Baseline Anxiety	.006	.004	.161	.015	.006	.013	-.019	.009	.054	-.022	.008	.013
	Time of day	-.014	.028	.621	.004	.026	.863	-.014	.033	.681	-.028	.038	.464
	Interval-level DS (ILDS)	.381	.082	<.001	.244	.142	.091	-.283	.188	.138	-.095	.132	.469
2													
	ILDS $\times$ Treatment	-.339	.125	.007	-.040	.273	.884	-1.210	.241	<.001	-.304	.211	.149
	ILDS $\times$ Age	-.022	.009	.015	-.020	.015	.187	.036	.016	.024	.051	.017	.004
	ILDS $\times$ Baseline Anxiety	-.012	.010	.220	-.013	.020	.521	-.001	.018	.939	-.014	.019	.440
3													
	ILDS $\times$ Mean Diabetes Symptoms	.196	.129	.130	.797	.361	.032	.371	.270	.169	.126	.273	.617

Note. Time of day 0 = a.m., 1 = p.m. Only the slope variance component for sad affect was significant; all others fixed to zero.