J Behav Med (2020) 43:892–903
https://doi.org/10.1007/s10865-020-00134-5

# The separation in coordination between social- and self-regulation for emerging adults with type 1 diabetes

**A. K. Munion[1] · Jonathan E. Butner[1] · Caitlin S. Kelly[1] · Deborah J. Wiebe[2] · Sara L. Turner[1] · Amy Hughes Lansing[1,3] · Cynthia A. Berg[1]**

Received: 29 July 2019 / Accepted: 10 January 2020 / Published online: 23 January 2020
© Springer Science+Business Media, LLC, part of Springer Nature 2020

**Abstract** To examine how self-regulation and social-regulation surrounding type 1 diabetes (T1D) management are coordinated during early emerging adulthood and whether classes of coordination relate to HbA1c and executive functioning (EF). Emerging adult participants ($N = 212$) with T1D (M age = 18.8 years, SD = .40) completed a 14-day diary to capture components of self-regulation and social-regulation. A mixture multi-level latent coordination model first determined the separate but coordinated factor structure of self- and social-regulation, then determined the number of distinct classes of coordination and how those classes linked to HbA1c and EF. The best-fitting model included three coordinative factors (self, mother, and father) of regulation and two distinct classes. The class with lower HbA1c and higher EF had more stable self- and social-regulation, more connections between self- and social-regulation and reflected more adaptive patterns, consistent with medical management goals. Social connection with parents may aid in regulation during this at-risk transitional time of emerging adulthood.

**Keywords** Diabetes · Emerging adulthood · Parents · Self-regulation · Social relationships · Coordination

**Electronic supplementary material** The online version of this article (https://doi.org/10.1007/s10865-020-00134-5) contains supplementary material, which is available to authorized users.

✉ A. K. Munion
u1008334@utah.edu

Jonathan E. Butner
jonathan.butner@psych.utah.edu

Caitlin S. Kelly
ckelly1219@gmail.com

Deborah J. Wiebe
dwiebe@ucmerced.edu

Sara L. Turner
sara.turner@psych.utah.edu

Amy Hughes Lansing
alansing@unr.edu

Cynthia A. Berg
cynthia.berg@csbs.utah.edu

[1] Department of Psychology, University of Utah, Salt Lake City, USA

[2] Psychological Sciences, University of California-Merced, Merced, USA

[3] Present Address: Department of Psychology, University of Nevada-Reno, Reno, USA

## Introduction

Type 1 diabetes (T1D) management requires self-regulation in the context of social relationships. Components of self-regulation of T1D include managing one's emotions and cognitions (e.g., self-confidence for diabetes management), while simultaneously engaging in adherence behaviors such as monitoring blood glucose and counting carbohydrates (Berg et al., 2014; Hood, Peterson, Rohan, & Drotar, 2009). A large literature indicates that both adherence behaviors and average blood glucose levels (i.e., HbA1c) are improved when adolescents and emerging adults display higher levels of these components of self-regulation (see Berg et al., 2017; Wiebe et al., 2018). Additionally, self-regulation for diabetes management is facilitated by social relationships, and the active utilization of such relationships can be thought of as 'social' regulation. One important example of social-regulation is teens' use of disclosure—actively talking about diabetes problems to a parent or friend—to garner the support they

need to problem solve or engage in better self-care behaviors (Berg et al., 2016; Wiebe et al., 2018). Disclosure not only solicits support, but helps ensure that support providers have enough knowledge about the problem to provide more effective help when needed (Osborn et al., 2013). To reach an optimal pattern of T1D management, one must coordinate many different interconnected daily individual and social processes. Self- and social-regulation (referred to as components throughout this paper) vary individually and together to produce a pattern of diabetes management.

By conceptualizing diabetes management as an ongoing process of self- and social-regulation that occurs daily, we can model the system of regulation to characterize the unique daily patterns of the many components of self- and social-regulation through time. These patterns can be described in terms of the *set point*, or the homeostatic place or value that the component returns to in spite of ongoing disruptions to regulation, and *stability*—how quickly the component is pulled back to the set point when disrupted. For example, individuals' completion of adherence behaviors fluctuates day to day, but there is a set point—the typical number of adherence behaviors that individuals perform—even as life complexities interrupt, or perturb, their daily adherence. Some individuals may be less sensitive to life stresses and have very stable adherence, in which nothing will move them out of their typical adherence pattern. Others may be more sensitive to stress and have less stable adherence, in which they are more easily knocked out of their typical pattern and may take longer to get back to their typical adherence.

In addition to a pattern of diabetes management, individuals likely develop a coordinated pattern of self- and social-regulation that results in an overall stable system of regulation, with multiple components bidirectionally interacting over time, some belonging to the teen, some belonging to other people involved in management—like parents. At its simplest, coordination can be thought of as how *changes* in two or more components (adherence behaviors, self-confidence, affect etc.) are correlated through time (for coordination review see Turvey, 1990). More nuanced models examine *how* many components change together through time, and *which* components push and pull most on the entire system of regulation. First, characterizing how many components change through time requires understanding how changes in components of self- and social-regulation are grouped together through time (i.e., latent coordination factors). Second, addressing which components push and pull on the system, a component's current value can also uniquely predict the latent coordination factors, representing an unequal directional influence on the coordination throughout time (called drivers). A driver component is the best predictor of where the system goes, and can be conceptualized as maintaining the stable pattern of regulation.

In a previous paper based on baseline data from the current longitudinal sample (i.e., when the present participants were late adolescents), we found that self- and social-regulation were best represented by separate coordination factors for self-, mother, and father regulation (Butner et al., 2018). Only some components of self-regulation (i.e., adherence behaviors and self-regulation failures) were drivers of the self-coordination factor, and only mothers' and fathers' knowledge of their teens' diabetes management were drivers of the other parent's coordination factor. Further, the only social-regulation component that was a driver of teens' self-coordination was mothers' helpfulness (Butner et al., 2018). These drivers are the components that stabilize teens' and parents' regulatory patterns through time, and may represent the best variables on which to intervene in the face of difficulties regulating T1D, in order to shift the system of regulation to a different, healthier, more stable pattern.

Although it is clear that children and adolescents with T1D benefit from social-regulation in connection with their parents, the evidence for the connection between self- and social-regulation beyond adolescence and into emerging adulthood is less clear. The period of emerging adulthood (i.e., ages 18–25) is a potentially high-risk time for T1D management, with many individuals showing their poorest levels of glycemic control in the initial years after high school, as early emerging adults (Miller et al., 2015). This may be because parental involvement in the day-to-day management of T1D declines across adolescence and emerging adulthood (Helgeson et al., 2014; King et al., 2014; Wiebe et al., 2014), at the same time that individuals are required to engage in self-regulation in the context of new social relationships at work and school. Parental involvement may still be beneficial for diabetes management into early emerging adulthood, as growing evidence indicates that emerging adults with T1D benefit from the involvement of parents (Berg et al., 2019; Hanna et al., 2013; Helgeson et al., 2018; Palladino & Helgeson, 2012; Wiebe et al., 2018). However, this research has largely examined how individual differences during adolescence predict later outcomes during emerging adulthood (Hanna et al., 2003; Helgeson et al., 2013), rather than the ongoing transactional process at the daily level.

In the present study we examine whether the previously established coordinative structure captures self- and social-regulation during early emerging adulthood and then further model classes of coordination. Classes of coordination established via mixture modeling can capture whether early emerging adults differ systematically in component set points and stability, as well as in the drivers of self- and mother- and father-coordination. Further, the classes of regulation identified via the mixture can be related to global capacity for self-regulation (e.g., executive functioning) or glycemic control (e.g., HbA1c). For example, individuals

may differ in the extent to which their coordination of self- and social-regulation are linked (as shown by covariances between factors), with stronger covariances suggesting a more socially-orientated pattern of regulation. Additionally, differences in which components function as drivers of self-regulation also suggest individually- or socially-orientated regulation, with the presence of social-regulation drivers of self-regulation suggesting more socially-orientated regulation. This socially-orientated pattern of regulation may be protective during challenges to self-regulation that emerging adults face as a result of changing social contexts (Wiebe et al., 2018). If socially-orientated regulation is protective, it would be evidenced by lower HbA1c (better medical management) as well as higher global capacities for self-regulation (higher executive functioning). In contrast, individually-orientated regulation—where the pattern of coordination is less linked between self- and social-regulation and where there are fewer social-regulation drivers—may be attributed to difficulties in managing diabetes, evidenced by higher (worse) HbA1c and lower capacities for self-regulation (lower executive functioning). As emerging adulthood is hypothesized to be a high risk and volatile time for glycemic control, understanding *how* the complex patterns of daily self- and social-regulation differ for those with higher and lower HbA1c and executive functioning may provide integral information for intervention.

### Aims and hypotheses of current study

In the present study, we aimed to replicate our earlier findings in late adolescence by determining if the three coordinated factor structure—separate factors for self-, mother- and father-coordination—is maintained during early emerging adulthood. Further, we expand on our previous model to index how many classes or groups exist in our sample that differ on set points, stability, and drivers, and examine if those classes differ in levels of glycemic control (i.e., HbA1c) and executive functioning. As part of a larger longitudinal study, early emerging adults with T1D reported separately on components of their self- and social-regulation involving mothers and fathers across a 14-day daily diary. We then used mixture modeling to determine the number of classes (or groups differing on set points, stability, and drivers) underlying the data. We compared the one- to three-class solutions to identify the number of different underlying patterns. For the best fitting model, we examined which components were drivers of the coordination factors and compared patterns of stability and set points across classes. Given the paucity and inconsistent findings in the literature regarding the way in which parents are involved in diabetes management during emerging adulthood (Wiebe et al., 2018), we expected that there would be a positive link between socially-oriented regulation and lower HbA1c and higher executive functioning, but did not make a priori predictions regarding which components would function as drivers for each class.

## Methods

### Participants

High-school seniors with T1D were recruited for a two-year longitudinal study on diabetes and self-regulation during late adolescence and early emerging adulthood. Participants were recruited from three outpatient pediatric endocrinology clinics where healthcare providers were affiliated with local universities in two southwestern U.S. cities. Of the qualifying 507 individuals approached, 301 (59%) initially agreed to participate, with 247 teens completing baseline assessments. Reasons for not participating at baseline included being too busy in their senior year to participate (34%), lack of interest (33%), and 33% cited other reasons or declined to give a reason. Participants were eligible to participate at enrollment if they had been diagnosed with T1D for at least one year ($M$ length of diagnosis = 7.35 years, $SD$ = 3.88), spoke English as their primary language, were in their final year of high school, lived with at least one parent or parental figure full-time (68.4% lived at home with both biological parents, 27.1% with one biological parent and 4.5% lived with adoptive parents or grandparents), would be able to have regular contact with one or both parents over the subsequent two years and had no condition that would prohibit study completion (e.g., severe intellectual disability, blindness)—see Butner et al. (2018) for additional details.

Consistent with the patient population at participating clinics, 75.2% of the full sample ($N$ = 247) identified as non-Hispanic White, 14.2% as Hispanic, 4.8% as African American, and the remainder identified as Asian/Pacific Islander, American Indian, or more than one race. At enrollment, patients were 17.76 years old on average ($SD$ = 0.39) and 60% were female. Parents reported a range of educational backgrounds, with 12.9% of mothers and 18.2% of fathers having a high school education or less, 37.2% of mothers and 25.1% of fathers reporting some college or a vocational degree, and 34% of mothers and 46.3% of fathers holding a bachelor's degree or higher. For reports of social-regulation involving mothers and fathers, teens selected the mother and father figure most involved with their diabetes management to ensure consistent reporting across days of the diary (97.2% of teens nominated their biological mother and 90.9% nominated their biological father).

The present study analyzed data from participants who responded to the daily diary one year after enrollment, at time 2 ($N$ = 212). Individuals who completed the diary at time 1 but not time 2 (i.e., who dropped out or skipped time

2) were significantly more likely to be men than women and to have higher HbA1c at time 1 compared to those who completed both time points. Emerging adults in this subsample were on average 18.75 years of age ($SD = .40$), had been diagnosed with T1D for an average of 8.36 ($SD = 3.86$) years, 65% were female, 46.05% of patients reported using an insulin pump, and 76.60% of our subsample was above the American Diabetes Association (ADA, 2014) age-specific recommendations for glycemic control for HbA1c < 7.0% ($M$ HbA1c = 8.94, $SD = 1.91$).

## Procedure

The study was approved by all affiliated university Institutional Review Boards. Participants provided assent along with parental consent (if under aged 18) or consent (if 18 years or older) during the baseline assessment at time 1 (as seniors in high school). At time 2 (one year after high school), individuals who initially assented provided consent once they reached the age of 18. During the initial recruitment session, participants received instructions for completing a subsequent confidential on-line survey, the daily diary procedure, and an HbA1c mail-in assay kit. The 14-day daily diary data obtained one year later at time 2 were used for the present analyses. A confidential brief electronic survey was sent to participants each day, where participants indicated their experiences in the past 24 h. Participants received phone calls or text messages daily if they had not completed the diary by 9:00 p.m. Participants were compensated $50 for lab procedures and the online survey, and $5 for each daily diary.

## Daily diary measures of components of self-regulation

### *Daily self-regulation failures*

Participants rated from 1 (strongly disagree) to 5 (strongly agree) their experience of eight self-regulatory failures surrounding blood glucose monitoring, a crucial daily adherence behavior (e.g., "Each time I was about to test my blood glucose, I got distracted.")—see Butner et al. (2018) for additional items. We used a daily item average; higher values indicated more self-regulation failures. Inter-item reliability calculated via random intercept models with both time and item treated as nested levels was excellent ($\alpha = .92$).

### *Daily adherence and blood glucose tests*

Participants rated how well they followed adherence recommendations for six items from the Self Care Inventory (Lewin et al., 2009) in the past 24 h from 1 (did not do it) to 5 (did it exactly as recommended) – $\alpha = .86$.

Participants reported each blood glucose (BG) reading from their glucometers at the end of each day. We used self-reported BG as participating clinics did not routinely download glucometer data and the larger longitudinal study precluded physical downloads as teens were geographically mobile. A count of the number of BG tests per day was then computed. In our sample, individuals checked their BG an average of 3.75 times per day ($SD = 1.26$).

### *Daily diabetes problems*

Participants completed a checklist designed by the authors (Beveridge, Berg, Wiebe, & Palmer, 2006). The number of problems was computed from the number of items participants endorsed on a five item diabetes-specific stressful events checklist (e.g., problem with high BG, problem with low BG), and those who used an insulin pump or continuous BG monitor reported on one additional problem (e.g., problem with insulin pump or continuous BG monitor).

### *Daily positive and negative affect*

Participants rated negative (9 items; 3 each reflecting depressed mood, anxious mood, and anger) and positive affect (9 items; 3 each reflecting happiness, interest, and contentment) over the prior 24 h using items developed for use with daily diaries (Cranford et al., 2006). Items were rated on a 1 (not at all) to 5 (extremely) scale. Average daily positive ($\alpha = .89$) and negative ($\alpha = .88$) affect scores were analyzed.

### *Daily self-confidence in ability to self-manage diabetes*

Participants answered one item ("How sure are you that you can manage your diabetes even when you feel overwhelmed?") on a 1 (not at all confident) to 5 (extremely confident) scale.

## Daily diary measures of components of social-regulation

Participants reported on their interactions with mothers and fathers separately. To measure *daily teen disclosure* about diabetes, participants responded "yes" or "no" to the prompt "Did you tell your mother/father about things that happened with your diabetes today, without her/him asking you?" To measure *daily parental knowledge* participants rated "How much does your mother/father REALLY know about the diabetes problems you had today (e.g., high or low blood glucose)" on a 1 (nothing) to 5 (a lot) scale. To measure *daily parental helpfulness*, participants rated how helpful their mother/father was in providing support for diabetes on a 1 (not at all helpful) to 5 (very helpful) scale.

### Performance-based executive functioning (EF)

EF was measured through four subtests of the Delis-Kaplan Executive Function System battery (Delis et al., 2001) at baseline, using widely- recognized components of EF: Trail Making Test (Letter Number Sequencing Condition completion time), Color-Word Interference (Inhibition and Inhibition/Switching Condition completion times), Verbal Fluency (Letter and Category Conditions correct responses) and Design Fluency (correct responses for each of the three conditions). The mean of the eight norm-based age-corrected scaled scores (based on test manual; Delis et al., 2001) was computed to generate a single EF performance score. Cronbach's alpha for this composite was .83.

### HbA1c

Glycated hemoglobin (HbA1c) was obtained on the day of cognitive testing, and at time 2 with HbA1c mail-in kits (processed by CoreMedica Laboratories, accredited by the College of American Pathologists; www.coremedica.net). This approach was chosen over obtaining HbA1c from medical records to ensure that HbA1c measures occurred on the day of cognitive testing, the same procedures were used across time points, and HbA1c could be obtained from those who were not under routine care. At baseline, the kit was completed after receiving instructions from an assistant who observed test completion. This measure was highly correlated with point-of-care HbA1c assays in medical records at baseline ($r = .74$, $p < .001$).

### Analysis strategy

Discrete change differences at day t + 1 minus the component at day t were computed for each of the thirteen components (i.e., seven self-regulation components and six social-regulation components) to represent daily change scores. Then, latent coordination factors of these changes were constructed to represent how components changed together through time. Three different multilevel latent variable models were applied to the discrete changes. Each model related to a different conceptualization of the coordinated structure that comprised self- and social-regulation (one factor of self-coordination, two factors of self-coordination and a social-coordination factor and three factors of self-, mother-, and father-coordination). The covariances between factors represent regular movement of the coordination factors with one another—though not consistent enough to collapse into a single latent coordination factor.

The mixture hybrid multilevel structural equation model was conducted in Mplus 7.2 from the best-fitting factor structure (1–3). One, two, and three class solutions were compared and the best solution was interpreted. Akin to weak factorial invariance logic, the factor loadings were held constant across class, but the relationships (covariances) between latent factors were allowed to differ between classes. The drivers, set points, covariances between factors, component means, and stability effects were all allowed to differ by class. Parameters were determined to be significantly different across classes when neither class's estimates were contained in the other class's 95% confidence interval. Components were not allowed to predict the discrete changes of other components, which forced the relationships between components through the coordination factors. The coordination decomposition contains a stable pattern for each component and a portion shared with other components. To capture this decomposition, both the discrete changes and the latent coordination factors were predicted by the current values of each component (not the changes) at day t. The prediction of a component's change by that component's value at day t encompasses both *where* (set point) and *how quickly* the components were pulled back to their set points (stability). The prediction of a component at day t onto a latent coordination factor characterizes a *driver* relationship, wherein earlier values uniquely predict how the shared changes will move forward in the future (Butner et al., 2018). Drivers can be conceptualized as containing unique information indexing how the system will change over time. In the stable characterization of coordination, the drivers serve both as the greatest predictors of the coordination, and also as maintainers of the stable coordination patterns.

## Results

### Preliminary analysis: replication of coordinative structure

To determine the factor structure, as was done in Butner et al. (2018), we examined the minimization of the BIC for the one, two, and three coordinated factor structure (BIC = 51,074, 44,001, and 27,906 respectively). As we expected and previously found when the current participants were seniors in high school, the three-factor solution was the best solution among early emerging adults, with separate self-, mother-, and father-coordination factors. The factor loadings for self-, mother-, and father-coordination factors were all in the expected direction and are provided in Table 1. For example, loadings for adherence and self-confidence were positive, while negative affect and self-regulation failures were negative.

### Determining the number and nature of classes

To determine the number of classes, we compared the one, two, and three class solutions, with all fit indices indicating

**Table 1** Table of factor loadings

| Factor loadings | Self Estimate (SE) | Mother Estimate (SE) | Father Estimate (SE) |
|---|---|---|---|
| #of BG tests | 1.00 (NA) | | |
| Adherence | 2.189 (.367)* | | |
| #Diabetes problems | −2.851 (.714)* | | |
| Self-regulation failures | −2.525 (.511)* | | |
| Self-confidence | 3.768 (.731)* | | |
| Positive affect | 1.244 (.362)* | | |
| Negative affect | −1.400 (.362)* | | |
| Mother's knowledge | | 1.000 (NA) | |
| Disclosure to mother | | .169 (.024)* | |
| Mother's help | | .785 (.098)* | |
| Father's knowledge | | | 1.000 (NA) |
| Disclosure to father | | | .300 (.102)* |
| Father's help | | | .940 (.102) * |

*Significant at $p < .05$

that using two classes was the correct solution. The BIC minimized at 2 classes and a significant Lo-Mendell-Rubin Likelihood Ratio Test (LMR) for the 2-class ($p < .001$), and non-significant LMR for the three class ($p = .764$) indicate that the inclusion of a third class did not significantly improve model fit (Nyluund et al., 2007). Classes differed on HbA1c, with Class 2 lower than Class 1 by .237 ($p = .039$) units, as well as on executive functioning, with Class 2 higher than Class 1 by 1.02 ($p = .001$) units. The component means, set points and stabilities, drivers of latent coordination factors and covariances among latent coordination factors were allowed to differ by class, while the factor structure of the latent coordination factor was held constant across classes.

Within this 2-class model, results were consistent with the interpretation of Class 1 being a more Individually-Oriented Class and Class 2 being a more Socially-Oriented Class. One indication of this distinction was Class 1 (individually-oriented regulation) having weaker covariances between latent factors than Class 2 (socially-oriented). The positive covariances between factors represent the stable movements of the coordination factors together, and indicate that the components of factors tend to be high or low together, but not consistently enough to collapse into a single factor. It is important to note that both classes are individually and socially regulating, but Class 2 (socially-oriented regulation) is utilizing social-regulation components to a greater degree compared to Class 1 (individually-oriented regulation). For the more Individually-Oriented Class (Class 1), only the mother- and father- coordination factors significantly covaried—were bi-directionally associated—(see bottom rows of Table 2), but neither parent coordination factor related to the self-coordination factor. For the Socially-Oriented Class (Class 2), the self's coordination factor was significantly associated with the mother-coordination factor, and the mother-coordination factor was also significantly associated with the father-coordination factor. The lack of covariation (association) between the self- and the father-coordination factor is consistent with all teens transitioning towards more independence. The positive association between the distinct mother- and father-coordination factors suggests that components for mothers and fathers (helpfulness, management knowledge and disclosure) tend to be high and low together, but do not change together consistently enough to collapse into a single factor. 73% of the observations belonged to the Individually-Oriented Class, suggesting that there were adequate data representing each class.[1]

## Differences in component patterns by classes

With evidence that there are two distinct classes that differ on important metrics related to HbA1c and EF, we further characterized differences across classes. To examine the difference in patterns of coordination between classes, we compared component means, *where* and *how quickly* components return to their stable values (set points and stability), and which components help to maintain the global pattern of coordination (drivers).

### *Differences in means by class*

All the means for components were significantly different between classes (see Table 3). Consistent with the implied group names, the Socially-Oriented Class had significantly higher reports of parental involvement (mother and father knowledge, helpfulness, disclosure), and also had higher means for adherence, number of BG tests, self-confidence, and positive affect components of self-regulation than the Individually-Oriented Class.

### *Differences in set points by class*

We tested the difference in component set points between classes (Table 3). All components except mother's help, negative affect and number of regulation failures had significantly different set points between classes, indicating that the Socially- and Individually-Oriented Classes tended to return to different stable values. For the components that have different set points, the Socially-Oriented Class was

[1] Entropy can be used in mixture modeling as an indicator of the difference between classes. With an entropy of .938, we can be reasonably certain that the classes are in fact capturing distinct patterns.

**Table 2** Table of estimates of drivers of coordination factors and stability

| Items predicting | Self factor | | Mother factor | | Father factor | | Stability (own effect) | |
|---|---|---|---|---|---|---|---|---|
| | Estimate (SE) | | Estimate (SE) | | Estimate (SE) | | Estimate (SE) | |
| | Individual | Social | Individual | Social | Individual | Social | Individual | Social |
| #of BG tests | −.006 (.003) | −.004 (.005) | −.017 (.012) | −.013 (.047) | −.017 (.010) | .022 (.041) | **−.087 (.013)*** | **−.113 (.025)*** |
| Self-regulation failures | .023 (.008)* | .037 (.013)* | .026 (.035) | −.091 (.103) | .002 (.028) | −.077 (.074) | −.326 (.029)* | −.292 (.059)* |
| Adherence | **−.046 (.013)*** | **−.017 (.013)** | −.058 (.043) | .142 (.142) | −.005 (.031) | .095 (.127) | **−.288 (.031)*** | **−.396 (.084)*** |
| #Diabetes problems | .003 (.005) | .002 (.008) | .026 (.035) | .147 (.092) | .025 (.027) | .126 (.042)* | −.499 (.036)* | −.464 (.056)* |
| Positive affect | 0.001 (.007) | .014 (.010) | **−.025 (.031)** | **.285 (.117)*** | .025 (.033) | −.038 (.096) | −.378 (.036)* | −.402 (.078)* |
| Negative affect | **0.011 (.008)** | **.031 (.014)*** | **.003 (.043)** | **.416 (.130)*** | −.001 (.025) | .067 (.113) | −.436 (.047)* | −.475 (.063)* |
| Self-confidence | .007 (.007) | −.007 (.014) | −.027 (.038) | .060 (.128) | .022 (.013) | −.079 (.089) | **−.491 (.035)*** | **−.640 (.075)*** |
| Mother's knowledge | **.007 (.008)** | **−.011 (.008)** | .335 (.087)* | .146 (.171) | −.057 (.029)* | −.105 (.143) | −.371 (.057)* | −.360 (.125) |
| Disclosure to mother | .023 (.054) | .011 (.016) | .157 (.140) | −.160 (.247) | **−.075 (.155)** | **−.556 (.204)*** | −.765 (.075)* | −.604 (.123)* |
| Mother's help | −.002 (.009) | .007 (.007) | **.611 (.079)*** | **.408 (.119)*** | −.109 (.082) | −.296 (.167) | −.395 (.100)* | .444 (.110)* |
| Father's knowledge | −.006 (.013) | .003 (.006) | −.205 (.068)* | −.265 (.089)* | −.057 (.133) | −.119 (.084) | −.615 (.084)* | −.593 (.079)* |
| Disclosure to father | .077 (.054) | .005 (.016) | **.254 (.107)*** | **−.085 (.207)** | **.069 (.051)** | **.426 (.202)*** | −.650 (.085)* | −.710 (.095)* |
| Father's help | −.006 (.013) | −.016 (.007)* | −.059 (.043) | .076 (.135) | **−.003 (.020)** | **−.264 (.121)*** | **−.389 (.076)*** | **−.530 (.067)*** |
| Covariances | | | | | | | | |
| Teen factor with | – | | **.003 (.004)** | **.030 (.010)*** | **.002 (.002)** | **.008 (.005)** | | |
| Mother factor with | – | | – | | **.208 (.049)*** | **.347 (.041)*** | | |

Bold indicates parameter estimates that differ by class

*Significant at $p < .05$

**Table 3** Table of means and set points

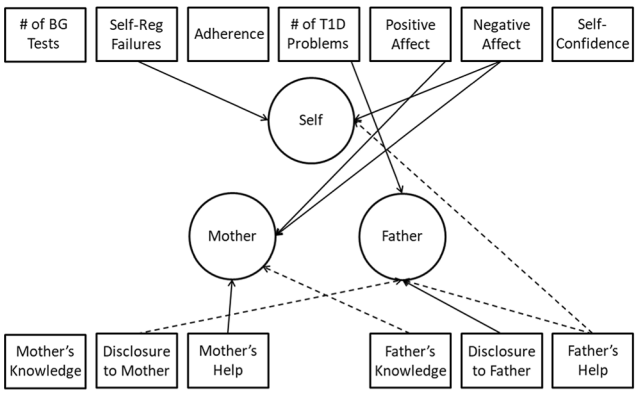
| Items predicting | Means | | Set points | |
|---|---|---|---|---|
| | Estimate (SE) | | Estimate (SE) | |
| | Individual | Social | Individual | Social |
| #of BG tests | **2.37** | **4.05** | **2.35** | **3.99** |
| #of Regulation failures | **3.34** | **1.33** | 2.89 | 2.25 |
| Adherence | **3.89** | **4.88** | **3.81** | **4.80** |
| #Diabetes problems | **1.41** | **1.08** | **1.31** | **1.04** |
| Positive affect | **1.63** | **3.51** | **1.55** | **3.44** |
| Negative affect | **2.14** | **1.61** | 2.13 | 1.91 |
| Self-confidence | **2.58** | **3.99** | **2.57** | **3.98** |
| Mother's knowledge | **2.07** | **3.69** | **2.04** | **3.61** |
| Disclosure to mother | **.15** | **.51** | **.10** | **.50** |
| Mother's help | **1.65** | **2.56** | 2.34 | 2.82 |
| Father's knowledge | **.56** | **2.37** | **.49** | **2.33** |
| Disclosure to father | **.19** | **.45** | **.11** | **.43** |
| Father's help | **2.25** | **3.03** | **2.21** | **3.03** |

Bold indicates parameter estimates that differ by class

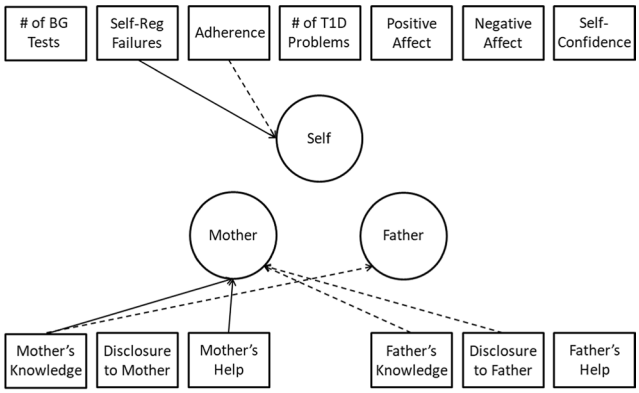
pulled back to (or returned to) set points in line with higher regulation behaviors (e.g., greater frequency of BG tests, higher mothers' knowledge).

*Difference in stability by class*

For both classes, all components significantly predicted their own change scores (see Table 2, last column stability—own effect), with the negative signs indicating that they act as stabilizers, helping to maintain their own unique patterns through time (Butner et al., 2018). Further, all stability coefficients that were different between classes (bolded values in table)—number of blood glucosetests, adherence, self-confidence, mother's knowledge and father's help—were all more negative in the socially–oriented class. These coefficients indicate that components were pulled back to their stable points faster for those who are more socially-oriented in their diabetes regulation than those who are more individually-oriented. It is important to note that stronger stability (or faster return to the set point) is only adaptive if *where* the system is returning to is good. The stability and the set




**(a)** Significant Drivers of the Coordinated Factors for the Socially-Oriented Class of Regulation. Dashed lines indicate negative associations. Solid lines indicate positive associations.




**(b)** Significant Drivers of the Coordinated Factors for the Individually-Oriented Class of Regulation. Dashed lines indicate negative associations. Solid lines indicate positive associations.

**Fig. 1** **a** Significant drivers of the coordinated factors for the socially-oriented class of regulation. Dashed lines indicate negative associations. Solid lines indicate positive associations. **b** Significant drivers of the coordinated factors for the individually-oriented class of regulation. Dashed lines indicate negative associations. Solid lines indicate positive associations

points indicate that the Socially-Oriented Class both had better set points (closer to accepted target range of diabetes outcomes), and were pulled back more quickly to those set points when disruptions occurred.

*Drivers of the coordinative process by class*

Estimates for drivers—the components that predict change in the system of regulation—are reported in columns 1–3 of Table 2. For the Individually-Oriented Class, number of regulation failures, and adherence were drivers of the self-coordination factor (see Fig. 1a). This means that fewer self-regulation failures and higher adherence served to re-regulate the teens' management. For the mother-coordination factor, mother's knowledge, mother's help, father's knowledge, and disclosure to fathers were drivers of the mother-coordination factor. Finally, for the father's coordination factor, mother's knowledge was a significant driver. Overall, this suggests there is an important transactional dynamic between the two parents, even while they may maintain a degree of independence, but that the father has less of a stabilizing influence (i.e., the lack of covariances between coordination factors).

For the Socially-Oriented Class, self-regulation failures, negative affect and father's help were drivers of the self-coordination factor (see Fig. 1b). For the mother-coordination factor, positive and negative affect, mother's help and father's knowledge were drivers. Finally, for the father-coordination factor, number of diabetes problems, disclosure to mother and to father, and father's helpfulness were significant drivers. The Socially-Oriented Class's coordination pattern shows more cross factor drivers—where both the mother- and father-coordination factors had drivers from the self-coordination factor. This is important as it suggests the emerging adult is driving the involvement of the parents. Further, the self-coordination factor had a cross-factor driver involving father's helpfulness. This pattern is consistent with the Socially-Oriented Class showing a pattern of greater connection between self- and social-regulation. This pattern was associated with lower HbA1c and higher executive functioning suggests that such a connection may be important to maintaining their beneficial pattern of diabetes regulation.

### Summary of class differences

Overall the set points, component means, stabilities, and associations between factors indicated more social connection for the class with lower HbA1c and higher executive functioning. Further, those with higher executive functioning and lower HbA1c had a pattern, on average, of more social connection as indicated by differences in component means, set points, stabilities, associations among factors and more cross-factor drivers, demonstrating the potential continued impact of social support involving parents during early emerging adulthood.

## Discussion

This approach to modeling coordination between self- and social-regulation components of T1D management during early emerging adulthood offers a number of unique insights. First, our results support recent theoretical models of regulation for chronic illness management (Berg et al., 2017; Wiebe et al., 2018), by showing that self- and social-regulation parse into separate, but related, coordinated factors (represented by self-, mother- and father-coordination

factors). In general, our results suggest that the family system during emerging adulthood functions as a constellation of distinct factors, consistent with the factor structure found in this same sample a year earlier, during late adolescence (Butner et al., 2018). Consistent with emerging adults transitioning towards independence, the self-coordination factor did not significantly covary with the father-coordination factor, unlike at the previous time point. The positive association between the distinct mother- and father-coordination factors suggests that components for mothers and fathers (helpfulness, management knowledge and disclosure) tend to be high and low together. Since the father-coordination factor did not significantly covary with the self-coordination factor for either class, the association between mother- and father-coordination factors may represent the flow of information between parents, helping to keep fathers connected to the regulation process.

### Socially-versus individually-oriented classes of coordination

We found two distinct classes of regulation, where teens were either more socially- or more individually-oriented. When teens were more socially-oriented, they demonstrated more desirable patterns of self- and social-regulation (e.g., significantly different set points & means consistent with better medical management). The Socially-Oriented Class also had a stronger link between self- and mother- and between the mother- and father-coordination factors than the Individually-Oriented Class, indicating a more coordinated or connected self- and social-regulation system. Finally, the Socially-Oriented Class had lower HbA1c and higher executive functioning than the Individually-Oriented Class. Taken together, these results are suggestive that more connection between parents and emerging adults may be important for sustained diabetes management during emerging adulthood, consistent with theoretical accounts of the importance of self- and social regulation during emerging adulthood (Berg et al., 2017; Wiebe et al., 2018).

This pattern of results suggests the importance of not just independence, but also interdependence in teens' type one diabetes regulation. Emerging adults and their parents are given the strong message in the clinical setting that their goal is to be "independent" in their diabetes management (Monaghan, Hilliard, Sweenie, & Riekert, 2013). However, the results from our study support the view that independence in self-care, while developmentally normative, is not necessarily beneficial for diabetes management, given that emerging adulthood has been characterized as a "high-risk" period (Weissberg-Benchell et al., 2007). Our results suggest that when individuals are socially-oriented in their regulation, they have more desirable patterns of regulation (consistent with recommended management). This is contrary to the message of prioritizing independence that emerging adults are given, and more consistent with the growing acknowledgement that family and caregiver engagement may still be beneficial during emerging adulthood (Peters & Laffel, 2011). Emerging adults may increasingly need to disclose to parents in order for parents to be knowledgeable about their diabetes activities and assist when needed (Kelly et al., in press). To bolster clinical outcomes, it may be that early emerging adults could benefit from greater social coordination during this time (see Butner et al., 2018).

Further, given that drivers may indicate places to intervene within the system, our work is suggestive of multiple different potential intervention strategies. Since self-regulation failures were drivers for both emerging adults who were socially-oriented and individually-oriented, it may be the most efficacious component to intervene on for both classes of regulators. Self-regulation failures consisted of items related to cognitive failures, such as forgetting to test and failing to initiate testing when motivation was low—failures that have previously been connected to problems with attention and executive functioning (Berg et al., 2014). These results support the growing literature that general capacities such as executive function are associated with greater maintenance of diabetes management across this high-risk time (Butner et al., 2018; Duke & Harris, 2014). These results suggest interventions aimed at supporting emerging adults' daily attempts at self-regulation. One avenue for such support may be through text or phone reminders aimed at assisting individuals in their diabetes management (Jones et al., 2014).

Additionally, different interventions could be differentially successful for when emerging adults are individually-oriented versus socially-oriented. For example, when individuals were socially-oriented, negative affect functioned as a driver for both the self- and the mother- coordination factor, indicating that it may be especially good at shifting multiple parts of the regulation system. The importance of changing negative affect to produce changes in the system are consistent with results from the T1-REDEEM trial (Fisher et al., 2018), which found that targeting emotion regulation was especially beneficial in reducing diabetes distress for those with poorer cognitive and/or emotion regulation abilities. Number of self-regulation failures drove the father-coordination factor, and may indicate a part of the regulation system fathers are sensitive to during this transitional time. However, for the Individually-Oriented Class, no parent components were drivers of the self-regulation factor, and no self-regulation components drove either parent coordination factor. This implies that interventions for the Individually-Oriented Class either should predominantly target components of self-regulation (e.g., self-regulation failures and adherence behaviors) or attempt to shift the Individually-Oriented Class to function

more like the Socially-Oriented Class. It is possible that an intervention on individually oriented regulators attempting to strengthen interdependence may result in more teens having socially-oriented regulation patterns. Future research is needed to determine whether interventions work differently for these different classes. Future research is also needed to understand if individuals who are individually-oriented have improved patterns of regulation if they increase their utilization of their social regulation network.

The present findings differ in several important ways from our previous work. In contrast to our earlier work with the same sample during late adolescence (Butner et al., 2018), during early emerging adulthood there was less of an influence of parents' social-regulation on emerging adults' self-regulation. For instance, only father's helpfulness had a driving relationship in coordinating self-regulation over the 14-day diary, and only for the smaller Socially-Oriented Class. Thus, for the Individually-Oriented Class (which comprised the largest number of emerging adults), individuals' components of self-regulation were not strongly tied to their reports of components of social-regulation from mothers or fathers across a two-week period. For the Individually-Oriented Class, the self- and social-regulation system is especially reflective of the transition of early emerging adults towards independence in regulation.

### Limitations

The results of our study must be considered in the context of some limitations. First, our data relied on emerging adults' self-reports of self- and social-regulation. Although perceptions of social involvement may be especially informative (Uchino, 2009), gathering reports of social-regulation provided from parents or others could lead to the emergence of alternative patterns. Second, participants in our sample were only one year out of high school and very early in emerging adulthood. It may be that as these individuals move further into emerging adulthood, other patterns with stronger or weaker associations with self- and social-regulation may emerge. Third, the comparison of results to those when the sample was in late adolescence should be meted accordingly since the changes in driving relationships were always tested simultaneously, equivalent to simultaneous regressions—where each relationship was above and beyond all the other components in the system. Further, this model was run as a mixture model, essentially parsing the different coordination patterns for different sub-populations of regulation. Thus, the finding that mothers did not drive the coordinated aspect of the teen's reports of the self may be more a lack of unique prediction rather than no relationship. Further, although the differences in HbA1c and EF across classes were small, they round out a pattern suggesting that the Socially-Oriented Class is displaying patterns of regulation and glycemic control consistent with recommended medical management. Additionally, patterns of self- and social-coordination may vary depending on physical or emotional proximity to parents throughout the day. Future research is needed to model how self-and social-regulation coordination patterns may vary according to the living arrangements of emerging adults (living with vs. apart from family, friends or partners) as well as other relationship types, such as romantic relationships (Seiffge-Krenke, 2013). Finally, though the racial and ethnic breakdown of our sample was similar to national incidence of type 1 diabetes in this age group, our participants were largely non-Hispanic White. Our observed patterns of self- and social-regulation along with the pattern of diabetes management may be different in samples with different racial or ethnic backgrounds. Evidence suggests that patterns of diabetes management may be different in racial or ethnic minority individuals with type 1 diabetes compared to their non-Hispanic White peers (Willi et al., 2015). However, it is less clear to what extend race/ethnicity would contribute to different observed patterns of social regulation. Future research should over sample minority individuals in order to compare patterns of self- and social-regulation in the context of diabetes management to address these issues.

## Conclusion

This study revealed new insights about how families are connected during early emerging adulthood in the context of T1D. By examining differences in coordination by class, we found that teens who displayed socially-oriented regulation patterns are capitalizing more on their social relationships to stabilize regulation across this transitional time than the individually-oriented teens. The identification of both coordinated structures and drivers can be applied to a wide array of phenomena that occur within health over time, including how families relate in the context of other chronic illnesses (e.g., cancer, asthma), especially as they transition to managing a chronic illness, or to understand how bio-behavioral processes of illness management move together through time. Future research is needed to expand social-regulation to include new supportive relationships (e.g., friends, romantic partners) in addition to parents. Such research may reveal how to target interventions to change how disease management functions, especially as individuals move into emerging adulthood. Finally, important for behavioral medicine, identifying drivers may aid researchers and clinicians in targeting the component of the system most capable of creating change and thus used for intervention. By targeting these aspects of management, health psychologists and health researchers may be able to more effectively support emerging adults' self-management efforts in the context of their social environments.

**Acknowledgements** Funding was provided by National Science Foundation and National Institute of Diabetes and Digestive and Kidney Diseases (Grant No. R01DK092939).

**Compliance with ethical standards**

**Conflict of interest** A. K. Munion, Jonathan E. Butner, Caitlin S. Kelly, Deborah J. Wiebe, Sara L. Turner, Amy Hughes Lansing and Cynthia A. Berg declare that they have no conflict of interest.

**Ethical approval** All research was conducted under the guidance and oversight of the University of Utah, University of California at Merced, and University of Texas Southwestern Institutional Review Boards.

**Human and animal rights and informed consent** All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

## References

American Diabetes Association. (2014). Standards of medical care in diabetes. *Diabetes Care, 37,* S14–S80. https://doi.org/10.2337/dc14-S014

Berg, C. A., Butner, J. E., Wiebe, D. J., Lansing, A. H., Osborn, P., King, P. S., et al. (2017). Developmental model of parent-child coordination for self-regulation across childhood and into emerging adulthood: Type 1 diabetes management as an example. *Developmental Review, 46,* 1–26.

Berg, C. A., Queen, T., Butner, J. E., Turner, S. L., Lansing, A. H., Main, A., et al. (2016). Adolescent disclosure to parents and daily management of type 1 diabetes. *Journal of Pediatric Psychology*. https://doi.org/10.1093/jpepsy/jsw056

Berg, C. A., Wiebe, D. J., Suchy, Y., Hughes, A. E., Anderson, J. H., Godbey, E. I., et al. (2014). Individual differences and day-to-day fluctuations in perceived self-regulation associated with daily adherence in late adolescents with type 1 diabetes. *Journal of Pediatric Psychology, 39,* 1038–1048. https://doi.org/10.1093/jpepsy/jsu051

Berg, C. A., Wiebe, D. J., Tracy, E. L., Kelly, C. S., Mello, D., Turner, S. L., et al. (2019). Parental involvement and executive function in emerging adults with type 1 diabetes. *Journal of Pediatric Psychology, 44*, 970–979.

Beveridge, R. M., Berg, C. A., Wiebe, D. J., & Palmer, D. L. (2006). Mother and adolescent representations of illness ownership and stressful events surrounding diabetes. *Journal of Pediatric Psychology, 31*, 818–827.

Butner, J. E., Berg, C. A., Munion, A. K., Turner, S. L., Hughes-Lansing, A., Winnick, J. B., et al. (2018). Coordination of self- and parental-regulation surrounding type I diabetes management in late adolescence. *Annals of Behavioral Medicine, 52*, 29–41.

Cranford, J. A., Shrout, P. E., Iida, M., Rafaeli, E., Yip, T., & Bolger, N. (2006). A procedure for evaluating sensitivity to within-person change: Can mood measures in diary studies detect change reliably? *Personality and Social Psychology Bulletin, 32,* 917–929.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis–Kaplan Executive Function System®(D-KEFS®): Examiner's manual: Flexibility of thinking, concept formation, problem solving, planning, creativity, impluse control, inhibition*. London: Pearson.

Duke, D. C., & Harris, M. A. (2014). Executive function, adherence, and glycemic control in adolescents with type 1 diabets: A literature review. *Current Diabetes Reports, 14,* 532.

Fisher, L., Hessler, D., Polonsky, W. H., Masharani, U., Guzman, S., Bowyer, V., et al., (2018). T1-REDEEM: A randomized controlled trial to reduce diabetes distress among adults with type 1 diabetes. *Diabetes Care, 41*, 1862–1869.

Hanna, K. M., Juarez, B., Lenss, S. S., & Guthrie, D. (2003). Parent–adolescent communication and support for diabetes management as reported by sdolescents with type 1 diabetes. *Issues in Comprehensive Pediatric Nursing, 26,* 145–158.

Hanna, K. M., Weaver, M. T., Stump, T. E., Dimeglio, L. A., Miller, A. R., Crowder, S., et al. (2013). Initial findings: Primary diabetes care responsibility among emerging adults with type 1 diabetes post high school and move out of parental home. *Child: Care, Health and Development, 39*(1), 61–68.

Helgeson, V. S., Palladino, D. K., Reynolds, K. A., Becker, D. J., Escobar, O., & Siminerio, L. M. (2013). Relationships and health among emerging adults with and without type 1 diabetes. *Health Psychology, 38,* 506–517. https://doi.org/10.1037/a0033511

Helgeson, V. S., Palladino, D. K., Reynolds, K. A., Becker, D. J., Escobar, O., & Siminerio, L. (2014). Relationships and health among emerging adults with and without type 1 diabetes. *Health Psychology, 33,* 1125–1133. https://doi.org/10.1037/a0033511

Helgeson, V. S., Vaughn, A. K., Seltman, H., Orchard, T., Becker, D., & Libman, I. (2018). Relation of parent knowledge to glycemic control among emerging adults with type 1 diabetes: A mediational model. *Journal of Behavioral Medicine, 41,* 186–194.

Hood, K. K., Peterson, C. M., Rohan, J. M., & Drotar, D. (2009). Association between adherence and glycemic control in pediatric type 1 diabetes: A meta-analysis. *Pediatrics, 124*, e1171–e1179.

Jones, K. R., Lekhak, N., & Kaewluang, N. (2014). Using mobile phones and short message service to deliver self-management interventions for chronic conditions: A meta-review. *Worldviews on Evidence-Based Nursing, 11,* 81–88.

King, P. S., Berg, C. A., Butner, J., Butler, J. M., & Wiebe, D. J. (2014). Longitudinal trajectories of parental involvement in type 1 diabetes and adolescents' adherence. *Health Psychology, 33,* 424–432.

Lewin, A. B., LaGreca, A. M., Geffken, G. R., Williams, L. B., Duke, D. C., Storch, E. A., et al., (2009). Validity and reliability of an adolescent and parent rating scale of type 1 diabetes adherence behaviors: The self-care inventory (SCI). *Journal of Pediatric Psychology, 34*, 999–1007.

Miller, K. M., Foster, N. C., Beck, R. W., et al. (2015). Current state of type 1 diabetes treatment in the U.S.: Updated data from the T1D exchange clinic registry. *Diabetes Care, 38*(6), 971–978. https://doi.org/10.2337/dc15-0078

Monaghan, M, Hilliard, M., Sweenie, R., & Riekert, K. (2013). Transition readiness in adolescents and emerging adults with diabetes: The role of patient-provider communication. *Current Diabetes Reports, 13*, 900–908.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal, 14,* 535–569.

Osborn, P., Berg, C. A., Hughes, A. E., Pham, P., & Wiebe, D. J. (2013). What mom and dad don't know CAN hurt you: Adolescent disclosure to and secrecy from parents about type 1 diabetes. *Journal of Pediatric Psychology, 38,* 141–150.

Palladino, D. K., & Helgeson, V. S. (2012). Friends or foes? A review of peer influence on self-care and glycemic control in adolescents with type 1 diabetes. *Journal of Pediatric Psychology, 37,* 591–603. https://doi.org/10.1093/jpepsy/jss009

Peters, A., & Laffel, L. (2011). Diabetes care for emerging adults: Recommendations for transition from pediatric to adult diabetes care systems: A position statement of the American Diabetes Association, with representation by the American College of Osteopathic Family Physicians, the American Academy of Pediatrics, the American Association of Clinical Endocrinologists,

the American Osteopathic Association, the Centers for Disease Control and Prevention, Children with Diabetes, The Endocrine Society, the International Society for Pediatric and Adolescent Diabetes, Juvenile Diabetes Research Foundation International, the National Diabetes Education Program, and the Pediatric Endocrine Society (formerly Lawson Wilkins Pediatric Endocrine Society). *Diabetes Care, 34*, 2477–2485.

Seiffge-Krenke, I. (2013). "She's leaving home…" antecedents, consequences, and cultural patterns in the leaving home process. *Emerging Adulthood, 1*(2), 114–124.

Turvey, M. T. (1990). Coordination. *The American Psychologist, 45,* 938–953.

Uchino, B. N. (2009). Understanding the links between social support and physical health: A life-span perspective with emphasis on the separability of perceived and received support. *Perspectives on Psychological Science, 4,* 236–255.

Weissberg-Benchell, J., Wolpert, H., & Anderson, B. J. (2007). Transitioning from pediatric to adult care: A new approach to the post-adolescent young person with type 1 diabetes. *Diabetes Care, 30,* 2441–2446. https://doi.org/10.2337/dc07-1249

Wiebe, D. J., Berg, C. A., Mello, D., & Kelly, C. S. (2018). Self- and social-regulation in type 1 diabetes management during late adolescence and emerging adulthood. *Current Diabetes Reports, 18,* 23–32. https://doi.org/10.1007/s11892-018-0995-3

Wiebe, D. J., Chow, C. M., Palmer, D. L., Butner, J. E., Butler, J. M., Osborn, P., et al. (2014). Developmental processes associated with longitudinal declines in parental responsibility and adherence to type 1 diabetes management across adolescence. *Journal of Pediatric Psychology, 39,* 532–541. https://doi.org/10.1093/jpepsy/jsu006

Willi, S. M., Miller, K. M., DiMeglio, L. A., Klingensmith, G. J., Simmons, J. H., Tamborlane, W. V., et al. (2015). Racial-ethnic disparities in management and outcomes among children with type 1 diabetes. *Pediatrics, 135,* 424–434.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.