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Review

# Psychophysiological Correlates of Emotion Regulation in Type 1 Diabetes: A Scoping Review

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**Key Messages**

- Greater difficulties in emotion regulation are related to higher levels of depressive symptoms, diabetes distress, HbA1c and insulin restriction.
- Inversely, greater use of more adaptive strategies (e.g. reappraisal, acceptance) was related to lower levels of these psychophysiological correlates.
- Future research should consider individual (e.g. gender), proximal (e.g. family dynamics), and distal (e.g. stigma) factors in these associations.

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ABSTRACT

Daily management of type 1 diabetes (T1D) can trigger various psychological and physiological responses, including depressive symptoms and hyperglycemia. Substantial evidence shows that emotion regulation modulates psychological and physiological experiences in the general population; yet, its role among individuals with T1D has yet to be systematically investigated.

In 2024–2025, a comprehensive literature search for psychological and physiological correlates of emotion regulation among individuals with T1D was conducted using PRISMA guidelines. Eight studies (with cohorts ranging from 60 to 301 patients; 69.3% women), consisting of 5 cross-sectional and 3 longitudinal studies, met the inclusion criteria. Emotion regulation was measured using either the Difficulties in Emotion Regulation Scale (n=3); the Emotion Regulation Questionnaire (n=2); or subscales from the coping, executive function, and mindfulness questionnaires deemed to capture emotion regulation (n=3). Among psychological correlates, most studies assessed diabetes distress (n=5), whereas 2 assessed depressive symptoms. Overall, results indicate that greater difficulties in emotion regulation correlated with higher diabetes distress levels, whereas greater use of certain emotion regulation strategies, such as cognitive reappraisal, correlated with lower diabetes distress levels. As for physiological correlates, most studies evaluated glycated hemoglobin (A1C) (n=7) and insulin restriction (n=1). The included studies show that greater difficulties in emotion regulation correlated with higher A1C and insulin restriction levels. Taken together, we introduced a conceptual model connecting emotion regulation and psychophysiological correlates with broader sociocontextual factors. Although emotion regulation relates to psychophysiological functioning among individuals with T1D, further longitudinal research considering sociocontextual factors is warranted to confirm the directionality of effects.



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RÉSUMÉ

*Contexte :* La prise en charge quotidienne du diabète de type 1 (DT1) peut déclencher diverses réactions psychologiques et physiologiques, notamment des symptômes dépressifs et une hyperglycémie. De nombreuses données montrent que la régulation des émotions module les expériences psychologiques et physiologiques dans la population générale ; cependant, son rôle chez les personnes atteintes de DT1 n'a pas encore fait l'objet d'études systématiques.
*Méthodologie :* En 2024-2025, une recherche bibliographique exhaustive sur les corrélats psychologiques et physiologiques de la régulation émotionnelle chez les personnes atteintes de DT1 a été menée selon les lignes directrices PRISMA.
*Résultats :* Huit études répondaient aux critères d'inclusion (N = 60 à 301 ; 69,3 % de femmes), dont 5 études transversales et 3 études longitudinales. La régulation émotionnelle a été mesurée soit à l'aide de l'échelle des difficultés de régulation émotionnelle (n = 3), du questionnaire sur la régulation des émotions (n = 2), soit à l'aide de sous-échelles issues de questionnaires sur l'adaptation, les fonctions exécutives et la pleine conscience, considérées comme permettant de saisir la régulation émotionnelle (n = 3). Parmi les corrélats psychologiques, la plupart des études ont évalué la détresse liée au diabète (n = 5), tandis que deux examinaient les symptômes dépressifs. Dans l'ensemble, les résultats indiquent que des difficultés plus importantes dans la régulation des émotions sont associées à des niveaux plus élevés de détresse liée au diabète, tandis qu'un recours accru à certaines stratégies de régulation des émotions, comme la réévaluation cognitive, est associé à des niveaux plus faibles de détresse liée au diabète.
En ce qui concerne les corrélats physiologiques, la plupart des études ont évalué le taux d'hémoglobine glyquée (HbA1c) (n = 7) et la restriction d'insuline (n = 1). Les études incluses montrent que des difficultés accrues dans la régulation des émotions sont associées à des niveaux plus élevés d'HbA1c et de restriction d'insuline. Dans l'ensemble, nous avons présenté un modèle conceptuel reliant la régulation des émotions et les corrélats psychophysiologiques à des facteurs socio-contextuels plus larges.
*Conclusion :* Bien que la régulation des émotions soit liée au fonctionnement psychophysiologique chez les personnes atteintes de DT1, des recherches longitudinales supplémentaires tenant compte des facteurs socio-contextuels sont nécessaires pour confirmer la directionnalité des effets.


## Introduction

### *Type 1 diabetes*

In 2021, 500,000 new cases of type 1 diabetes (T1D) were reported worldwide. Projections indicate that the number of individuals with this condition could reach up to 17.4 million in 2040 [1]. T1D is an autoimmune disease affecting pancreatic functioning that is characterized by the absence of insulin production, which converts carbohydrates into energy [2]. Compared to type 2 diabetes (T2D), which usually appears in older individuals, T1D is more common among younger individuals—although its cause remains not fully understood [1]. To prevent possible diabetes-related complications, individuals with T1D also need to administer daily doses of insulin. Consequently, a T1D diagnosis comes with newly required lifestyle habits, such as regular insulin administration and carbohydrate calculation, that are needed to maintain blood glucose levels within the recommended range [3]. Therefore, disease management can be time-consuming and life-altering, such as by affecting social and professional activities [4], making T1D a biopsychosocial condition that can be physiologically and psychologically demanding.

### *Psychological distress*

Besides social and physiological challenges, up to 20% of the T1D population reports having anxiety or depressive symptoms [5,6]. Individuals with T1D are also more likely to develop diabetes distress, a specific distress related to the burden of the disease's management [7]. In instances of greater severity of distress symptoms, consequences can be fatal, with evidence suggesting a higher suicide rate in individuals with T1D than in individuals with T2D [8], and a higher prevalence of suicidal ideations in adolescents with T1D than in the general population [9,10]. These manifestations of psychological distress are related to the duration and acceptance of the condition, such that longer duration of diabetes and lower acceptance levels predict higher anxiety and depressive symptoms [11,12] and diabetes distress [13]. Psychological distress has also been related to unfavourable physiological functioning in this population, including higher daily glycemia and glycated hemoglobin (A1C) levels [11,14–18], as well as poorer metabolic control and diabetes management [19].

### *Psychological well-being*

Positive psychological functioning has been less studied in individuals with T1D, although various dimensions of psychological well-being (e.g. optimism, positive emotions including happiness) represent more than the absence of anxiety/depression symptoms and negative emotions [20,21]. Among available T1D studies, higher psychological well-being has been cross-sectionally associated with lower depressive symptoms [22]. Regarding physiological functioning, greater positive emotions have been associated with better metabolic control cross-sectionally [23] and longitudinally [24]. Although some findings suggested no association between a composite score of several psychological well-being dimensions and A1C specifically [25], others showed an overall association between greater psychological well-being and lower A1C levels [22,26].

### *Emotion regulation*

The etiology of higher psychological distress and lower psychological well-being in T1D is poorly understood [4]. However, emotion regulation may be a promising avenue to explore because psychological distress and well-being are influenced by regulatory strategies used by individuals in the general population [27,28].

Emotion regulation, one of the most studied psychological regulatory processes, has been defined as "attempts to influence which emotions people have, when they have them, and how they experience or express them" [29].

Emotion regulation strategies are typically considered adaptive or maladaptive depending on their effect on psychological and physical functioning among nonclinical populations [28,30,31]. For example, acceptance and reappraisal are usually labelled adaptive because their use is associated with lower psychological distress, greater positive emotions, and healthier cardiovascular functioning, whereas rumination and suppression are often judged as maladaptive because they relate to these outcomes in the opposite direction [31–33]. However, strategies' effectiveness is also context-dependent, whereby a strategy typically deemed maladaptive (e.g. excessive planification) can be adaptive in some circumstances (e.g. to avoid hypoglycemia). Thus, flexible use of emotion regulation strategies should be favoured for optimal adjustment [34].

When managing T1D on a daily basis, whether individuals will experience psychological distress/well-being and physiological fluctuations could be due to their upstream regulatory strategies [16]. This hypothesis is consistent with existing conceptual models that posit emotion regulation as an overarching psychological process that modulates not only psychological distress and well-being levels, but also physiological functioning over time in the general, nonclinical population [35,36]. Of note, although not the focus of the current review, bidirectional associations likely exist, whereby physiological markers, including insulin resistance and glucose levels, may also alter subsequent psychological processes in the general [37] and T1D [38] populations. Previous reviews have summarized prevalence and correlates of psychological distress and well-being among individuals with T1D [4,26,39], but no work to date has comprehensively synthesized the literature on the psychological and physiological correlates of emotion regulation in this population.

### *Objective and research question*

In this scoping review, we aim to comprehensively synthesize the literature on the relationship of emotion regulation with psychological and physiological correlates among individuals with T1D. The research question is the following: Is emotion regulation related to psychological and physiological functioning among individuals with T1D? To achieve our objective, a scoping review framework was prioritized, as advised when the concepts involved are broad and have not yet been summarized [40,41].

## Methods

### *Inclusion and exclusion criteria*

To be retained for assessment, studies had to: 1) include participants with a T1D diagnosis; 2) evaluate the construct of emotion regulation; 3) investigate psychological (e.g. anxiety, optimism) or physiological (e.g. glucose, insulin) factors; 4) be published in a peer-reviewed journal; and 5) be written in English or French (the latter being a language understood by all coauthors, which broadened our literature search). Conversely, studies were excluded if participants were ≤12 years of age, because a T1D diagnosis occurs typically around this age [42]. Studies that did not assess the relation between emotion regulation and a psychological or physiological factor were also excluded. Moreover, grey literature (e.g. thesis, conference papers), qualitative research, case studies, meta-analyses, and systematic reviews were excluded, as suggested in prior guidelines [43]. No *a priori* date restriction was used.

### *Data sources and search strategy*

The guidelines and recommended stages for conducting scoping reviews were followed [40,41]. Identification and selection of studies were conducted according to the PRISMA guidelines for scoping reviews [44]. In June 2024, articles were searched throughout 4 databases: APA PsycINFO, PubMed, Scopus, and CINAHL. The search was updated in April 2025. The reference lists of selected articles were also inspected. The keywords used in this search strategy are presented in Table 1, with search strings included for the concepts related to diabetes, emotion regulation, and psychophysiological factors.

### *Study selection process*

As presented in Figure 1, the database search resulted in 862 records, all downloaded in an Endnote file. Duplicates were removed before starting the screening of 812 records, based on titles and abstracts. A total of 756 records were withdrawn at the abstract screening stage, mainly because participants did not have a T1D diagnosis, or emotion regulation was not assessed. Then, a total of 56 records were assessed for full-text eligibility. Of these, 48 were excluded for one of the following reasons: 1) no measure or subscale of emotion regulation (n=39); 2) participants included did not have a T1D diagnosis (n=3); 3) no analysis of the association between emotion regulation and a psychological or physiological factor (n=1); 4) participants were ≤12 years of age (n=2); 5) article not available (n=2); and 6) grey literature (e.g. theses/dissertations) (n=1). Thus, a total of 8 articles were included in this scoping review.

**Table 1**
Keywords used in the scoping review

| Concepts | Search no. | English keywords | French keywords |
|---|---|---|---|
| Type 1 diabetes | 1 | ("Type 1 diabetes" OR "t1d" OR "Diabet*" OR "Diabetes mellitus" OR "insulin dependent diabetes") | ("Diabète type 1" OU "Diab*" OU "dt1") |
| Emotion regulation | 2 | ("Emotion* regulation" OR "Emotion dysregulation" OR "Emotion*") | ("Régulation émotionnelle" OU "Dysrégulation émotionnelle" OU "Émotion*") |
| Emotional functioning | 3 | ("Anxi*" OR "Depress*" OR "Distress" OR "Wellbeing" OR "Well-being" OR "Wellness" OR "Positive emotion" OR "Negative emotion") | (Anxi*" OU "Dépress*" OU "Détresse" OU "Bien-être" OU Émotion positive" OU "Émotion négative") |
| Physiological functioning | 4 | ("HbA1c" OR "Glycated hemoglobin" OR "Hemoglobin a1c" OR "Glycaemia" OR "Blood sugar" OR "Insulin") | ("Hémoglobine glyquée" OU "HbA1c" OU "Glycémie" OU "Taux de sucre" OU "Insuline") |
| Combined search | 5 | 1 AND 2 AND 3 AND 4 | |

* Each line represents a different search. First, a search was led with keywords related to the T1D concept. Then, the same procedure was led with the respective keywords of the other concepts. The fifth line represents the combined search led by combining the results of the previous concepts.

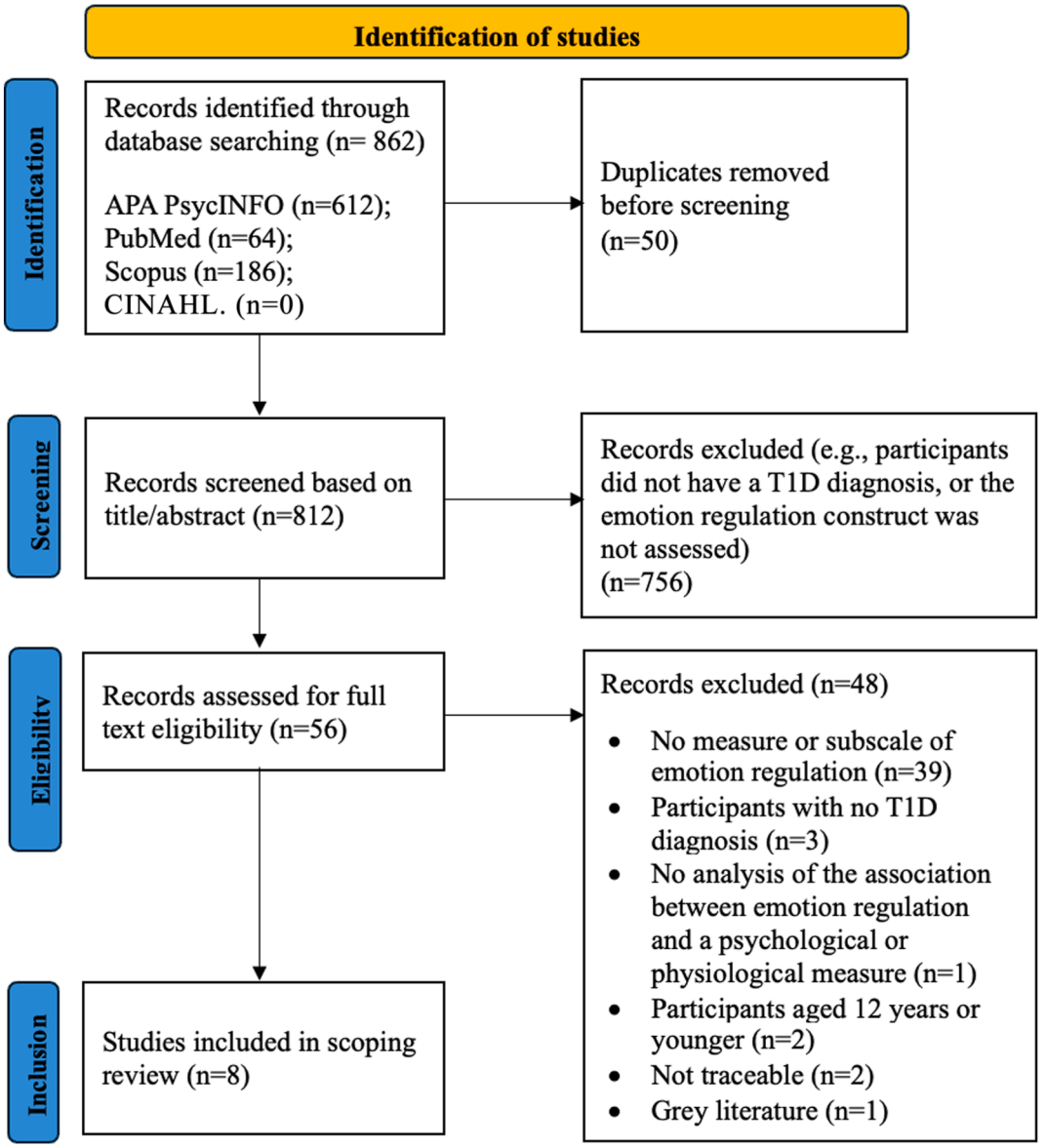


**Figure 1.** PRISMA flowchart of study selection process. *T1D*, type 1 diabetes.

*Data extraction*

As presented in Table 2, the following data from each included study were extracted: authors, country where the study was conducted, year of publication, main psychological and physiological variables, sample size, participants' sex and age, study design, psychological and physiological measures, and number and duration of follow-up assessments. Additional information, including time since T1D diagnosis and statistical analyses performed, is presented in Supplementary Table 1. Data were extracted by G.B. and verified by C.T.F.

## Results

*Descriptive characteristics of studies*

Retained studies (n=8) are detailed in Table 2. The studies were conducted in 5 countries, namely the United States (n=5), Canada (n=2), Italy (n=2), Spain (n=1), and The Netherlands (n=2), with 4 studies being conducted in 2 countries concurrently. The publication years ranged from 2014 to 2023. All studies were observational, except for 2 that were experimental studies aiming to enhance emotion regulation, cognitive skills, and T1D adherence [19,45]. Five studies used a cross-sectional design and 3 a longitudinal one. Sample sizes ranged from 60 to 301 participants, yielding a total of 1,628 participants (1,128 women; 69.3%). The mean ages ranged from 15.0 to 45.1 years, whereas the mean time since diagnosis, when available, varied from 6.0 to 26.1 years.

Regarding emotion regulation measurement, all studies relied on self-reported scales. Three studies used the 41-item Difficulties in Emotion Regulation Scale, which includes 6 subdomains (i.e. awareness and acceptance of emotions, clarity of emotions, access to regulatory strategies, impulse control, and engagement in goal-directed behaviours to regulate emotions) [46]. Two studies administered the 10-item Emotion Regulation Questionnaire on cognitive reappraisal and expressive suppression strategies [30]. Authors from 3 other studies instead selected subscales from coping, executive functioning, and mindfulness questionnaires, arguing that they capture emotion regulation processes [19,45,47]: the 4-item Emotional Processing subscale from the Emotional Approach and Coping Scale [48], the 10-item Emotional Control subscale from the Behavior Rating Inventory of Executive

**Table 2**
Articles included in the scoping review

| First author, year of publication, country where the study was conducted, and reference no. | Study design | Number and duration of follow-ups | Psychological and physiological constructs of interest | Psychological and physiological measures of interest | Sample size, n | Age, years (mean ± SD) | Sex/gender |
|---|---|---|---|---|---|---|---|
| Bassi et al, 2023, Italy and The Netherlands [51] | Cross-sectional | N/A | Emotion regulation, emotional self-awareness, diabetes distress, A1C | Emotion regulation: Emotion Regulation Questionnaire (ERQ); emotional self-awareness: Trait Meta-Mood Scale (TMMS); diabetes distress: Problem Areas in Diabetes Scale—Short Form 5 (PAID-SF-5); A1C: mean glucose control over the past 3 months | 262 | 38.1±12.14 | 211 women, 50 men, 1 nonbinary |
| Beam et al, 2021, United States [53] | Cross-sectional | N/A | Difficulties in emotion regulation, depressive symptoms, insulin restriction, A1C | Emotion regulation: Difficulties in Emotion Regulation Scale (DERS); depressive symptoms: Center for Epidemiologic Studies—Depression (CES-D) scale; insulin restriction: a single item assessing IR, "How often do you take less insulin than you should?"; A1C: average blood glucose over the prior few months | 236 | 17.7±0.40 | 144 women, 92 men |
| Embaye et al, 2023, Italy and The Netherlands [52] | Cross-sectional | N/A | Emotion regulation, diabetes distress, A1C | Emotion regulation: ERQ; diabetes distress: PAID-SF-5; A1C: most recent measure of A1C | 291 | 39.6±13 | 229 women, 61 men |
| Fisher et al, 2018, United States and Canada [47] | Cross-sectional | N/A | Emotion regulation; diabetes distress, depressive symptoms, A1C | Emotion regulation: Emotional Processing subscale from the Emotional Approach and Coping Scale and Non-Judging of and the Non-Reactivity to Inner Experience subscales from the Five Facet Mindfulness Scale; diabetes distress: Type 1 Diabetes Distress Scale (T1-DDS); A1C: obtained from medical records | 301 | 45.1±15 | 208 women, 93 men |
| Ruiz-Aranda et al, 2018, Spain [55] | Cross-sectional | N/A | Emotion regulation, diabetes distress, A1C | Emotion regulation: DERS; diabetes distress: Diabetes Distress Scale (DDS-17); A1C: latest A1C value | 67 | 15.9 | 33 women, 34 men |
| Berg et al, 2014, United States [54] | Longitudinal | Baseline and daily diary for 14 days | Emotion regulation; A1C | Emotion regulation: DERS at baseline; A1C levels: latest measure of A1C obtained from medical records; blood glucose checks: reported daily | 110 | 17.8±0.39 | 68 women, 42 men |
| Fisher et al, 2019, United States and Canada [19] | Longitudinal | Baseline and 9 months later for follow-up | Emotion regulation, diabetes distress | Emotion regulation: Emotional Processing subscale from the Emotional Approach and Coping Scale and Non-Judging of Inner Experience subscale from the Five Face Mindfulness Scale; diabetes distress:T1-DDS | 301 | 45.1±15 | 208 women, 93 men |
| Lansing et al, 2019, United States [45] | Longitudinal | Baseline and 6-month follow-up | Emotion regulation, A1C | Emotion regulation: Emotional Control subscale from the Behavior Rating Inventory of Executive Function—Self-Report (CRIEF-SR); A1C: measure taken in laboratory at baseline and 6-month follow-up | 60 | 15.0 | 26 women, 34 men |

*A1C*, glycated hemoglobin; *N/A*, not applicable; *SD*, standard deviation; *T1D*, type 1 diabetes.

Function—Self-Report [49], and the 8-item Non-Judging of Inner Experience subscale from the Five Facet Mindfulness Scale [50], respectively.

Various psychological and physiological correlates were examined across studies. The most common psychological correlate was diabetes distress (n=5). Two other studies focused on depressive symptoms. Regarding physiological correlates, A1C was assessed in 7 studies and insulin restriction in 1 study. Of note, 6 of the included studies evaluated associations of demographic and clinical characteristics with emotion regulation and psychophysiological correlates. Age was generally not related to psychophysiological markers [19,51,52], except in 1 study where it was inversely related to diabetes distress and A1C levels [47]. Other demographic characteristics (e.g. gender, ethnicity) were not clearly related to psychophysiological markers [19,53] or did not moderate the association between emotion regulation and diabetes distress [52]. As for clinical characteristics, disease duration and acceptance were inconsistently related to psychophysiological markers across studies [52–54].

### *Psychological correlates of emotion regulation*

Five cross-sectional studies and 1 longitudinal study evaluated the psychological correlates of emotion regulation. Most studies evaluated diabetes distress and generally suggested that fewer difficulties in regulating emotions and greater use of emotion regulation strategies typically considered adaptive are each associated with lower diabetes distress levels. Specifically, participants with greater adaptive emotion regulation reported lower diabetes distress ($b=-0.36$, $p<0.001$) and depressive symptoms ($b=-0.64$, $p<0.001$) in a cross-sectional study of 301 middle-aged adults, after controlling for age and diabetes complications [47].

Additional cross-sectional research conducted among adolescents showed that greater overall difficulties in emotion regulation and all related subdomains (e.g. lower acceptance of emotions) were correlated with higher depressive symptoms (overall emotion regulation difficulties: $r$=0.77, p<0.01; difficulties subdomains: $r$=0.31 to 0.77, p<0.01) [53] and several diabetes distress indicators (overall emotion regulation difficulties: $r$=0.24 to 0.51, p<0.05; difficulties subdomains: $r$=0.25 to 0.52, p<0.05) [55]. Another study addressed specific emotion regulation strategies (i.e. cognitive reappraisal, mood repair, expressive suppression) and broader emotional awareness (i.e. attention to feelings, clarity of feelings) in 262 Italian and Dutch adults [51]. After controlling for diabetes duration, greater clarity of feelings correlated with lower diabetes distress levels in both countries ($r$=−0.26 and −0.48, respectively), whereas greater reappraisal and mood repair correlated with lower diabetes distress levels in Italian participants only ($r$=−0.21 and −0.25, respectively); no clear associations were identified with suppression and attention to feelings [51]. Similarly, findings from another cross-sectional investigation of 291 adults suggested that greater use of cognitive reappraisal, but not expressive suppression, correlated with lower diabetes distress levels ($r$=−0.19, p<0.01) [52].

Only 1 longitudinal study assessed psychological correlates of emotion regulation. In that study, 301 adults reported on their use of emotional processing and nonjudgement, and diabetes distress at baseline and at 9 months, after a 3-month psychosocial intervention [19]. Distress diabetes was subdivided in 4 subdomains: powerlessness, eating distress, management distress, and hypoglycemia distress. Using path analyses, the authors found that an increase in emotional processing scores over 9 months predicted an increase in hypoglycemia-related diabetes distress ($b$=2.85, p<0.01), whereas an increase in nonjudgement predicted a decrease in powerlessness- and hypoglycemia-related diabetes distress ($b$=−2.22 and $b$=−2.04, p<0.05) over the same period. Interestingly, when testing paths in the reverse direction, none of the 4 diabetes distress subdomains were predictive of emotional processing and nonjudgement, suggesting that these facets of emotion regulation may be predictors rather than consequences of diabetes distress.

### *Physiological correlates of emotion regulation*

Five cross-sectional and 2 longitudinal studies assessed physiological correlates of emotion regulation. Results generally suggested that emotion regulation difficulties were related to higher A1C and insulin restriction levels. In a cross-sectional study conducted among 67 adolescents, overall emotion regulation difficulties, and subdomains of accepting emotional responses and difficulties controlling impulses when experiencing negative emotions, correlated with higher A1C levels ($r$=0.27 to 0.28, p<0.05) [55]. These relationships were all mediated by diabetes-related distress, suggesting that individuals who struggle with regulating emotions are more likely to experience diabetes-related distress and, consequently, exhibit higher A1C levels. Notably, another study that instead addressed the role of adaptive emotion regulation strategies (e.g. emotional processing) in A1C levels also showed that diabetes distress mediated this association in a cohort of 301 adults [47]. In the cross-sectional study conducted among 236 late adolescents noted previously, greater overall difficulties in regulating emotions correlated with higher A1C ($r$=0.14, p<0.05) and insulin restriction ($r$=0.25, p<0.01), with the latter association being stronger among individuals with higher vs lower depressive symptoms [53]. Most subdomains of difficulties in regulating emotions also correlated with A1C and insulin restriction ($r$=0.18 to 0.26, p<0.05) [53]. However, in the 2 cross-sectional studies conducted among Italian and Dutch adults described previously, various emotion regulation indicators (e.g. cognitive reappraisal, expressive suppression) did not show a clear correlation with A1C levels [51,52].

One longitudinal study used the daily diary method in 110 adolescents [54]. Although the correlation between greater emotion regulation difficulties and higher A1C levels was cross-sectional (i.e. at study baseline; $r$=0.38, p<0.01), the results showed that greater emotion regulation difficulties at baseline correlated with fewer blood glucose checks averaged over the 14-day period ($r$=−0.21, p<0.05). Similarly, another study conducted among 60 adolescents indicated that greater problems in emotional control correlated with smaller improvements in self-monitoring of blood glucose ($b$=−0.06, p<0.05), which then correlated with higher A1C levels ($b$=−0.19, p<0.05) [45].

## Discussion

In this scoping review, we have summarized psychological and physiological correlates of emotion regulation in individuals with T1D. A thorough examination of the literature yielded 8 studies (5 cross-sectional and 3 longitudinal studies). All studies evaluated emotion regulation with a self-report questionnaire, with some capturing specific strategies (e.g. cognitive reappraisal, n=5) and others characterizing emotion regulation difficulties (e.g. non-acceptance of emotions, n=3). Regarding psychophysiological correlates of emotion regulation, diabetes distress (n=5), depressive symptoms (n=2), A1C (n=7), and insulin restriction (n=1) were assessed. Overall, the results showed that greater emotion regulation difficulties were associated with higher levels of diabetes distress, depressive symptoms, A1C, and increased insulin restriction, whereas greater use of emotion regulation strategies typically considered adaptive (e.g. cognitive reappraisal) was related to lower diabetes distress and higher A1C levels.

### *Emotion regulation and psychophysiological correlates*

It is noteworthy that some studies addressed associations between emotion regulation, psychological correlates, and physiological correlates, highlighting their synergy. Specifically, some authors found that diabetes distress levels mediated the relationship between emotion regulation strategies/difficulties and A1C [47,55], whereas others reported a stronger association between difficulties in regulating emotions and insulin resistance in individuals with higher vs lower depressive symptoms [53]. However, because those studies were cross-sectional, greater diabetes distress may have also led to higher A1C levels over time, either directly or via the use of less adaptive regulatory strategies. Likewise, physiological factors may alter psychological processes subsequently in T1D [38].

The associations observed herein are consistent with the broader literature from other medical populations and the general population. For instance, research among middle-aged adults with T2D demonstrated that greater ability to identify emotions and use of adaptive emotion regulation strategies correlated with lower diabetes distress and A1C levels and better glycemic control [16,56]. More broadly, the association of such emotion regulation processes with psychological and physiological health has been reported in the general population, in expected directions [31,57]. Notably, the effect sizes observed herein are comparable overall and at times stronger than those observed in the general population. For instance, meta-analytic findings from non-medical populations showed coefficients of $r$=−0.20 and $r$=−0.15 between negative psychological indicators (e.g. depression, negative emotions) and reappraisal and suppression, respectively [28]. Results with physiological markers in non-medical populations have been

inconsistent, showing, for instance, both null and small associations of emotion regulation strategies with inflammation [58].

*Coping and psychophysiological correlates*

Another construct closely related to emotion regulation and evaluated among individuals with T1D is stress-related coping. Coping has been defined as the "cognitive and behavioral efforts to master, reduce, or tolerate the internal and/or external demands" [59,60]. This framework centers around the stress construct, which occurs when individuals evaluate their environment as taxing or exceeding their resources [59,61], which likely reflects a perception experienced by many individuals with T1D, given the various demands generated by this condition. As for emotion regulation, coping strategies are typically adaptive or maladaptive, depending on their association with health outcomes [60,62,63].

Among individuals with T1D specifically, previous cross-sectional and longitudinal studies indicated that greater use of maladaptive coping strategies, such as self-blame and rumination, correlated with more depressive symptoms, whereas greater use of adaptive strategies, including positive reappraisal/refocussing and problem-solving, correlated with fewer depressive symptoms [14,64,65]. Other maladaptive coping strategies, such as avoidance, have also been related to higher diabetes distress levels in this population [66,67]. Regarding physiological correlates, cross-sectional evidence suggests that lower use of reappraisal/refocussing and greater use of blaming others correlates with higher A1C levels [68,69]. When using a longitudinal design, studies showed that greater use of active coping predicted lower A1C levels at 1 year but not 3 years later [38], although another study showed no association between avoidant coping and A1C levels 5 years later [70]. The intertwined association between coping, distress, and physiological markers was investigated in 1 longitudinal study, which indicated that greater use of avoidant coping predicted higher A1C levels via greater diabetes distress [66].

*Emotion regulation, coping, and psychophysiological correlates of T1D*

Interestingly, some of the included studies used coping measures or subscales to measure emotion regulation [14,47], underlining that both constructs share similarities. In fact, coping and emotion regulation research evolved separately for decades given some key differences between the 2 constructs. Emotion regulation can occur while facing a stressor but also multiple times a day in the presence of positive or negative emotions, whereas coping occurs specifically in response to a stressor, which is of negative valence [59,71–73]. Because emotion regulation is mostly focussed on brief emotional experiences, it occurs over shorter periods than coping, which can be of short- to long-term duration [72]. Lastly, emotion regulation would emerge during childhood, earlier in life than coping abilities, which are acquired over time [71].

Yet, several authors have acknowledged the conceptual and measurement overlap between coping and emotion regulation [36,73,74]. Both processes: 1) are dynamic, as they tend to fluctuate with time and throughout different contexts [71,73]; 2) help manage and adapt psychological reactions while facing various stressors, and have been determined to be key mechanisms of resilience [71–73]; and 3) include strategies considered either adaptive or maladaptive, depending on their associations with psychological and physiological outcomes [28,62,75].

Lastly, some measures are remarkably similar [36]. For instance, some reappraisal items from the Emotion Regulation Questionnaire and awareness items from the Difficulties in Emotion Regulation Scale, both measures used in the studies retained herein, overlap substantially with items about positive reinterpretation and focus on emotions from coping measures [36]. Furthermore, in some of the studies we have included [19,47], coping items were used because they were believed to capture key cognitive elements of the emotion regulation process. Altogether, the study of psychological and physiological correlates of emotion regulation in T1D would benefit from considering stress-related coping as well.

*Role of clinical and sociocontextual factors*

Among individuals with T1D, emotion regulation (and coping) can modulate psychological experiences and stressors generated by the daily management of this condition. As suggested by findings from our review, the strategies used to regulate emotions (and cope with stressors), as well as the difficulties in regulating emotions, may influence certain psychological and physiological factors, including diabetes-specific distress symptoms and A1C levels.

Other factors could also contribute to one's psychological and physiological functioning in T1D. From a clinical standpoint, a longer time since T1D diagnosis would predict poorer psychological and physiological outcomes, including depressive symptoms and metabolic control [11,12]. Selection of regulatory strategies may also change as time since diagnosis gets longer. For example, the distraction used to divert negative emotions away after a T1D diagnosis can be progressively replaced by reappraisal to handle the new condition in the longer term. Therefore, the temporal dimension must be considered when studying psychophysiological correlates of emotion regulation in T1D.

From a sociocontextual standpoint, the research underlines the role of family characteristics (e.g. responses to the disease, overall functioning) in one's adjustment to T1D [12,76]. In parallel, the study of psychological functioning cannot occur without consideration of the individual's social context, which will shape how and when one will select and implement certain strategies to handle stressors and related psychological responses [77–79]. Interconnected systems of the social context go beyond the family level and can include other proximal (e.g. friends, romantic partner) and more distal influences (e.g. cultural affiliation, social norms, health care policies), analogous to the Ecosystemic Model [80]. These systems can lead to positive influences (e.g. friends' sustained social support during a major life transition) or negative ones (e.g. poor relationships during such life transition) on a person's psychophysiological functioning, thus either amplifying or attenuating the various challenges encountered with T1D.

Several studies have documented the role of individual, proximal, and distal systems in psychophysiological functioning in the context of T1D. At the individual level, findings have shown that diabetes distress and depression levels, coping strategies used, and A1C levels vary across sociodemographic (e.g. race/ethnicity, socioeconomic status) [81,82] and behavioural factors (e.g. physical activity, sleep) [83]. At the proximal level, evidence suggests the benefits of family and school support on quality of life in adolescents with T1D, while also noting that receiving diabetes-specific support from friends may exacerbate diabetes distress if individuals are dissatisfied with the support received [84–86]. At the distal level, some studies have documented higher A1C and depressive symptoms as well as poorer metabolic control with the experience of stigma, present in up to 98% of adolescents with T1D [87,88]. Consequently, a T1D diagnosis represents a bio-psychological experience embedded into nested individual, proximal, and distal systems that will synergistically influence how one will adjust to the disease from both a psychological and physiological standpoint.

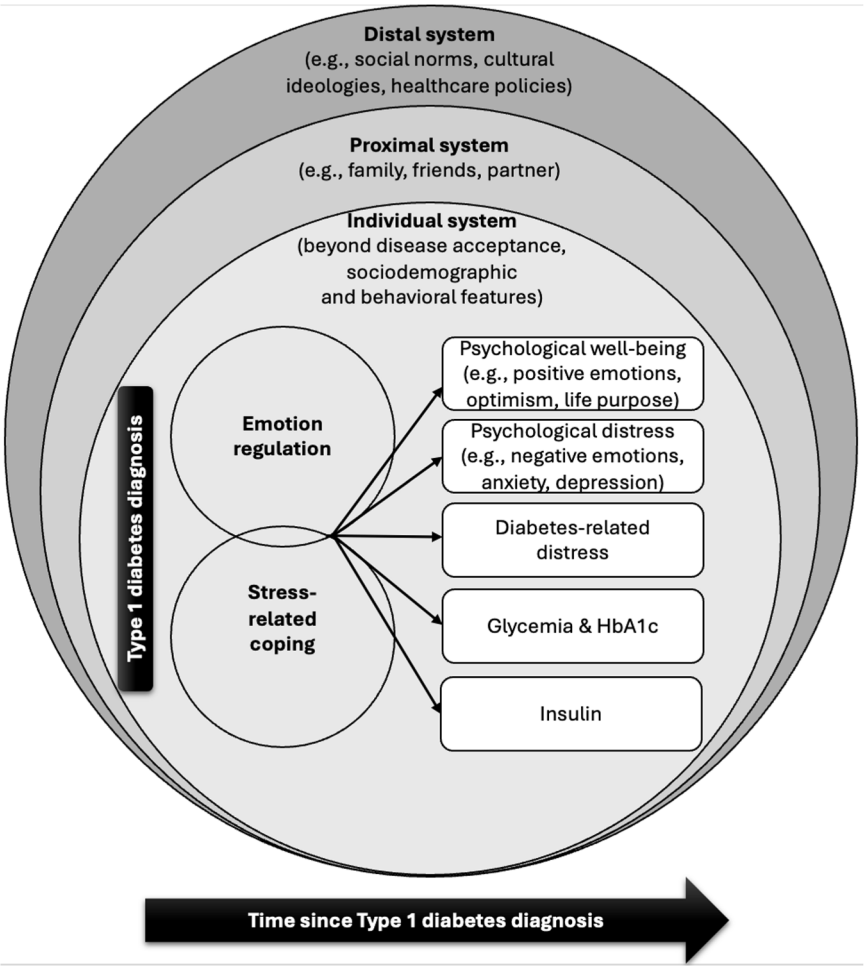


**Figure 2.** Conceptual model of T1D diagnosis as a biopsychosocial experience. In keeping with the focus of this review, only unidirectional arrows are portrayed, even though bidirectional relationships likely exist between these concepts. Regulatory processes of emotion regulation and stress-related coping include both strategies and difficulties, as well as flexibility in strategies used across contexts, but these nuances were not depicted for the sake of parsimony. Likewise, not illustrated here are the positive and negative influences that different system levels may have on regulatory processes and psychophysiological markers. *HbA1c*, glycated hemoglobin.

*Conceptual model of T1D diagnosis as a biopsychosocial experience*

We have integrated empirical evidence from these distinct areas of research and propose in Figure 2 a conceptual model illustrating how both emotion regulation and coping processes are embedded into a social context and contribute to psychological and physiological functioning in individuals with T1D. By incorporating sociocontextual factors, the conceptual model also offers an opportunity to evaluate the extent to which the effectiveness of emotion regulation and coping strategies on psychophysiological correlates varies across contexts. Conceptual models of adjustment to T1D have been proposed, including those highlighting the importance of coping [12,89,90] and emotion regulation [76]. For instance, the Childhood Adaptation Model to Chronic Illness postulates that individual and family responses to T1D, including coping abilities, influence the level of adaptation [12]. In parallel, the Developmental Model of Parent–Child Coordination for Self-Regulation, applied to T1D, posits that one's self-regulatory skills developed in early childhood are necessary, along with parental involvement, for positive health management [76]. Albeit informative, these models do not include more distal systems or specific psychological well-being dimensions (e.g. optimism) beyond quality of life. Importantly, most of these models do not consider the role of emotion regulation even if it is a core regulatory process that shapes psychological functioning in the shorter term, in the absence of stressors, and for positive emotions, which is not the case with coping processes [59,71–73]. We acknowledge that this model will likely be refined with emerging research specifically testing these associations (e.g. emotion regulation–A1C linkages, depending on disease acceptance or partner's support levels).

*Gaps in literature*

The emerging research documenting emotion regulation's psychophysiological correlates among individuals with T1D is informative, but several knowledge gaps remain. First, participants' ages ranged widely, from 13 to 65 years in the included studies. However, most studies focussed on a specific age range, such as school-age children (~8 to 12 years), adolescents (~13 to 19 years), or midlife and older individuals (~30 to 90 years). Young adulthood (~18 to 25 years), albeit rarely considered, usually comes with its own challenges (e.g. moving, new employment), making young adults particularly vulnerable to poorer psychological functioning [91]. This period is also critical in T1D management because it is when related skills, such as insulin administration and carbohydrate counting, are established [3].

Second, most studies used a cross-sectional study design that prevents conclusions about directionality and causality. As psychological and physiological factors can vary across weeks and months [92,93], it remains unclear whether emotion regulation is

associated with such T1D correlates daily and over time. Third, research has mainly characterized regulatory strategies as either adaptive or maladaptive. However, strategies are not inherently (mal)adaptive, as their effects on psychological functioning can depend on the context [34,74,94,95]. Relatedly, scarce work has addressed psychological well-being dimensions (e.g. positive emotions) in this population.

*Future avenues*

To address the knowledge gaps, future work should aim to determine whether emotion regulation/coping strategies can influence daily psychophysiological functioning in T1D, including with a specific focus on young adults. To do so, ecological momentary assessment and use of daily diaries could provide information that better reflects the day-to-day reality, hence permitting the study of proximal associations of emotion regulation/coping processes with psychophysiological correlates. Such study designs further allow investigation of temporality and bidirectionality between these variables. The joint consideration of emotion regulation and coping strategies in future research would also yield a comparative framework that clarifies boundaries and distinctions between these regulatory processes in relation to psychophysiological markers of T1D specifically [36]. Beyond individual (mal)adaptive strategies, more scientific attention should be devoted to the flexibility with which individuals use these strategies to regulate emotions and cope with stressors, because lower flexibility—likely reflecting a rigid pattern of strategies used, somewhat regardless of the context—has been predictive of poorer psychological outcomes in the general population [34,74,95–97]. Beyond these self-reported measures of psychological processes, future research could also address physiological measures of stress, including cortisol and allostatic load [98], in relation to psychological correlates in T1D. Lastly, diabetes-related behavioural factors should be considered in future work. For instance, greater medical adherence has been associated with fewer emotion regulation difficulties; lower symptoms of diabetes distress, depression, and anxiety; as well as healthier A1C levels [54,99–101].

From a clinical standpoint, meta-analyses indicate benefits of psychotherapies that aim to improve emotion regulation and coping skills, such as cognitive-behavioural therapy (CBT), on anxiety, depressive, and diabetes distress symptoms among T1D populations; favourable trends were also noted on physiological markers, including A1C levels, although the evidence is less consistent [102,103]. Importantly, CBT's impact on psychophysiological markers does not always persist over time [102,104]. Inconsistencies and attenuation in associations may be due to the lack of consideration of tertiary factors that may influence these effects, both during and beyond psychotherapies. In accordance with our conceptual model, future intervention research should indeed address whether individual (e.g. disease acceptance), proximal (e.g. family dynamics), and distal (e.g. stigma) features make CBT's short- and long-term effects on psychophysiological markers more potent for certain subgroups of individuals with T1D.

*Limitations and strengths*

Our scoping review has several limitations. Because our search strategy focussed solely on English and French studies published in peer-reviewed journals, work in other languages or from the grey literature was not included in our review. Likewise, studies that included both T1D and T2D participants but did not distinguish results across conditions were not included. The possible publication bias of retained studies represents another limitation. Lastly, heterogeneity in emotion regulation measures across studies, with some authors even using a subscale of a coping questionnaire, limits direct comparison across results. Yet, this review has notable strengths. Among others, the search strategy followed the rigorous PRISMA guidelines. We also considered an upstream and transdiagnostic psychological process, namely emotion regulation, which may possibly lead to more efficient interventions than targeting psychological distress and well-being separately. We further introduced a novel conceptual model connecting emotion regulation and its psychophysiological correlates to stress-related coping and the broader social context. Finally, we considered various relevant psychophysiological correlates of emotion regulation that may affect functioning and adjustment to T1D.

In conclusion, in this scoping review we have summarized psychological and physiological correlates of emotion regulation in individuals with T1D. Five cross-sectional and 3 longitudinal studies were identified, generally revealing that greater difficulties in regulating emotions correlated with higher levels of diabetes distress, depressive symptoms, A1C, and insulin restriction, with reverse associations observed with greater use of adaptive emotion regulation strategies (e.g. reappraisal, acceptance). However, the limited number of studies, which were mainly cross-sectional, underlines the critical importance of future longitudinal research on the role of emotion regulation (and related regulatory processes such as coping) in psychophysiological markers among individuals with T1D, particularly young adults. Altogether, the findings of this review, albeit limited, suggest that intervention research aiming to improve the ways individuals with T1D regulate their emotions may have downstream psychological and physiological benefits.

## Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Diabetes* at www.canadianjournalofdiabetes.com.

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## Author Disclosures

Conflicts of interest: None.

## Author Contributions

G.B. and C.T.F.: acquisition of funding, conceptualization and visualization of study; G.B., S.D., and C.T.F.: methodology, writing—review and editing; G.B.: project administration; G.B.: data curation and writing of original draft; C.T.F.: supervision.

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**Supplementary Table 1**
Articles included in the scoping review

| First author, year of publication, country in which the study was conducted, and reference no. | Title | Psychological and physiological constructs of interest | Psychological and physiological measures of interest | Number of participants, mean age, and diabetes duration (mean ± SD) | Study design | Analyses | Results |
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| Bassi et al, 2023, Italy and The Netherlands [51] | The relationship between emotional self-awareness, emotion regulation, and diabetes distress among Italian and Dutch adults with type 1 diabetes | Emotion regulation (cognitive reappraisal, expressive suppression), diabetes distress, emotional self-awareness (attention to feelings, clarity of feelings, mood repair), A1C levels | Emotion regulation: Emotion Regulation Questionnaire (ERQ); diabetes distress: Problem Areas in Diabetes Scale—Short Form 5 (PAID-SF-5); emotional awareness: Trait Meta-Mood Scale (TMMS); A1C: mean glucose control over the previous 3 months | N=262 Italian and Dutch adults with T1D (80.5% women), mean age 38.1±12.1 years, mean diabetes duration 19.1±12.9 years | Cross-sectional | Multiple linear regression | Cognitive reappraisal but not expressive suppression was related to diabetes distress.<br>Greater use of mood repair and clarity of feelings, but not attention to feelings were related to lower diabetes distress.<br>No association was found between emotion regulation strategies and A1C levels. |
| Beam et al, 2021, United States [53] | Insulin restriction, emotion dysregulation, and depressive symptoms in late adolescents with diabetes | Emotion regulation (difficulties), depressive symptoms, insulin restriction, A1C | Emotion regulation: Difficulties in Emotion Regulation Scale (DERS); depressive symptoms: (CES-D); diabetes self-care: Diabetes Behavior Rating Scale (DBRS); insulin restriction: a single item assessing insulin restriction, either "How often do you take less insulin than you should?" or "How often do you take less insulin or skip a dose of insulin to lose weight or keep from gaining weight?"; A1C: average blood glucose over the previous few months | N=236 (61% women), mean age 17.7±0.40 years, mean diabetes duration 7.4±3.92 years | Cross-sectional | Bivariate correlations and regressions | Greater overall difficulties in emotion regulation and several related subdomains (e.g. lower acceptance of emotions) were associated with greater depressive symptoms, insulin restriction, and A1C levels. The association of difficulties in emotion regulation with insulin resistance was stronger among individuals with higher vs lower depressive symptoms. |
| Embaye et al, 2023, Italy and The Netherlands [52] | Associations between disordered eating behaviour, diabetes distress and emotion regulation strategies in adults with type 1 diabetes: results from a Dutch–Italian cross-sectional study | Emotion regulation, diabetes distress, A1C, disordered eating behaviour | Emotion regulation: ERQ; diabetes distress: PAID-SF-5; A1C: most recent measure of A1C | N=291 participants diagnosed with T1D (78.9% women), mean age 39.0±13 years, mean diabetes duration 19.3±13.3 years | Cross-sectional | Correlations | Lower diabetes distress was associated with greater use of cognitive reappraisal, bidirectionally. No significant associations were found between A1C levels and the use of either cognitive reappraisal or expressive suppression. Greater diabetes distress was associated with more disordered eating behaviours. |
| Fisher et al, 2018, United States and Canada [47] | Emotion regulation contributes to the development of diabetes distress among adults with type 1 diabetes | Emotion regulation, diabetes distress, depressive symptoms, A1C | Emotion regulation: Emotional Processing scale from the Emotional Approach and Coping scale and the Non-Judging of and the Non-Reactivity to Inner Experience subscales from the Five Facet Mindfulness Scale; diabetes distress: T1-Diabetes Distress Scale; control: Personal Control subscale from the Illness Perception Questionnaire; depressive symptoms: Patient Health Questionnaire-8; A1C: obtained from medical records; hypoglycemic episodes: number of hypoglycemic episodes in the past 7 days were self-reported | N=301, mean age 45.1±15 years, mean diabetes duration >12 months (mean not available) | Cross-sectional | Structural equation models | Greater adaptive emotion regulation was related to lower diabetes distress, depressive symptoms, and A1C levels. Diabetes distress but not depressive symptoms mediated the association of emotion regulation with A1C levels. |

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| Ruiz-Aranda et al, 2018, Spain [55] | Emotional abilities and A1C levels in patients with type 1 diabetes | Emotion regulation, diabetes distress, A1C levels | Study 1: Unrelated to emotion regulation and conducted in Israel; study 2: Emotion regulation: DERS; diabetes distress: 17-item diabetes distress scale (DDS-17); A1C: latest A1C value | Study 2: N=67 (48.5% women), mean age 15.9 years, mean diabetes duration 5.9±4.24 years | Cross-sectional | Multiple regressions, moderation analyses | Study 2: The association between difficulties in emotion regulation and A1C levels is mediated by diabetes distress, where individuals with higher diabetes distress levels tend to have higher A1C levels. |
| Berg et al, 2014, United States [54] | Individual differences and day-to-day fluctuations in perceived self-regulation associated with daily adherence in late adolescents with type 1 diabetes | Emotion regulation (difficulties), adherence to T1D, A1C levels | 1) Baseline measures: emotion regulation: DERS; diabetes adherence: Diabetes Behavior Rating Scale (DBRS) and Self-Care Inventory (SCI); A1C: latest measure of A1C obtained from medical record; 2) Daily measures: diabetes adherence: SCI; glucose: total number of blood glucose checks reported per day | N=110 (78% women), mean age 17.8±0.39 years, mean diabetes duration 7.5±3.79 years | Longitudinal (daily diary for 14 days) | Correlations, hierarchical linear models | Greater emotion regulation difficulties were correlated with lower diabetes adherence and higher A1C levels at study baseline. Greater emotion regulation difficulties at study baseline were also associated with lower diabetes adherence and fewer blood glucose checks when averaged over the 14-day period. |
| Fisher et al, 2019, United States and Canada [19] | Toward effective interventions to reduce diabetes distress among adults with type 1 diabetes: Enhancing emotion regulation and cognitive skills | Emotion regulation, diabetes distress, cognitive skills | Emotion regulation: Emotional Processing subscale from the Emotional Approach and Coping scale and the Non-Judging of Inner Experience subscale from the Five Face Mindfulness Scale; diabetes distress: T1-DDS; cognitive skills: Personal Control subscale from the Revised Illness Perception Questionnaire, and Effective Problem-Solving subscale from the Health Problem Solving Survey | N=301, mean age 45.1±15 years, mean diabetes duration 26.1±13.9 and 23.2±13.3 years for each of the 2 experimental groups | Longitudinal (baseline and 9-month follow- up) | Structural equation path models | Changes in emotional processing are associated with an increase in hypoglycemia-related diabetes distress but not other subdomains of diabetes distress, whereas an increase in nonjudgment is associated with a decrease in hypoglycemia-related diabetes distress. Inversely, when testing the reverse direction, changes in hypoglycemia-related diabetes distress were not associated with greater emotional processing and nonjudgment over time. |
| Lansing et al, 2019, United States [45] | Adolescent emotional control moderates benefits of a multicomponent intervention to improve type 1 diabetes adherence: A pilot randomized controlled trial | Emotion regulation, SMBG, A1C | Emotion regulation: Emotional Control subscale from the Behavior Rating Inventory of Executive Function—Self-Report (BRIEF-SR); glucose: self-monitored blood glucose over the past 14 days to obtain the average daily frequency of SMBG at baseline and 6-month follow-up; A1C: measure taken in laboratory at baseline and 6-month follow-up | N=60 (43% women), mean age 15.0 years, mean diabetes duration 6 years | Longitudinal (baseline, 6 months) | Mediation models and moderated mediation models | Greater problems in emotional control were related to smaller improvements in SMBG, which in turn was related to higher A1C levels. Severity of problems in emotional control also moderated the benefits of the intervention on improvements in SMBG and, in turn, A1C levels. |

*A1C*, glycated hemoglobin; *SD*, standard deviation; *SMBG*, self-monitoring of blood glucose; *T1D*, type 1 diabetes.