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**Diabetes distress is more strongly associated with HbA<sub>1c</sub> than depressive symptoms in adolescents with type 1 diabetes: results from Diabetes MILES Youth – Australia**

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**Abstract** (250 words)

*Background*

Glycated hemoglobin (HbA<sub>1c</sub>) is higher during adolescence than at any other life stage. Some research among adolescents indicates that depressive symptoms are associated with suboptimal HbA<sub>1c</sub>. However, research among adults, suggests diabetes distress is a stronger predictor of HbA<sub>1c</sub> than depressive symptoms.

*Aim*

To determine the relative contributions of depressive symptoms and diabetes distress to explaining the variance in HbA<sub>1c</sub> among adolescents with type 1 diabetes.

*Participants and Methods*

Diabetes MILES Youth Study respondents aged 13-19 years completed questionnaires assessing depressive symptoms (Patient Health Questionnaire for Adolescents: PHQA-8), diabetes distress (Problem Areas in Diabetes-Teen version: PAID-T), and self-reported socio-demographic and clinical variables, including their most recent HbA<sub>1c</sub>. Stepwise hierarchical multiple regression was conducted to examine the contributions of depressive symptoms and diabetes distress to HbA<sub>1c</sub>.

*Results*

Participants (N=450) had a (mean±SD) age of 15.7±1.9 years; diabetes duration of 6.9±4.3 years; and 38% (n=169) were male. Twenty-one percent (n=96) experienced moderate-to-severe depressive symptoms (PHQA-8 e 11) and 36% (n=162) experienced high diabetes distress (PAID-T >90). In the final regression model, HbA<sub>1c</sub> was explained by: diabetes duration ( $r^2 = .14$ ,  $p=0.001$ ), self-monitoring of blood glucose ( $r^2 = -.20$ ,  $p<0.001$ ) and diabetes

distress ( $r^2 = .30$ ,  $p < 0.001$ ). Following the addition of diabetes distress, depressive symptoms were no longer significantly associated with HbA<sub>1c</sub> ( $p = 0.551$ ). The final model explained 18% of the variance in HbA<sub>1c</sub>.

### *Conclusions*

Consistent with evidence from studies among adults, diabetes distress mediated the relationship between depressive symptoms and HbA<sub>1c</sub> among adolescents with type 1 diabetes. These findings suggest that clinicians need to be aware of diabetes distress.

**Keywords:** Diabetes Mellitus, Type 1; Adolescent; Depression; Emotions; Hemoglobin A1c

## Introduction

Achieving optimal glycaemic control, with the avoidance of hyper- and hypoglycaemic excursions, is central to the prevention of long-term complications among people with type 1 diabetes (T1D). Glycated haemoglobin (HbA<sub>1c</sub>, a well-established risk factor for future complications), is higher in late adolescence than during childhood, early adolescence or adulthood (1). This is due to the biological and psychosocial changes that accompany puberty and adolescent development (2). Young people with T1D and mental health problems are at higher risk of adverse diabetes outcomes than those without such comorbidities, including more frequent episodes of diabetic ketoacidosis and higher rates of hospitalisation (3).

Some studies in adolescents show a significant association between depressive symptoms and sub-optimal HbA<sub>1c</sub> (4, 5), whereas others have found no independent relationship (6, 7). Two case control studies (using clinical interview to determine depression incidence) found no association between glycaemic control and severity of depression, despite up to three-fold higher prevalence of severe depressive symptoms among adolescents with T1D than those without diabetes (8, 9). These contradictory findings may be due to inconsistent measurement and definition of depression across studies, and it has been noted elsewhere that the source and severity of distress appear to contribute to the variance in HbA<sub>1c</sub> (10).

In studies among adults with T1D, depression is not independently associated with HbA<sub>1c</sub> when examined concurrently with diabetes distress (11, 12). Diabetes distress explains a large proportion (39%) of the variance in depressive symptoms (12), suggesting there is overlap in

these constructs (10). It is postulated that self-report depression measures also reveal diabetes distress, because individuals appraise depressive symptoms in the context of living with diabetes (11). Hence, those experiencing negative feelings related to their diabetes may also endorse depressive symptoms, but the depression measure does not attribute those symptoms to any particular source. Although closely correlated with depressive symptoms, diabetes distress is not the same construct. It is not a psychiatric condition, but rather reflects the experiences and negative emotions that arise from living with and managing diabetes (13). Measures of diabetes distress typically refer to issues such as worry about the future and complications, over-vigilance and lack of understanding by family and friends, and feeling guilty/anxious about diabetes management (13). Diabetes distress is a heterogeneous construct, and studies in adults indicate that regimen-related items are more closely related to HbA<sub>1c</sub> than other dimensions, and the relationship with self-management is bi-directional (14). About 11–30% of adults with T1D are estimated to experience moderate-to-severe depressive symptoms (11, 12, 15) and 15–40% report moderate-to-severe diabetes distress (11, 12). Experiencing both depression and diabetes distress is associated with greater psychological distress and suboptimal diabetes management (12).

Depression has been studied widely in adolescents with T1D but less is known about diabetes distress and the inter-relationships between depressive symptoms, diabetes distress and HbA<sub>1c</sub>, because these constructs have not been examined concurrently in this age group. A systematic review found only 16 studies that assessed diabetes distress in adolescents, but despite age-appropriate measures being available (e.g. DSQ, PAID-T) almost half (43%) of

these had used adult measures (PAID or DDS), which have not been validated among adolescents and do not include age-related concerns (e.g. parental ‘nagging’ or body image concerns) (16). Eight studies showed an association between diabetes distress and HbA<sub>1c</sub> and four found no association. A positive correlation was more likely when age-appropriate diabetes distress measures were used. Now that an adolescent-specific measure of diabetes distress (the Problem Areas in Diabetes – Teen version: PAID-T) (17) has been validated among youth aged 11-19 years, the opportunity exists to investigate the interaction between depressive symptoms, diabetes distress and HbA<sub>1c</sub> robustly in this age group. Furthermore, clinically meaningful levels of diabetes distress can now be defined through established cut-points (18). Therefore, the aim of this study, among adolescents with T1D, was to examine the interaction between depressive symptoms and diabetes distress and HbA<sub>1c</sub>, and to determine the extent to which severity of depressive symptoms and diabetes distress explain the variance in HbA<sub>1c</sub>.

## **Research Design and Methods**

### *Protocol*

The Diabetes MILES (Management and Impact for Long-term Empowerment and Success) Youth – Australia Study (MILES Youth) is a national, cross-sectional survey of the psychosocial aspects of T1D. Full study methods were published previously (19). In brief, invitations to participate were posted to 5,928 National Diabetes Services Scheme (NDSS) registrants with T1D aged 10 to 19 years, who had previously consented to be contacted for research purposes (59%). The NDSS is an initiative of the Australian Government, providing subsidised products (e.g. insulin syringes, pump consumables, blood glucose test strips) and

support services for all Australians with T1D. The survey (available for online completion over eight weeks) was promoted in diabetes clinics, and relevant print and electronic media. Deakin University Human Research Ethics Committee approved the study (2014-060). All participants (and parents for those aged under 18 years) provided informed consent.

### *Participants*

In total, 781 (13%) adolescents with T1D completed the demographic and core question sets concerning emotional well-being and quality of life. Eligibility for the current study was limited to adolescents aged 13 to 19 years who completed the key measures of interest to this study; diabetes distress and depressive symptoms. These measures were not presented to those aged 10-12 years due to concerns about asking such questions of this age group in an anonymous internet-based survey.

### *Measures*

#### *Demographic and clinical characteristics*

Participants self-reported their gender, age, and postcode, which was used to index socioeconomic status (SES), age at T1D onset, most recent HbA<sub>1c</sub>, and insulin delivery mode (pump or injections). They also reported their usual daily frequency of self-monitoring of blood glucose (SMBG), using a 9-point scale; 0 (<once per day) to 8 (e7 times per day), which was dichotomised for statistical analysis around the recommendation of SMBG at least four times per day: <4/day; e4/day.

### *Psychological measures*

Participants completed the following self-report measures:

The 26-item Problem Areas in Diabetes – Teen (PAID-T) (17) is an age-specific (11-19 years) unidimensional measure of diabetes distress adapted from the adult PAID (13), assessing the perceived emotional burden of living with diabetes. Items are rated on a 6-point scale: 1-2 (not a problem), 3-4 (moderate problem), 5-6 (serious problem). Scores are summed (range 26-156), with higher scores indicating greater diabetes distress; based on recently validated cut-points, distress can be categorised as none/minimal (26-69), moderate (70-90), or high (>90) (18). Cronbach's alpha in this sample was 0.96, indicating very high internal consistency.

The 8-item version of the Patient Health Questionnaire for Adolescents (PHQA-8) was used to assess the presence and severity of depressive symptoms. Suicidal ideation (item 9 of the more commonly used PHQ-9) was omitted, in accordance with accepted procedures in population surveys (20) and previously reported problems with this item (15). Items are rated 0 (not at all) to 3 (nearly every day). Scores are summed (range 0-24), with higher total scores indicating more depressive symptoms. Previously validated thresholds (21) were used to categorise symptom severity: none/minimal (0-4); mild (5-10); moderate-to-severe (e 11). Cronbach's alpha was 0.91, indicating satisfactory internal consistency.

### *Statistical analysis*

Data were analysed using the Statistical Package for the Social Sciences (SPSS), Version 24 for Windows (IBM Corporation, Armonk, NY). Individuals (N=101) were excluded from analysis because they had missing data (SES, HbA<sub>1c</sub>, SMBG, PAID-T) or an extreme value/outlier (HbA<sub>1c</sub> <5.0%; 31 mmol/mol, or >16%; 151 mmol/mol). Pearson's correlation coefficients, Student's t-tests and ANOVAs or non-parametric tests as appropriate for the data distribution (Mann-Whitney, Kruskal-Wallis) were calculated to examine the relationships between self-reported HbA<sub>1c</sub> and demographics, SMBG, insulin delivery mode, depressive symptoms and diabetes distress. To determine associations with self-reported HbA<sub>1c</sub>, variables with significant univariate associations with HbA<sub>1c</sub> were entered step-wise into a hierarchical multiple regression: Step 1: male gender, diabetes duration, SMBG; Step 2: depressive symptoms; Step 3: diabetes distress (as continuous variables). Multicollinearity was not considered to be a problem where the variance inflation factor (VIF) and tolerance values were <4 and >0.2 respectively. A series of linear regression analyses were performed to determine whether age, gender or depressive symptom severity moderates the relationship between diabetes distress and HbA<sub>1c</sub>, and whether the interaction between diabetes distress and SMBG contributes to the variance in HbA<sub>1c</sub>. Results are reported as mean ± SD or median and % (n). Differences were accepted as significant at p<0.05 (two-sided).

## **Results**

### *Participant characteristics*

A total of 551 adolescents (aged 13-19 years) completed relevant measures. Respondents with incomplete data were excluded (n=101), most of whom (85%, n=85) were missing self-reported HbA<sub>1c</sub>. Compared to participants with complete data, those excluded due to missing

data had shorter T1D duration ( $p<0.001$ ), were more likely to use injections ( $p<0.001$ ), and have a higher SES ( $p=0.07$ ).

The characteristics of the final sample ( $N=450$ ) are detailed in Table 1. They had a mean age of  $15.7 \pm 1.9$  years; T1D duration of  $6.9 \pm 4.3$  years; 38% ( $n=169$ ) were male; and 53% ( $n=240$ ) managed their diabetes with an insulin pump. The mean self-reported HbA<sub>1c</sub> was  $8.1 \pm 1.5\%$  ( $65 \pm 16$  mmol/mol), and 69% had been assessed within the previous three months. Twenty-one percent ( $n=96$ ) reported moderate-to-severe depressive symptoms, while 36% ( $n=162$ ) had high diabetes distress. Forty-one percent ( $n=183$ ) adolescents experienced moderate-to-severe depressive symptoms and/or high diabetes distress; among these, 17% ( $n=75$ ) reported both diabetes distress and depressive symptoms, 19% ( $n=87$ ) reported only diabetes distress, and 5% ( $n=21$ ) only depressive symptoms.

Compared to the group reporting none-to-minimal diabetes distress or depressive symptoms (59%,  $n=267$ ), the median self-reported HbA<sub>1c</sub> was significantly higher in the two groups with elevated diabetes distress (7.5%; 58 mmol/mol vs 8.3%; 67 mmol/mol,  $p<0.001$ , ‘only diabetes distress’; 8.5%; 69 mmol/mol,  $p<0.001$ , ‘both diabetes distress and depressive symptoms’), but not the ‘depressive symptoms only’ group (7.6%; 60 mmol/mol,  $p=0.95$ ).

*Table 1 here*

In univariate analyses (Table 2), there was a strong positive correlation between depressive symptoms and diabetes distress. Depressive symptoms explained 40% of the variance in diabetes distress ( $R^2=0.40$ ). The positive correlation between HbA<sub>1c</sub> and diabetes distress was stronger than that between HbA<sub>1c</sub> and depressive symptoms. HbA<sub>1c</sub> had a small positive correlation with diabetes duration but was not associated with age (Table 2). HbA<sub>1c</sub> was on average higher among girls than boys ( $8.3 \pm 1.6\%$ ,  $67 \pm 17$  mmol/mol vs  $7.9 \pm 1.3\%$ ,  $62 \pm 15$  mmol/mol,  $p=0.04$ ) and adolescents reporting less frequent SMBG (<4/day:  $8.9 \pm 1.6\%$ ,  $73 \pm 17$  mmol/mol;  $\geq 4$ /day:  $7.9 \pm 1.4\%$ ,  $63 \pm 15$  mmol/mol,  $p<0.001$ ). HbA<sub>1c</sub> did not differ according to participants' socioeconomic status ( $p=0.85$ ) or mode of insulin delivery ( $p=0.32$ ). Both depressive symptoms and diabetes distress were positively correlated with age ( $p=0.32$ ) but there was no association with diabetes duration (Table 2). Adolescents with less frequent SMBG reported higher mean depressive symptoms ( $9.5 \pm 7.0$  vs  $5.8 \pm 5.4$ ,  $p<0.001$ ) and diabetes distress ( $89.2 \pm 31.4$  vs  $73.2 \pm 29.2$ ,  $p<0.001$ ).

*Table 2 here*

In the multivariate analysis, diabetes duration and SMBG but not gender, remained significantly associated with elevated HbA<sub>1c</sub> (Table 3). In the final model, diabetes distress made the strongest independent contribution ( $p<0.001$ ), and the contribution of depressive symptoms became non-significant ( $p=0.551$ ). The model explained 18% of the variance in HbA<sub>1c</sub> ( $R^2=0.18$ ,  $F(5, 444)=19.31$ ,  $p<0.001$ ).

*Table 3 here*

The interaction between age and diabetes distress explained a small, but significant contribution to the variance in HbA<sub>1c</sub>, ( $p=0.025$ ); (Table 4). The association between diabetes distress and HbA<sub>1c</sub> was not moderated by gender ( $p=0.17$ ), or depressive symptoms ( $p=0.24$ ). Diabetes distress moderated the association between SMBG and HbA<sub>1c</sub> among adolescents with elevated distress ( $p=0.028$ ). The simple slopes of the interaction terms are shown in Figure 1. Depressive symptomatology was not independently associated with HbA<sub>1c</sub>, therefore this relationship was not explored further.

*Table 4 and Figure 1 here*

## **Discussion**

In this novel study examining the inter-relationships between depressive symptoms, diabetes distress and HbA<sub>1c</sub> in adolescents with T1D aged 13-19 years, high diabetes distress was more prevalent than moderate-to-severe depressive symptoms (36% vs 21%). While depressive symptoms made an initial contribution to the variance in self-reported HbA<sub>1c</sub>, this was no longer significant when diabetes distress was added to the model, corroborating studies among adults with T1D (11, 12).

In contrast to a study in adults (12), the association between diabetes distress and HbA<sub>1c</sub> did not change in the presence of depressive symptoms, even among adolescents with moderate-

to-severe depressive symptoms. After controlling for multiple variables, no gender difference remained for self-reported HbA<sub>1c</sub>. Nor did HbA<sub>1c</sub> differ by mode of insulin delivery, although those using pumps were more likely to recall their most recent HbA<sub>1c</sub> and were therefore, over-represented in the current study. Adolescents with longer duration of T1D reported higher HbA<sub>1c</sub>. Diabetes duration was unrelated to age or SMBG, suggesting that the difficulties young people experience trying to achieve and maintain optimal blood glucose over time may be explained by other metabolic and psychosocial factors. Indeed, the model explained only 18% of the variance in HbA<sub>1c</sub>. A previous longitudinal study found that HbA<sub>1c</sub> remained stable over time for most adolescents, whereas HbA<sub>1c</sub> increased steadily among adolescents experiencing emotional distress, peer conflict and who were less engaged in self-care (22). Lack of parental support and family conflict about diabetes are consistently associated with suboptimal glycaemia (23, 24).

As expected, HbA<sub>1c</sub> was higher among those reporting less frequent SMBG (25), which may reflect less attention to self-care overall, or that less frequent SMBG provides fewer opportunities to fine-tune diabetes management. Furthermore, this association was enhanced as the level of diabetes distress increased. While our study was cross-sectional, longitudinal studies indicate that individuals who are struggling emotionally with diabetes may be less engaged in self-management or more likely to engage in sub-optimal behaviours, while those who are less attentive to self-care may feel guilty or frustrated with their diabetes management (14, 26). Further, our previous analyses have demonstrated a stronger association between HbA<sub>1c</sub> and PAID-T items focused on regimen-related distress than other

PAID-T items (18). Thus, addressing self-management difficulties, and the psychological distress associated with these, may be more likely to improve HbA<sub>1c</sub> than interventions focused on depressive symptoms or diabetes management alone. Avoidant coping style has been found to predict diabetes distress among adolescents with T1D, which in turn influenced self-care and glycaemic control (27). Interventions that focus on the development of self-management skills, using cognitive-behavioural and empowerment approaches have improved both diabetes distress and HbA<sub>1c</sub> among adults (28) and youth with T1D (29), although low attendance has limited the reach of such programs in the adolescent age group (30, 31).

This study provides further evidence of the clinical significance of elevated diabetes distress, particularly among older adolescents, who may have greater responsibilities, but diminishing self-management support. Emerging adults may experience even greater diabetes distress than adolescents (32), thus adolescence is an optimal time to intervene, as unresolved problems may continue into adulthood (33). Routine psychological assessment (including depression screening) is recommended for all young people with diabetes (34), though such recommendations do not currently include assessment of diabetes distress. However, focusing on depressive symptoms alone is likely to miss many young people experiencing diabetes distress, and may lead to inappropriate or ineffective intervention. Indeed, elevated diabetes distress was more common than depressive symptoms. The high correlation and shared variance between depressive symptoms and diabetes distress indicates there is considerable overlap of these constructs among adolescents with T1D, and depressive symptom measures

are most likely to be revealing diabetes-related stressors (11). Our findings suggest that most adolescents with elevated depressive symptoms are also experiencing diabetes distress, which in many cases can likely be addressed by their diabetes health professionals. Age-appropriate measures are freely available and can be used in routine clinical practice to characterise specific sources of distress. Having a conversation about diabetes and emotional wellbeing can identify the areas where additional support is needed and may have psychosocial benefits (35). Offering support for self-management and developing coping skills, may have benefits in terms of both psychological wellbeing and diabetes management (29).

A strength of this study is that it is the first to examine the inter-relationships between general and diabetes-specific emotional distress in adolescents. Other strengths are the large national sample, and the use of age-specific measures. Over one-third (36%) of adolescents in this study experienced high levels of diabetes distress. The mean PAID-T is consistent with a closely matched age group in a US study ( $77\pm 30$  vs  $73\pm 27$  respectively) (27). The rate of elevated depressive symptoms reported here is similar to age-matched (13-18 years) clinic-based studies in youth with T1D (20-23%), assessed with the Children's Depression Inventory (CDI) (4, 36). Further comparison with the findings of other adolescent T1D studies is constrained by a lack of consistency in age groups and the use of measures and cut-points. Moderate-to-severe depressive symptoms were three-times more prevalent in our study than reported in a general adolescent population sample (aged 13-17 years) in the US (7%) (37).

There are limitations to be acknowledged. Diabetes MILES Youth participants were self-selected and the overall response rate was low, although consistent with a previous study using similar methods in this population (38). Girls and young people from higher socioeconomic backgrounds were over-represented (19), however these factors were unrelated to the study outcomes. Importantly, both HbA<sub>1c</sub> and SMBG were self-reported, thus they are potentially subject to recall and social-desirability bias, and almost one-third of respondents did not report their most recent HbA<sub>1c</sub>. Those using injections and with a more recent diagnosis of T1D were less likely to report HbA<sub>1c</sub>, thus they were under-represented in the current study. The mean self-reported HbA<sub>1c</sub> was only slightly lower than clinic-recorded results in a recent Australian study (8.1% vs 8.3%) (39), and the strength of the association with diabetes distress was similar to other adolescent studies (16). The reliability of self-reported SMBG has been found to be satisfactory when compared with meter download (40). Another limitation is our use of an internet-based rather than a clinic-based study. Adolescents responding to internet surveys have previously been found to report more severe depressive symptoms than respondents to conventional surveys, for example recruited via the school or clinic (41). Thus, the confidential nature of an internet-based survey may attract young people who are experiencing psychological distress, and over-represent those who are depressed (41). However, others have reported lower prevalence of mental health problems among respondents to a web-based survey due to selection bias towards socially-advantaged families (42). Finally, an important limitation is that the data are cross-sectional.

Clinical and psychological factors associated with HbA<sub>1c</sub> have been reported extensively among adolescents with T1D, but the relationship with diabetes distress had not been comprehensively investigated. In this study, we used self-reported HbA<sub>1c</sub> and SMBG, and it would be useful to replicate our study in a representative, unselected clinic sample, ideally using a diagnostic interview for depression, to minimise confounding with diabetes distress, and to explore these relationships longitudinally. In summary, this study found that diabetes distress mediated the relationship between depressive symptoms and HbA<sub>1c</sub>. It corroborates the findings of previous adult studies, suggesting the importance of paying attention to diabetes distress among adolescents with T1D.

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### **Competing interests**

The authors declare that they have no competing interests.



**Table 1: Participant characteristics (N=450)**

	<b>% (n)</b>	<b>Mean ± SD (range)</b>
<b>Age: years</b>		15.7 ± 1.9 (13-19)
<b>Gender: male</b>	38 (169)	
<b>Socioeconomic status</b>		
Low	19 (83)	
Mid	37 (164)	
High	44 (191)	
<b>Diabetes duration: years</b>		6.9 ± 4.3 (0-18)
<b>SMBG frequency: e4 checks / day</b>	78 (349)	
<b>Insulin delivery: pump</b>	53 (240)	
<b>Self-reported HbA<sub>1c</sub> %</b>		8.1 ± 1.5 (5.1-15.5)
<b>mmol/mol</b>		65 ± 16 (32-146)
<b>Depressive symptoms (PHQA-8)</b>		6.6 ± 6.0 (0-24)
None-to-minimal (<5)	47 (213)	
Mild (5-10)	31 (131)	
Moderate-to-severe (e 11)	21 (96)	
<b>Diabetes distress (PAID-T)</b>		76.8 ± 30.4 (26-156)
None-to-minimal (<70)	46 (207)	
Moderate (70-90)	18 (81)	
High (>90)	36 (162)	

*SMBG: self-monitoring of blood glucose*



**Table 2: Correlations between self-reported HbA<sub>1c</sub>, demographic and psychological outcomes**

	<b>Age</b>	<b>Diabetes duration</b>	<b>Depressive symptoms</b>	<b>Diabetes distress</b>
HbA <sub>1c</sub> %	0.09	0.17**	0.22**	0.34**
Age		0.21**	0.28**	0.18**
Diabetes duration			0.02	0.04
Depressive symptoms				0.63**

\* $p < 0.05$ ; \*\* $p < 0.001$

**Table 3: Hierarchical multiple regression analyses predicting self-reported HbA<sub>1c</sub>**

	Step 1				Step 2				Step 3			
	<i>b</i> (SE)	<sup>2</sup>	<i>t</i>	<i>p</i>	<i>b</i> (SE)	<sup>2</sup>	<i>t</i>	<i>p</i>	<i>b</i> (SE)	<sup>2</sup>	<i>t</i>	<i>p</i>
Gender: male	-.36 (.14)	.12	-2.58	0.01	-.25 (.14)	.08	-1.74	0.083	-.12 (.14)	.04	-0.88	0.378
Diabetes duration	.05 (.02)	.14	3.19	0.002	.05 (.02)	.15	3.25	0.001	.05 (.02)	.14	3.23	0.001
SMBG	-.91 (.16)	.25	-5.65	<0.001	-.79 (.17)	.22	-4.73	<0.001	-.72 (.16)	.20	-4.44	<0.001
Depressive symptoms					.04 (.01)	.14	3.0	0.003	-.01 (.01)	.03	-0.60	0.551
Diabetes distress									.02 (.003)	.30	5.36	<0.001
<i>R</i> <sup>2</sup>	0.11				0.13				0.18			
<i>F</i> (df1,df2)	17.97 (3,446) p<0.001				15.96(4,445) p<0.001				19.31(5,444) p<0.001			

*HbA<sub>1c</sub> entered as %*

*b: unstandardised coefficient; <sup>2</sup>: standardised coefficient*

*SMBG: self-monitoring of blood glucose e4 /day*

*Diabetes duration, depressive symptoms, diabetes distress entered as continuous variables*



**Table 4: Linear regression models of predictors of self-reported HbA1c (moderation analyses)**

	<i>b</i>	<i>SE</i>	<i>t</i>	<i>p</i>	$\Delta R^2$
<i>Model 1</i>					
Age	.02	.04	0.65	0.52	
Diabetes distress	.02	<.01	7.83	<0.001	
Age x diabetes distress	<.01	<.01	2.25	0.025	0.012
<i>Model 2</i>					
Gender: male	-.07	.14	-.50	0.62	
Diabetes distress	.02	<.01	7.52	<0.001	
Gender x diabetes distress	.01	<.01	1.36	0.17	0.003
<i>Model 3</i>					
Depressive symptoms	-.01	.02	-.34	0.73	
Diabetes distress	.02	<.01	6.29	<0.001	
Depressive symptoms x diabetes distress	<.01	<.01	1.18	0.24	0.003
<i>Model 4</i>					
Diabetes distress	.01	<.01	6.89	<0.001	
SMBG	-.65	.17	-3.74	<0.001	
Diabetes distress x SMBG	-.01	<.01	-2.21	0.028	0.009

*b: unstandardised coefficient*

*Continuous variables are mean centred*

*Self-reported HbA1c %*

*SMBG: self-monitoring of blood glucose e4 /day*

**Figure 1: Plots of the interactions between (a) diabetes distress and gender, (b) diabetes distress and age, (c) diabetes distress and depressive symptoms, and (d) diabetes distress and SMBG, predicting self-reported HbA1c.**

*Diabetes distress: 0 = mean PAID-T (76.8); data points 0±1 SD (30.4)*

*b: unstandardised coefficient*

*SMBG: self-monitoring of blood glucose*

(a) The simple slope of the relationship between diabetes distress and HbA1c increased with age, but the association was stronger for older ( $b = .02$ ,  $p < 0.001$ ) than younger adolescents ( $b = .01$ ,  $p < 0.001$ ). (b) Gender did not moderate the relationship between diabetes distress and HbA1c ( $b = .006$ ,  $p = 0.17$ ). (c) The interaction between diabetes distress and depressive symptoms did not contribute significantly to the variance in HbA1c ( $b = .0004$ ,  $p = 0.24$ ). (d) The simple slope of the relationship between SMBG frequency and HbA1c was significant for those with elevated diabetes distress (mean +1 SD;  $b = -.98$ ,  $p = < 0.001$ ), but not for those with low diabetes distress (mean -1 SD;  $b = -.32$ ,  $p = 0.22$ ).

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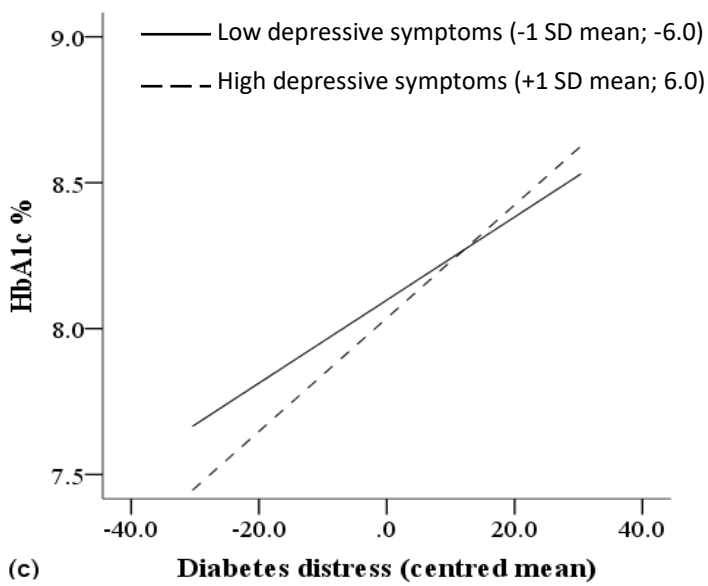
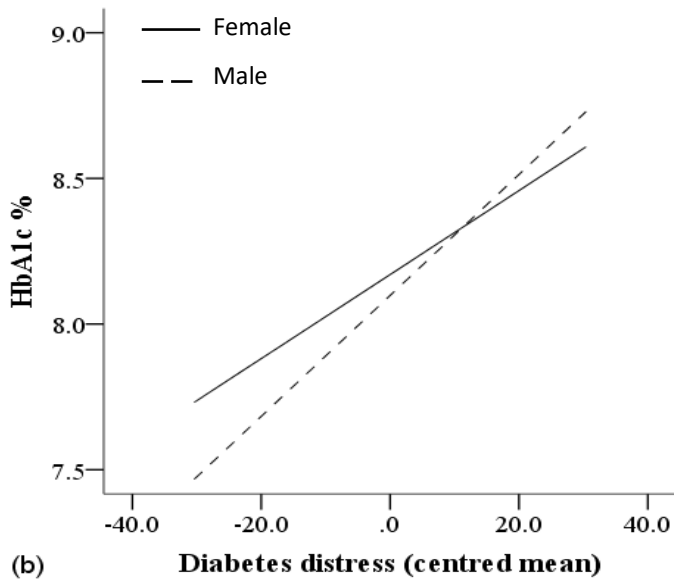
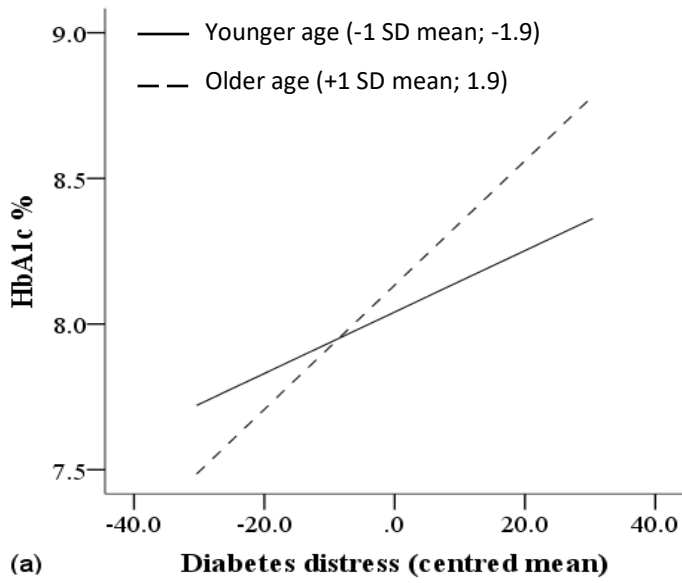
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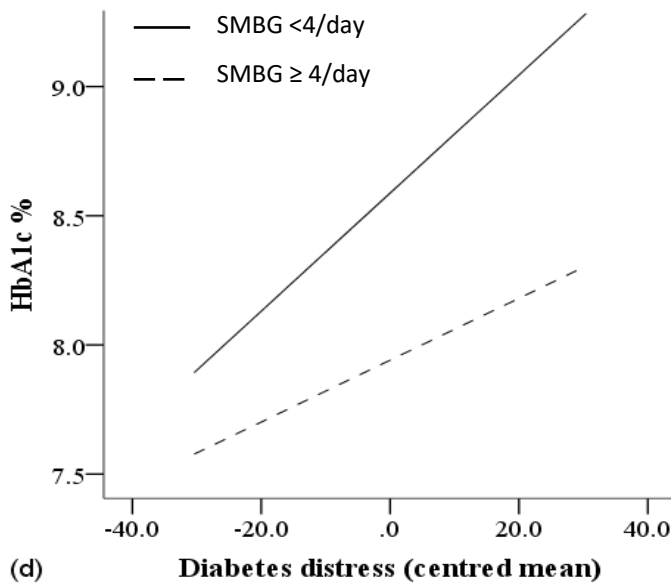
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