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A triadic perspective on control perceptions in youth with type 1 diabetes and their parents:

Associations with treatment adherence and glycemic control

Sofie Prikken[1,2], MSc

Koen Raymaekers[1], MSc

Leen Oris[1,2], MSc

Jessica Rassart[1,2], MSc

Ilse Weets[3], MD, PhD

Philip Moons[1,4], PhD

Koen Luyckx[1,5], PhD

[1] *KU Leuven, Leuven, Belgium*

[2] *Research Foundation Flanders, Brussels, Belgium*

[3] *Free University Brussels / University Hospital Brussels, Brussels, Belgium*

[4] *University of Gothenburg, Gothenburg, Sweden*

[5] *UNIBS, University of the Free State, Bloemfontein, South Africa*

Correspondence should be sent to Sofie Prikken, KU Leuven, Faculty of Psychology and Educational Sciences, Tiensestraat 102 – box 3717, 3000 Leuven, Belgium. Tel: 32 (0)16 37 42 53. E-mail: sofie.prikken@kuleuven.be.
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Abstract

Aims. A family approach was applied to examine youth, maternal, and paternal control perceptions in relation to type 1 diabetes outcomes in adolescents and emerging adults. Mean levels of personal and treatment control were compared among patients and parents. Their associations with diabetes outcomes were examined as well. **Methods.** The sample included 330 patient-mother-father triads. Patients' (48% male) mean age was 18.25 years (*SD*=2.98). All respondents reported on their control perceptions and youth treatment adherence. Physicians provided HbA1c-values. **Results.** Paired-samples *t*-tests revealed higher personal control in patients compared to parents. Regression analyses examined if control perceptions predicted treatment adherence and HbA1c. Main effects for patient and maternal personal control and two-way interactions showed the best outcomes when both patients and mothers reported high personal control. Main effects of patient, maternal, and paternal treatment control and three-way interaction terms revealed better outcomes in case of high treatment control in patients and at least one parent, while the poorest outcomes were observed in case of low treatment control in all respondents. **Conclusions.** The findings highlight the importance of parental control perceptions on top of patients' own perceptions. A family perspective on illness perceptions and their associations with diabetes outcomes is encouraged.

Keywords: Type 1 diabetes, illness perceptions, family, treatment adherence, glycemic control

1. Introduction

Type 1 diabetes is a chronic metabolic illness requiring an intensive treatment that consists of multiple self-management behaviors such as measuring blood glucose, administering insulin, and following diet prescriptions. Adhering to these treatment guidelines can be particularly challenging for young people as they are also facing major normative developmental challenges on their way to adulthood. For instance, adolescents typically engage in the establishment of close peer relationships and a personal sense of identity [1]. After the age of 18 until the mid-twenties, emerging adults continue to explore different life directions and postpone adult roles such as marriage and entry into the labor market [2]. Hence, the integration of diabetes management behaviors in their daily life constitutes a difficult balance for emerging adult patients as well, often reflected in poor treatment adherence and glycemic control [1, 3].

Substantial individual differences in treatment outcomes exist, and the beliefs one holds about the illness may constitute a key factor in this regard. According to the Common Sense Model of Self-Regulation [CSM; 4], illness perceptions are mental representations that individuals create when confronted with a health threat. These perceptions are constructed to make sense of the illness and guide behaviors to manage this threat [5]. Different dimensions can be distinguished, that is, identity, timeline, consequences, cause, and controllability, of which the latter can be further divided into personal and treatment control. Personal control refers to perceptions of one's own control over the illness and its symptoms, whereas treatment control refers to one's beliefs about the treatment being effective in controlling the illness [6]. The CSM assumes that these illness perceptions provide a framework for understanding and predicting behaviors to manage the illness [4]. Although Aujla et al. [7] discouraged the use of individual illness perceptions to predict self-management behaviors, a recent meta-analyses by Hagger et al. [5] provided further evidence for the unique effects of illness representations on

illness outcomes. For adolescents and emerging adults with type 1 diabetes, perceived control is considered an important dimension in predicting diabetes management [8, 9].

According to the CSM, illness management behaviors can also be influenced by the input and expertise of others [4], hence the role of family members' illness perceptions should also be taken into account. Indeed, because Gaston et al. [10] illustrated the relevance of a family perspective by observing that parental treatment control was associated with better adolescent dietary management in type 1 diabetes, we were inclined to take the family as the unit of study as well. Moreover, instead of the usual dyadic approach in which research on mother-patient dyads is largely overrepresented (at the expense of including fathers as well), we applied a triadic family perspective, including patients and both their parents. We examined patient, maternal, and paternal perceptions of personal and treatment control (with all respondents reporting on their own perspective) and their respective associations with treatment adherence and glycemic control.

Two main research questions were addressed. First, we examined similarities and differences in personal and treatment control among patients, mothers, and fathers. Such a triadic approach is innovative and may account for the relative underrepresentation of fathers in research and clinical practice [11]. Regarding personal control, we expected parents to report lower levels than patients because of the increasing independence of adolescents and emerging adults in their diabetes management [1]. Regarding treatment control, previous findings are rather inconsistent. Whereas Law [12] did not observe significant differences in treatment control in mothers as compared to youth, Gaston et al. [10] observed higher treatment control in caregivers. Given that both studies were based on rather small study samples, we did not formulate any concrete expectations but aimed to explore this issue in a larger study sample. In addition, because of the underrepresentation of fathers in the literature, research on differences between maternal and paternal perceptions is scarce. One study in parents of youth with autism

spectrum disorder did not observe significant differences between maternal and paternal control perceptions [13], yet because of the considerable difference in study population, we did not put forward concrete predictions on this issue.

Second, associations between control perceptions and diabetes outcomes (i.e., treatment adherence and glycemic control) were examined separately for personal and treatment control. Regarding treatment adherence, Berg et al. [14] recommend to take different family members' perspectives into account because of the different information they may provide. Accordingly, we included patient, maternal and paternal reports of youth treatment adherence in the current study. Up till now, few studies have applied a family approach on illness perceptions and those studies mainly focused on discrepancies between parental and youth perceptions as predictors of adjustment [15]. As methodological and interpretative concerns have been raised about the use of discrepancy scores as predictors of various outcomes [16], the current study relied on regression analysis with individual scores [17] and interactions among respondents' perceptions as independent variables. Regarding the individual effects, higher control perceptions in patients were generally expected to relate to better treatment adherence and glycemic control [18, 19]. Because parents fulfill an influential role for young people in their health beliefs and behaviors [20], we expected that positive parental control perceptions would be related to better outcomes as well [10]. Given that mothers are generally more involved in the diabetes management of their child [1], we would expect stronger effects for maternal as opposed to paternal control perceptions. The investigation of interaction terms in addition to individual effects was more explorative and was comparable to former studies on illness perceptions in couples and/or caregiver-patient dyads [21, 22]. This approach enabled us to detect specific patterns that are differently related to better or worse treatment adherence and/or glycemic control in youth. We explored whether the effects of control perceptions in patients would depend on the amount of control that mothers and/or fathers experience. As an example of a

two-way interaction, it may be that beneficial effects of high patient control perceptions on outcomes would be stronger when maternal or paternal control perceptions are also high. Because the current study included three family members per family, three-way interactions were also included and investigated in a similar explorative way. For instance, patient control could be unrelated to outcomes, except for when both maternal and paternal control are high.

2. Method

2.1 Participants and Procedure

Baseline data of an ongoing longitudinal project were used. Selected from the Belgian Diabetes Registry, Dutch-speaking patients with a diagnosis of type 1 diabetes between age 14 and 25 were invited for participation. Questionnaires were sent to 1,450 patients, 1,447 mothers, and 1,441 fathers; 53 envelopes were sent back unopened due to incorrect addresses. Five patients with impaired cognitive abilities were excluded. Completed questionnaires were returned by 575 patients (41%), 463 mothers (33%), and 384 fathers (27%). All participants signed a consent form and parents gave consent for minors as well. Four parental consents were missing for minor patients, resulting in 571 patient questionnaires. The study was approved by the Institutional Review Board at the University of Leuven. For the present study, families with participating patients, mothers, and fathers were selected from the total sample. Patients that were not living with their parents were omitted, resulting in 330 triads.

2.2 Measures

2.2.1 Personal and Treatment Control

Personal control (PC) and treatment control (TC) were assessed using the Brief Illness Perception Questionnaire (Brief IPQ). The Brief IPQ is a widely used nine-item questionnaire that shows good psychometric properties and taps into the different illness perceptions by use of single items [23, 24]. Concerning PC, patients reported how much they felt in control over their own illness, and parents reported how much they felt in control over their child's illness.

Concerning TC, patients reported how much they believed the treatment to be helpful in dealing with their illness, and parents indicated how much they believed the treatment to be helpful in dealing with their child's illness. Items were answered on a 0 to 10 scale, ranging from "absolutely no control (PC) / not at all (TC)" to "extreme amount of control (PC) / extremely helpful (TC)".

2.2.2 Treatment Adherence

All participants completed the Self-Care Inventory, a 14-item self-report questionnaire providing a global view on diabetes management behaviors [SCI; 25]. One item was removed (i.e., wearing a medic alert ID) because this is not a common part of treatment in Belgium. Patients reported on their own adherence during the past month and parents reported on their child's adherence by use of an adapted version of the SCI. Participants either rated the items on a Likert scale ranging from 1 (never do it) to 5 (always do this as recommended without fail), or they indicated "not applicable". The SCI was translated to Dutch using the back-translation procedure. Mean scores were calculated with higher scores indicating better treatment adherence. Cronbach's alphas were .74, .75, and .78 for patients, mothers, and fathers.

2.2.3 Glycemic control

Treating physicians provided us with the glycated haemoglobin values (HbA1c) closest to the date of questionnaire completion, that is, within a time range of three months before and after participation. HbA1c-values below 7.0% or 53 mmol/mol (adults) and 7.5% or 58 mmol/mol (adolescents) are recommended. Higher values indicate poorer glycemic control [26, 27].

2.3 Data Analytic Plan

R version 3.5.1 was used for analyzing the data[1]. Preliminary analyses consisted of two multivariate analyses of variance (MANOVAs) to assess relations between gender and type of insulin administration, and participants' control perceptions. Bivariate correlations among all

[1] For the description of the study sample and for the calculation of Cronbach's alphas, IBM SPSS Statistics Version 24 was used.

variables were calculated as well. Paired-samples *t*-tests were used to examine differences between patient, maternal, and paternal control perceptions. Separate regression analyses were conducted for PC and TC to examine their predictive value for treatment adherence and HbA1c[2]. Patient, maternal, and paternal reports of patient treatment adherence are clustered within families, meaning that reports of treatment adherence within a family are more alike than reports between different families (intraclass correlation = 0.55). To disaggregate the total variance in a between- and a within-cluster component, random intercept multilevel regressions were conducted for treatment adherence using the package lme4. Restricted maximum likelihood estimation was used to estimate the models. For glycemic control, regular linear regressions were run.

Patient, maternal, and paternal control perceptions and two- and three-way interactions were operationalized as independent variables predicting treatment adherence and glycemic control. Gender, type of insulin administration, age, and illness duration were added as control variables. Gender and type of insulin administration were dummy coded (0=female, 1=male; 0=pump, 1=insulin injections) and all predictor variables were standardized prior to analyses. The MuMIn package was used to estimate R^2 in the multilevel models, which calculates both the conditional R^2 (i.e., the proportion of variance explained by fixed and random effects) and the marginal R^2 (i.e., the proportion of variance explained by fixed effects only).

Using the templates available at www.jeremydawson.co.uk, significant interaction terms were plotted for high and low levels of predictors, that is, for one standard deviation above and below the mean. To obtain more insight in how the magnitude of the effect of one independent variable changes relative to the level of the other independent variable in two-way interaction terms, post-hoc *t*-tests were conducted for testing the significance of simple slopes. Hence, we tested whether the simple effect of one independent variable in the interaction term on the

[2] The terms "predictive value", "predict", and "prediction" are used in their statistical meaning of estimating outcomes variables based on predictor variables by use of regression analyses.

outcome significantly differed from zero when keeping the other independent variable constant at one standard deviation above or below its mean. In three-way interactions, post-hoc *t*-tests uncovered whether differences between pairs of slopes were significant [28], testing whether the effect of an independent variable differed significantly for each combination of high/low values of the other two independent variables (i.e. 1 *SD* above/below the mean).

2. Results

3.1 Sample Characteristics and Preliminary Analyses

When comparing the final sample (n=330) to the patients that were not included in the current study (n=241), no significant differences were found in terms of gender [$\chi^2(1)=1.31$, $p=.253$] or type of insulin administration [$\chi^2(1)=0.02$, $p=.897$]. As all included participants were living with their parents, they were significantly younger [18.25 (*SD*=2.98) vs. 19.78 (*SD*=3.41); $F(1,568)=32.40$, $p<.001$, $\eta^2=.05$], and were more recently diagnosed with type 1 diabetes [7.08 (*SD*=4.63) vs. 8.33 (*SD*=5.33); $F(1,564)=8.87$, $p=.003$, $\eta^2=.02$]. Included patients had significantly lower HbA1c-values than non-included patients (n=168), [7.6% (*SD*=1.10) or 60 mmol/mol vs. 8.0% (*SD*=1.81) or 64 mmol/mol; $F(1,429)=6.27$, $p=.013$, $\eta^2=.01$].

The current study sample consisted of 330 triads. There were 158 (48%) male patients with a mean age of 18.25 (*SD*=2.98). Most of them (79%) administered insulin through injections. The majority reported that their parents were married or living together (85%), while only a minority (12%) reported that their parents were divorced. Thirty-four patients (10%) had at least one stepparent. HbA1c-values were obtained from 263 patients, with a mean value of 7.60% (*SD*=1.10) or 60 mmol/mol. Regarding participating parents, mean ages were 47.49 (*SD*=3.62) and 49.60 (*SD*=5.33) for mothers and fathers, respectively. Approximately half of these parents reported that they obtained a higher education degree (mothers: 53%; fathers: 51%) and the majority was employed (mothers: 81%; fathers: 89%).

MANOVAs identified significant differences in control perceptions between male and female patients [Wilks' Lambda=0.96, $F(6,314)=2.17$, $p=.046$, $\eta^2=.04$], with male patients experiencing higher PC [male: 7.43 (*SD*=1.82); female: 6.67 (*SD*=2.10); $F(1,319)=11.65$, $p<.001$, $\eta^2=.03$]. Type of insulin administration was also significantly associated with control perceptions [Wilks' Lambda=0.94, $F(6,316)=3.33$, $p=.003$, $\eta^2=.06$)], with the use of injections being associated with higher PC. The latter results were found in reports by patients [injections: 7.18 (*SD*=1.93); pump: 6.54 (*SD*=2.16); $F(1,321)=5.67$, $p=.018$, $\eta^2=.02$], mothers [Injections: 5.71 (*SD*=2.28); pump: 4.41 (*SD*=2.64); $F(1,321)=16.60$, $p=<.001$, $\eta^2=.05$;], and fathers [Injections: 5.27 (*SD*=2.51); pump: 4.43 (*SD*=2.51)]; $F(1,321)=5.361$, $p=.021$, $\eta^2=.02$].

Bivariate correlations with *n* varying from 254 to 330 (See Table 1) indicated that patient age was negatively correlated with patient, maternal, and paternal PC and with maternal TC. Illness duration correlated negatively with maternal TC. Further, correlations between different respondents ranged from *r*=.22 to .35 for PC and from *r*=.22 to .31 for TC. Correlations between different treatment adherence reports varied from *r*=.45 to .65. HbA1c correlated negatively with all reports of treatment adherence.

3.1 Patient, Maternal, and Paternal Control Perceptions

To address the first research question, paired-samples *t*-tests were used to compare mean levels of control perceptions among family members. Concerning PC, mean scores were 7.05 (*SD*=1.99) for patients, 5.43 (*SD*=2.41) for mothers, and 5.09 (*SD*=2.53) for fathers. Patients experienced significantly higher PC than mothers and fathers. When comparing mothers and fathers, mothers experienced higher PC than fathers. Concerning TC, the scores were 8.21 (*SD*=1.85), 8.23 (*SD*=1.80), and 8.10 (*SD*=1.88) for patients, mothers, and fathers, respectively. No differences between these scores were significant (See Table 2).

3.2 Control Perceptions Predicting Illness Outcomes

3.2.1 Personal Control

The results of the regressions examining the predictive value of personal control perceptions on treatment adherence and HbA1c are presented in Table 3. For treatment adherence, conditional R^2 was .55 and marginal R^2 was .18. For HbA1c, R^2 was .14. Regarding the control variables, illness duration negatively predicted treatment adherence and positively predicted HbA1c. Age negatively predicted HbA1c. Higher patient PC predicted better treatment adherence and lower HbA1c. Maternal PC positively predicted treatment adherence. No main effects of paternal PC were observed.

Two-way interactions between patient and maternal PC were significant in predicting treatment adherence and HbA1c. In general, the best outcomes were observed in case of both patients and mothers experiencing high PC. For treatment adherence, the positive interaction coefficient illustrates patient PC to predict better treatment adherence with increased maternal PC. The simple slopes for patient PC at high and low maternal PC (i.e., 1 *SD* above/below the mean) predicting treatment adherence are visualized in Figure 1 (panel a). Both slopes were significant, indicating that patient PC relates to treatment adherence, both in case of high maternal and low maternal PC [high maternal PC: $t(309)=7.39$, $p<.001$); low maternal PC: $t(309)=3.69$, $p<.001$]. For HbA1c, the negative interaction coefficient shows that, with increased maternal PC, higher patient PC predicted lower HbA1c. The simple slopes for patient PC at high and low maternal PC (i.e., 1 *SD* above/below the mean) predicting HbA1c are visualized in Figure 1 (panel b). Only the simple slope for patient PC at high maternal PC was significant [high maternal PC: $t(244)=-4.17$, $p<.001$; low maternal PC: $t(244)=-1.83$, $p=.069$], indicating that when mothers experienced low PC (i.e., 1 *SD* below the mean), patient PC was not significantly related to HbA1c. No three-way interaction term was significant.

3.2.2 Treatment Control

The results of the regressions examining the predictive value of treatment control perceptions on treatment adherence and HbA1c are presented in Table 4. For treatment adherence,

conditional R^2 was .55 and marginal R^2 was .13. For HbA1c, R^2 was .22. Regarding the control variables, illness duration negatively predicted treatment adherence and positively predicted HbA1c. Patient age negatively predicted HbA1c. Main effects of patient, maternal and paternal TC were found for both treatment adherence and HbA1c. Higher TC consistently predicted more favorable outcomes.

Although no two-way interactions terms occurred, three-way interaction terms emerged for both treatment adherence and HbA1c. The simple slopes for patient TC at high and low maternal TC and high and low paternal TC (i.e., 1 *SD* above/below the mean) are visualized in Figure 2. Better adherence and better glycemic control were observed if patients reported high TC. If patients experienced low TC, high TC in at least one parent was associated with somewhat better outcomes, and even more so if both parents experienced high TC. However, if both parents experienced low TC, less favorable outcomes were observed regardless of patients' own TC. Regarding differences among slopes, for treatment adherence, the slope of the regression line combining low TC in both parents significantly differed from the slope combining low maternal and high paternal TC [$t(310)=2.28$, $p=.023$]. Patients' own TC seemed to be more predictive in case of low maternal TC and high paternal TC than in case of low TC in both parents. For HbA1c, differences between slopes were non-significant.

3. Discussion

This study applied a triadic family approach to illness perceptions of control and their associations with diabetes outcomes in a large sample of adolescents and emerging adults, and their parents. In previous research, associations between control perceptions and treatment adherence have been frequently confirmed [8], whereas associations with glycemic control seem more complex and rather inconsistent [19, 29]. As the current study included treatment adherence using multi-informant reports and glycemic control as outcome measures, it provided clear evidence for control perceptions being related to both. Parental control perceptions were

associated with illness outcomes as well. Hence, these findings provide further evidence for the supportive role that parents can play in promoting adaptive diabetes outcomes, even in adolescents and emerging adults who become increasingly independent from their parents [30]. This is particularly relevant because it suggests that parents may continue to fulfill a role in (partially) improving the widely observed deteriorating diabetes outcomes throughout adolescence and emerging adulthood [31, 32], although longitudinal research is needed to verify such a conclusion.

4.1 Patient, Maternal and Paternal Perceptions of Control

Patient age and illness duration were negatively related to patient personal control, suggesting that patients feel less in control over their illness as they become older and/or have been diagnosed for a longer time. This was somewhat surprising given that previous longitudinal research has found that early adolescents (aged 11-14) experienced increased personal control over time [18]. A potential explanation can be found in the older age group sampled in the present study and the accompanying shift from shared parent-patient responsibility to more patient responsibility in diabetes management during adolescence and emerging adulthood [32]. A good fit with patients' competence beliefs is considered crucial in this regard [33]. When patients feel incompetent in taking more responsibility for their diabetes management as they grow older, this may result in decreased perceived control in these patients.

Patient age was also negatively related to parental personal control, and parents reported lower personal control as compared to their children as well. These findings can be seen as a possible byproduct of the decrease in responsibilities parents assume in managing the diabetes over time [32]. No significant differences between respondents' reports of treatment control were found, which was in line with the findings of Law [12]. On average, patients and parents did not differ in their beliefs about the treatment being effective in controlling the diabetes. This finding may reflect a shared view on the illness and the importance and effectivity of its

treatment, possibly fostered by close family involvement and support in managing the illness, which remains important during the transition to adulthood [34].

4.2 Control Perceptions and Diabetes Outcomes

Regarding personal control, findings were largely in line with expectations. We consistently found better diabetes outcomes when patients reported high personal control. Feeling in control over one's illness may indeed enhance self-care [19, 29]. Higher maternal personal control was associated with better treatment adherence as well, but no main effects for fathers were observed. Two-way interactions showed that the most optimal outcomes were observed in case of high patient and maternal personal control. These findings suggest that maternal personal control can have an important role toward diabetes outcomes, particularly when patients also experience high personal control. No such interactions were found between patients and fathers, which may be explained by the different roles mothers and fathers adopt in households, with mothers generally perceived as being more involved in diabetes management [1].

Regarding treatment control, patients' positive beliefs about the effectiveness of the treatment were related to better treatment adherence and glycemic control, in line with previous findings [8]. Higher maternal and paternal treatment control were associated with better treatment adherence and glycemic control as well. No two-way interactions were found. However, the significant three-way interactions suggest that patients show better treatment adherence and glycemic control when they believe that the treatment is effective in controlling the diabetes, but only when at least one parent shares these beliefs. When all family members reported low treatment control, the poorest outcomes were observed, but when low patient treatment control was combined with high treatment control in both parents, these poor outcomes were somewhat attenuated. This might suggest that positive parental control perceptions can indeed serve a protective function. As a triadic approach seemed most informative when assessing treatment control in relation to diabetes outcomes, these findings

illustrate the importance of patients', mothers' and fathers' beliefs about treatment effectiveness.

4.3 Limitations and Suggestions for Future Research

Some limitations should be acknowledged. First, the cross-sectional design prevents us from drawing any conclusions on directionality of effects or possible underlying mechanisms. Longitudinal designs are warranted as it seems highly plausible that control perceptions and diabetes outcomes would mutually impact each other over time. Better diabetes outcomes may predict higher personal and/or treatment control, whereas worse outcomes may challenge such perceptions of control. Concerning underlying mechanisms, treatment adherence could possibly mediate the associations between control perceptions and glycemic control, which should also be investigated longitudinally. Second, the Brief IPQ consists of single items tapping into different illness perceptions [23]. Although single item measures may raise reliability and validity concerns, they can be used when assessing homogeneous concepts [35]. The Brief IPQ has been widely used in former research and clinical practice and shows good psychometric qualities, yet future studies should include more comprehensive questionnaires. Third, the rather low response rates increase the risk of a non-representative sample, possibly reducing the generalizability of our findings. When compared to a large sample of USA patients [31], the current sample shows notably better glycemic control values and, hence, our findings may only be applicable to rather high-functioning populations. Fourth, although we had no information on primary caregivers roles within families, effects of control perceptions of these primary caregivers may have been more pronounced as compared to non-primary caregivers. Lastly, we only included patients living with their parents. Findings might be different for those who do not live with their parents anymore, as parents might be less involved in their diabetes management.

4.4 Conclusions and Clinical implications

The current study provides further evidence on the relevance of control perceptions for diabetes outcomes. A triadic perspective including patient, maternal, and paternal perceptions seems to be even more valuable, because on top of patients' own perceptions, we found parental control perceptions to relate to diabetes outcomes as well. Although parents are less often addressed in routine clinical care for adolescents and emerging adults who are transitioning to adult care, the current findings further demonstrate that parents should not be overlooked during these life periods. Indeed, a carefully tailored transmission of treatment responsibilities seems crucial in this regard and may prevent patients from showing poorer illness outcomes [3]. Youth should continue to feel self-competent and in control over their illness as they grow older and have to take more responsibly in their diabetes management [33].

In standard clinical practice, the Brief IPQ may be well-suited as screening instrument providing an idea of both patients' and parents' illness experiences. The assessment of not only patient perceptions, but also parental illness perceptions, may offer a fruitful approach to facilitate better patient outcomes. Cognitive behavioral interventions targeting illness perceptions may then be useful in case of poorly controlled diabetes. Previous findings pointed to control perceptions in patients, and personal control in particular, as being most often changed and targeted [24]. Provided that our findings can be replicated in longitudinal study designs, targeting both parental and patient control perceptions to make them feel more in control over the illness might eventually lead to more optimal diabetes outcomes. Including close family members within these interventions would be in line with recommendations of Martire and Helgeson [36] who also stressed the importance of close relatives in managing chronic illnesses and who emphasized the utility of family-based interventions. Taken together, the current findings contribute to the notion of type 1 diabetes as a family condition, even throughout adolescence and emerging adulthood. Interesting perspectives are provided for both research and clinical practice in the domain of illness perceptions.

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References

[1] Seiffge-Krenke I. Diabetic adolescents and their families: Stress, coping, and adaptation. Cambridge University Press; 2001.

[2] Arnett JJ. Emerging adulthood. Am Psychol 2000;55:469-80. http://dx.doi.org/10.1037/0003-066X.55.5.469

[3] Weissberg-Benchell J, Wolpert H, Anderson BJ. Transitioning from pediatric to adult care: A new approach to the post-adolescent young person with type 1 diabetes. Diabetes Care 2007;30:2441-6. https://doi.org/10.2337/dc07-1249

[4] Leventhal H, Benyamini Y, Brownlee S, Diefenbach M, Leventhal EA, Patrick-Miller L et al. Illness representations: Theoretical foundations. In: J. Weinman and K. Petrie, eds. Perceptions of health and illness. Harwood Academic Publishers Amsterdam; 1997: 19-46.

[5] Hagger MS, Koch S, Chatzisarantis NLD, Orbell S. The common sense model of self-regulation: Meta-analysis and test of a process model. Psychol Bull 2017;143:1117-54.

[6] Moss-Morris R, Weinman J, Petrie K, Horne R, Cameron L, Buick D. The revised illness perception questionnaire (ipq-r). Psychol Health 2002;17:1-16. https://doi.org/10.1080/08870440290001494

[7] Aujla N, Walker M, Sprigg N, Abrams K, Massey A, Vedhara K. Can illness beliefs, from the common-sense model, prospectively predict adherence to self-management behaviours? A systematic review and meta-analysis. Psychol Health 2016;31:931-58. https://doi.org/10.1080/08870446.2016.1153640

[8] McGrady ME, Peugh JL, Hood KK. Illness representations predict adherence in adolescents and young adults with type 1 diabetes. Psychol Health 2014;29:985-98. https://doi.org/10.1080/08870446.2014.899361

[9] Harvey JN, Lawson VL. The importance of health belief models in determining self-care behaviour in diabetes. Diabet Med 2009;26:5-13. https://doi.org/10.1111/j.1464-5491.2008.02628.x

[10] Gaston AM, Cottrell DJ, Fullen T. An examination of how adolescent–caregiver dyad illness representations relate to adolescents' reported diabetes self-management. Child Care Health Dev 2012;38:513-9. https://doi.org/10.1111/j.1365-2214.2011.01269.x

[11] Phares V, Lopez E, Fields S, Kamboukos D, Duhig AM. Are fathers involved in pediatric psychology research and treatment? J Pediatr Psychol 2005;30:631-43. https://doi.org/10.1093/jpepsy/jsi050

[12] Law GU. Dissimilarity in adolescent and maternal representations of type 1 diabetes: Exploration of relations to adolescent well-being. Child Care Health Dev 2002;28:369-78. https://doi.org/10.1046/j.1365-2214.2002.00286.x

[13] Gatzoyia D, Kotsis K, Koullourou I, Goulia P, Carvalho AF, Soulis S et al. The association of illness perceptions with depressive symptoms and general psychological distress in parents of an offspring with autism spectrum disorder. Disabil Health J 2014;7:173-80. https://doi.org/10.1016/j.dhjo.2013.10.008

[14] Berg CA, Butner JE, Turner SL, Lansing AH, King P, Wiebe DJ. Adolescents', mothers', and fathers' reports of adherence across adolescence and their relation to hba1c and daily blood glucose. J Behav Med 2016;39:1009-19. https://doi.org/10.1007/s10865-016-9771-5

[15] Olsen B, Berg CA, Wiebe DJ. Dissimilarity in mother and adolescent illness representations of type 1 diabetes and negative emotional adjustment. Psychol Health 2008;23:113-29. https://doi.org/10.1080/08870440701437343

[16] Laird RD, De Los Reyes A. Testing informant discrepancies as predictors of early adolescent psychopathology: Why difference scores cannot tell you what you want to

know and how polynomial regression may. J Abnorm Child Psychol 2013;41:1-14. https://doi.org/10.1007/s10802-012-9659-y

[17] Laird RD, Weems CF. The equivalence of regression models using difference scores and models using separate scores for each informant: Implications for the study of informant discrepancies. Psychol Assess 2011;23:388-97. http://dx.doi.org/10.1037/a0021926

[18] Fortenberry KT, Berg CA, King PS, Stump T, Butler JM, Pham PK et al. Longitudinal trajectories of illness perceptions among adolescents with type 1 diabetes. J Pediatr Psychol 2014;39:687-96. https://doi.org/10.1093/jpepsy/jsu043

[19] Griva K, Myers LB, Newman S. Illness perceptions and self efficacy beliefs in adolescents and young adults with insulin dependent diabetes mellitus. Psychol Health 2000;15:733-50. https://doi.org/10.1080/08870440008405578

[20] Lau RR, Quadrel MJ, Hartman KA. Development and change of young adults' preventive health beliefs and behavior: Influence from parents and peers. J Health Soc Behav 1990:240-59.

[21] Benyamini Y, Medalion B, Garfinkel D. Patient and spouse perceptions of the patient's heart disease and their associations with received and provided social support and undermining. Psychol Health 2007;22:765-85. https://doi.org/10.1080/14768320601070639

[22] Dempster M, McCorry NK, Brennan E, Donnelly M, Murray LJ, Johnston BT. Illness perceptions among carer–survivor dyads are related to psychological distress among oesophageal cancer survivors. J Psychosom Res 2011;70:432-9. https://doi.org/10.1016/j.jpsychores.2010.07.007

[23] Broadbent E, Petrie KJ, Main J, Weinman J. The brief illness perception questionnaire. J Psychosom Res 2006;60:631-7. https://doi.org/10.1016/j.jpsychores.2005.10.020

[24] Broadbent E, Wilkes C, Koschwanez H, Weinman J, Norton S, Petrie KJ. A systematic review and meta-analysis of the brief illness perception questionnaire. Psychol Health 2015;30:1361-85. https://doi.org/10.1080/08870446.2015.1070851

[25] La Greca AM, Swales T, Klemp S, Madigan S. Self care behaviors among adolescents with diabetes (abstract). Presented at 9th Annual Sessions of the Society of Behavioral Medicine; 1988; Baltimore, MD.

[26] American Diabetes Association. Glycemic targets. Diabetes Care 2016;39:S39-S46. 10.2337/dc16-S008

[27] American Diabetes Association. Children and adolescents. Diabetes Care 2016;39:S86-S93. 10.2337/dc16-S014

[28] Dawson JF, Richter AW. Probing three-way interactions in moderated multiple regression: Development and application of a slope difference test. J Appl Psychol 2006;91:917-26. http://dx.doi.org/10.1037/0021-9010.91.4.917

[29] Mc Sharry J, Moss-Morris R, Kendrick T. Illness perceptions and glycaemic control in diabetes: A systematic review with meta-analysis. Diabet Med 2011;28:1300-10. https://doi.org/10.1111/j.1464-5491.2011.03298.x

[30] Luyckx K, Seiffge-Krenke I. Continuity and change in glycemic control trajectories from adolescence to emerging adulthood: Relationships with family climate and self-concept in type 1 diabetes. Diabetes Care 2009;32:797-801. https://doi.org/10.2337/dc08-1990

[31] Beck RW, Tamborlane WV, Bergenstal RM, Miller KM, DuBose SN, Hall CA. The t1d exchange clinic registry. J Clin Endocrinol Metab 2012;97:4383-9. https://doi.org/10.1210/jc.2012-1561

[32] Wiebe DJ, Chow CM, Palmer DL, Butner J, Butler JM, Osborn P et al. Developmental processes associated with longitudinal declines in parental responsibility and adherence

to type 1 diabetes management across adolescence. J Pediatr Psychol 2014;39:532-41. https://doi.org/10.1093/jpepsy/jsu006

[33] Berg CA, Butner J, Wiebe DJ, Lansing AH, Osborn P, King PS et al. Developmental model of parent-child coordination for self-regulation across childhood and into emerging adulthood: Type 1 diabetes management as an example. Dev Rev 2017:1-26. https://doi.org/10.1016/j.dr.2017.09.001

[34] Wiebe DJ, Berg CA, Korbel C, Palmer DL, Beveridge RM, Upchurch R et al. Children's appraisals of maternal involvement in coping with diabetes: Enhancing our understanding of adherence, metabolic control, and quality of life across adolescence. J Pediatr Psychol 2005;30:167-78. https://doi.org/10.1093/jpepsy/jsi004

[35] Loo R. A caveat on using single-item versus multiple-item scales. J Manage Psychol 2002;17:68-75. https://doi.org/10.1108/02683940210415933

[36] Martire LM, Helgeson VS. Close relationships and the management of chronic illness: Associations and interventions. Am Psychol 2017;72:601-12. http://dx.doi.org/10.1037/amp0000066

Table 1

Bivariate Correlations Among Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12
1. PC Patient	1											
2. PC Mother	.24***	1										
3. PC Father	.22***	.35***	1									
4. TC Patient	.55***	.17**	.07	1								
5. TC Mother	.23***	.27***	.17**	.24***	1							
6. TC Father	.21***	.21***	.28***	.22***	.31***	1						
7. TA Patient	.39***	.25***	.15**	.26***	.20***	.15**	1					
8. TA Mother	.35***	.25***	.12*	.24***	.30***	.20***	.57***	1				
9. TA Father	.28***	.11*	.21***	.17**	.19***	.27***	.45***	.65***	1			
10. HbA1c	-.25***	-.03	-.09	-.30***	-.27***	-.25***	-.26***	-.32***	-.35***	1		
11. Age	-.14*	-.36***	-.34***	-.10	-.13*	-.07	-.24***	-.04	-.01	-.10	1	
12. Illness duration	-.10	-.09	-.07	-.10	-.15**	-.06	-.10	-.16**	-.15**	.16*	.16**	1

Note. Pairwise deletion was used with *n* varying from 254 to 330.

TA = Treatment adherence; PC = Personal control; TC = Treatment control.

*** $p < .001$; ** $p < .01$; * $p < .05$.

Table 2

Descriptive Statistics of Control Perceptions and Treatment Adherence and Paired-samples T-tests on Control Perceptions

	Personal Control	Treatment Control	TA
Patient *M* (*SD*)	7.05 (1.99)	8.21 (1.85)	3.81 (0.50)
Mother *M* (*SD*)	5.43 (2.41)	8.23 (1.80)	3.91 (0.51)
Father *M* (*SD*)	5.09 (2.53)	8.10 (1.88)	3.96 (0.52)
Patient-Mother			
M of difference	1.60	-0.02	
95% CI of difference	1.30 – 1.90	-0.27 – 0.22	
t-value *(df)*	10.51*** (323)	-0.17 (324)	
Cohen's *d*	0.58	-0.01	
Patient-Father			
M of difference	1.95	0.10	
95% CI of difference	1.63 – 2.26	-0.15 – 0.36	
t-value *(df)*	12.34*** (327)	0.80 (326)	
Cohen's *d*	0.68	0.04	
Mother-Father			
M of difference	0.34	0.13	
95% CI of difference	0.03 – 0.65	-0.11 – 0.36	
t-value *(df)*	2.18* (325)	1.07 (327)	
Cohen's *d*	0.12	0.06	

Note. TA = Treatment adherence. *** $p < .001$; ** $p < .01$; * $p < .05$.

Table 3

Regression Coefficients of Personal Control Predicting Treatment Adherence and HbA1c

	Treatment Adherence *935 observations, 321 groups*		HbA1c *n* = 256	
	B	S.E.	B	S.E.
(Intercept)	3.87***	0.02	7.63***	0.07
Illness Duration	-0.06**	0.02	0.17*	0.07
Age	0.02	0.02	-0.18*	0.07
Gender	0.02	0.02	-0.01	0.07
Ins. Administration	0.00	0.02	-0.11	0.07
PC Patient	0.18***	0.02	-0.32***	0.07
PC Mother	0.07**	0.03	0.01	0.08
PC Father	0.04	0.02	-0.08	0.08
PC PxM	0.08***	0.02	-0.15*	0.07
PC PxF	-0.02	0.03	0.06	0.08
PC MxF	0.02	0.02	0.01	0.07
PC PxMxF	-0.02	0.02	0.05	0.05

Note. B = regression coefficients; S.E. = standard error; Ins. = insulin; PC = personal control; P = patient; M = mother; F = father.

*** $p < .001$; ** $p < .01$; * $p < .05$.

Gender and insulin administration were coded as dummy-variables; all predictor variables were standardized prior to analyses.

Table 4

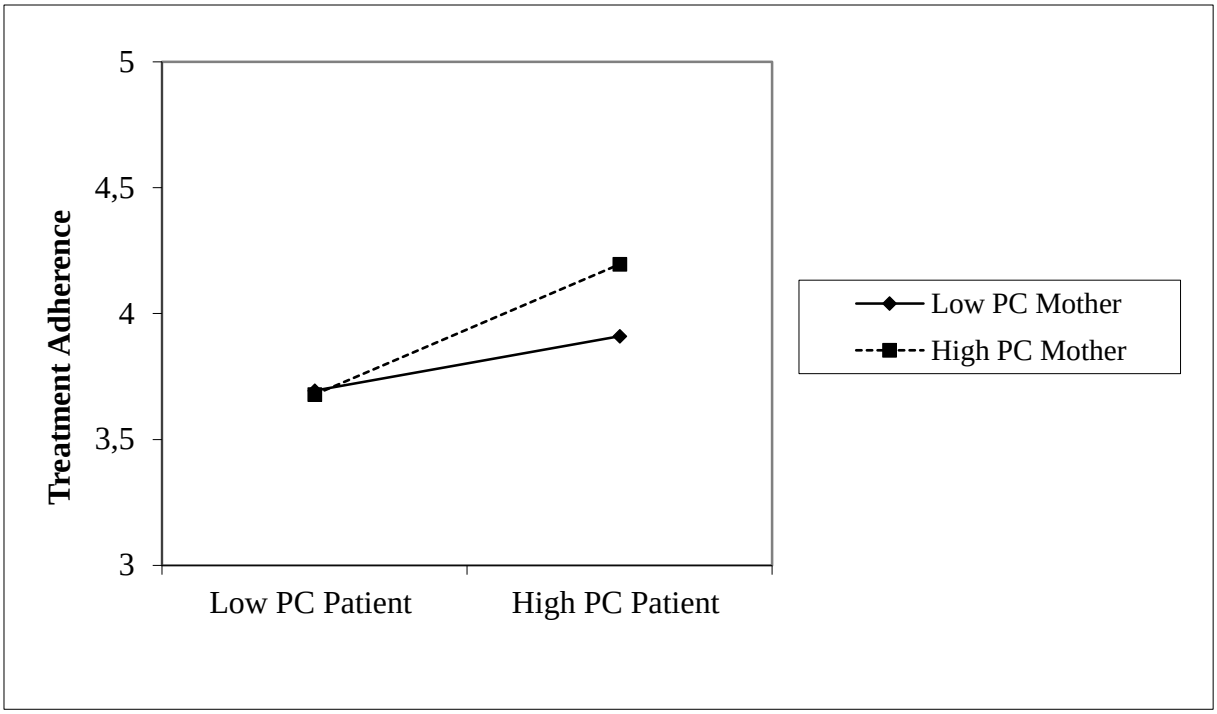
Regression Coefficients of Treatment Control Predicting Treatment Adherence and HbA1c

	Treatment Adherence *939 observations, 322 groups*		HbA1c *n* = 257	
	B	S.E.	B	S.E.
(Intercept)	3.89***	0.02	7.62***	0.07
Illness Duration	-0.05*	0.02	0.14*	0.07
Age	-0.03	0.02	-0.19**	0.06
Gender	-0.00	0.02	-0.02	0.06
Ins. Administration	0.02	0.02	-0.10	0.07
TC Patient	0.11***	0.02	-0.32***	0.07
TC Mother	0.06*	0.02	-0.15*	0.07
TC Father	0.08***	0.02	-0.22**	0.07
TC PxM	0.01	0.02	0.06	0.07
TC PxF	0.02	0.02	-0.01	0.07
TC MxF	-0.01	0.02	0.04	0.07
TC PxMxF	-0.04*	0.02	0.12*	0.05

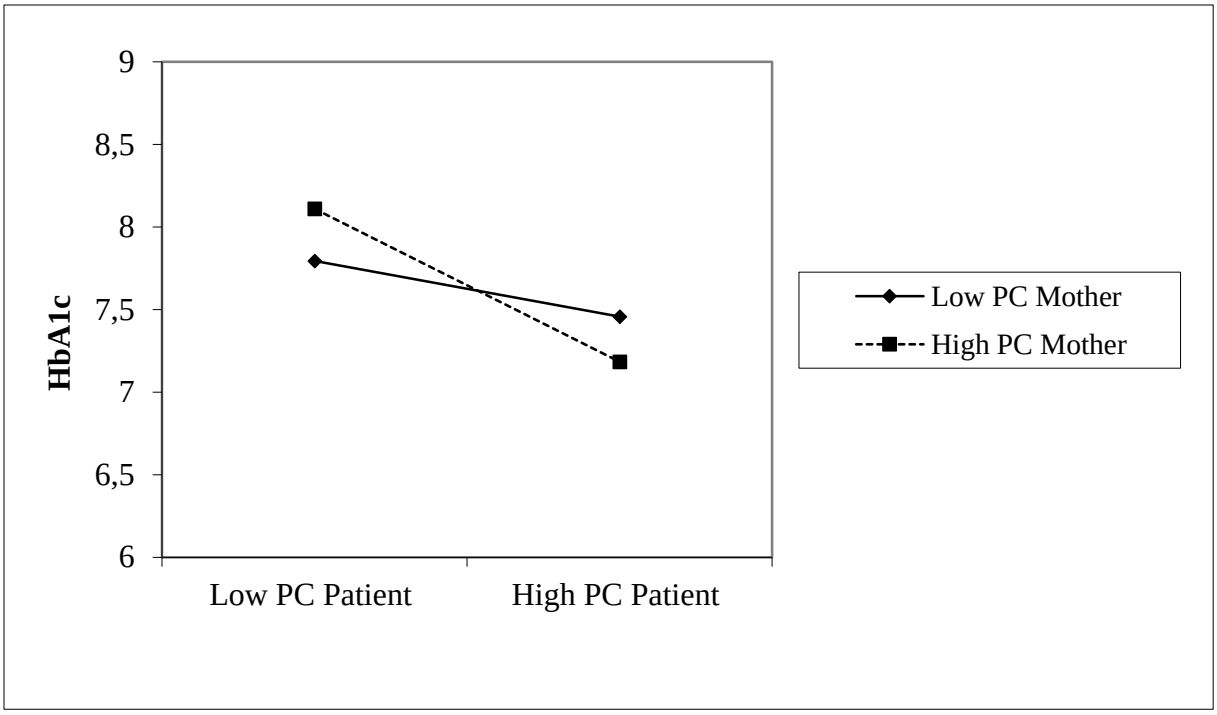
Note. B = regression coefficients; S.E. = standard error; Ins. = insulin; TC = treatment control; P = patient; M = mother; F = father.

*** $p < .001$; ** $p < .01$; * $p < .05$.

Gender and insulin administration were coded as dummy-variables; all predictor variables were standardized prior to analyses.

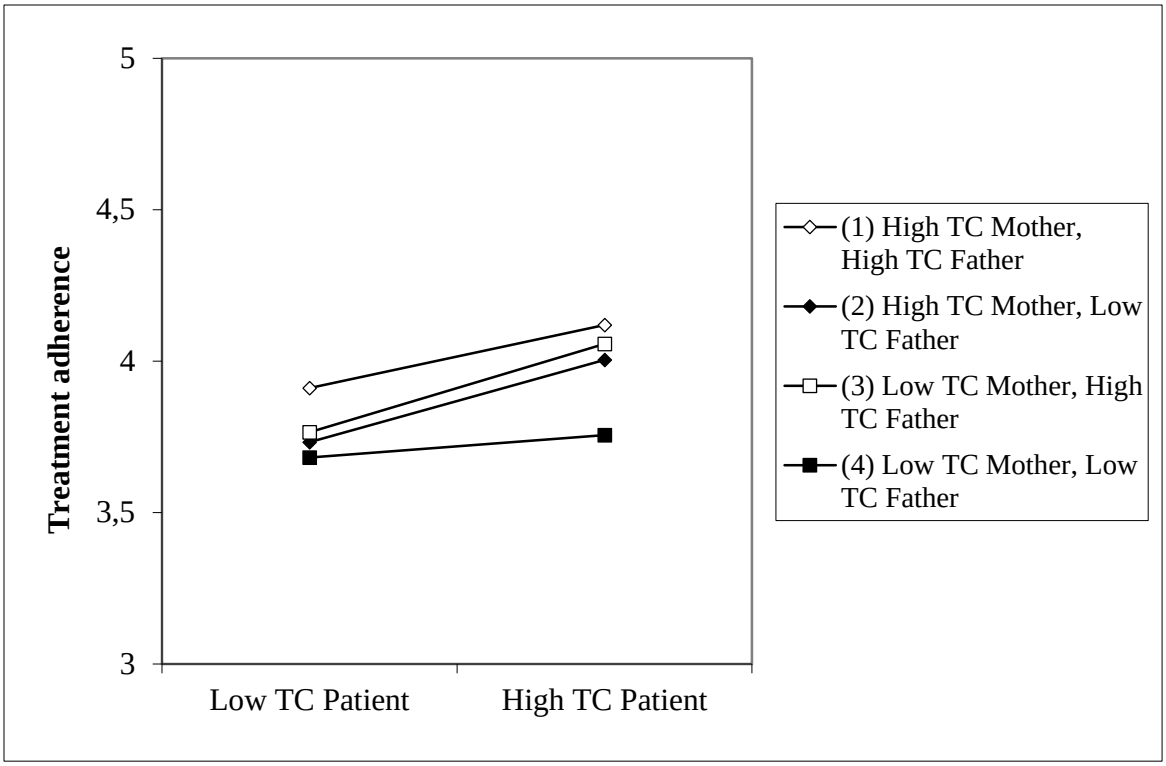


Panel a.

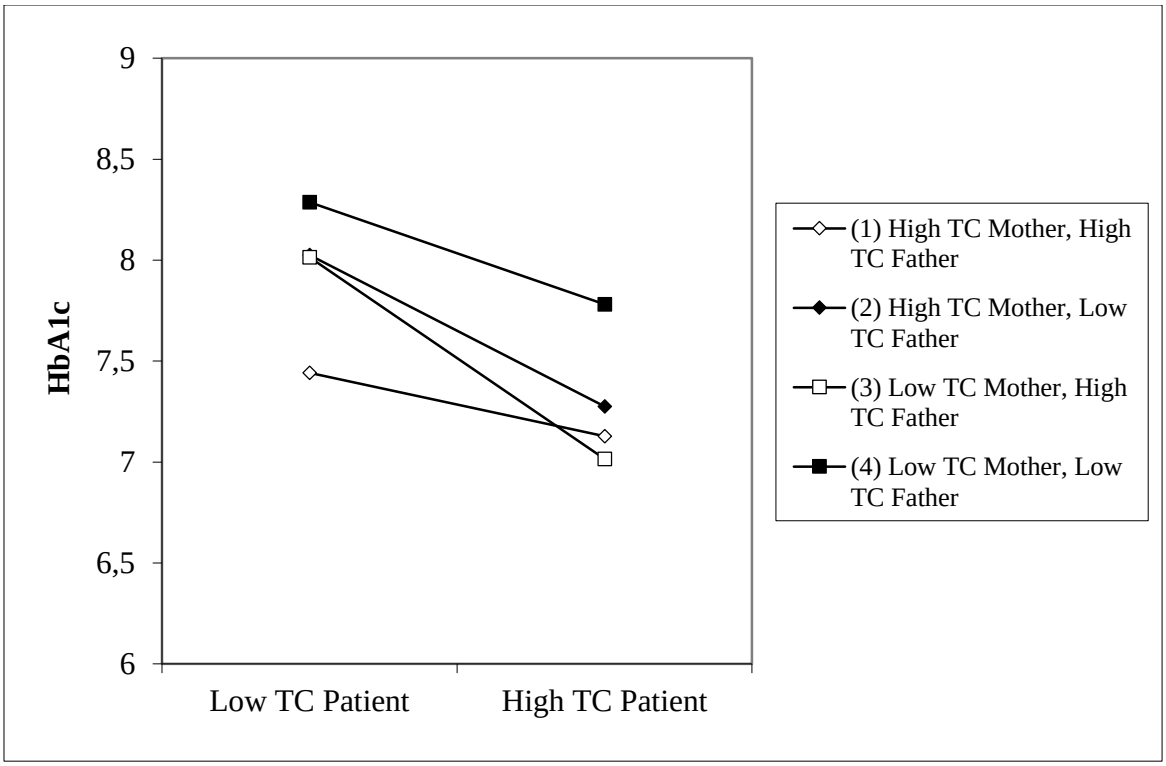


Panel b.

Figure 1. Interactions between patient and maternal personal control in predicting treatment adherence and HbA1c. Simple slopes are presented for low (-1 *SD*) and high (+1 *SD*) patient and maternal personal control. PC = Personal control. TA = Treatment adherence. Panel a) Two-way interaction between patient and maternal PC in predicting treatment adherence. Panel b) Two-way interaction between patient and maternal PC in predicting HbA1c.



Panel a.



Panel b.

Figure 2. Interactions between patient, maternal, and paternal treatment control in predicting treatment adherence and HbA1c. Simple slopes are presented for low (-1 *SD*) and high (+1 *SD*) patient, maternal, and paternal treatment control. TC = Treatment control. TA = Treatment adherence. Panel a) Three-way interaction between patient, maternal, and paternal TC in predicting treatment adherence. Panel b) Three-way interaction between patient, maternal, and paternal TC in predicting HbA1c.