Compensatory beliefs about glucose testing are associated with low adherence to treatment and poor metabolic control in adolescents with type 1 diabetes

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Abstract

The goal of this research was to investigate whether compensatory beliefs (CBs) regarding glucose testing predict blood glucose levels and adherence to treatment in adolescents with type 1 diabetes. CBs are convictions that the negative effects of one behavior (e.g. not testing one’s glucose level) can be compensated for by engaging in another behavior (e.g. not eating any sweets). Adolescent patients from the Diabetes Clinic at the Montreal Children’s Hospital and their parents filled out scales while coming for a regular visit. Results from their HbA1c blood test from that visit and prior visits were obtained from their medical records. Results showed that holding glucose testing CBs was associated with poorer HbA1c and poorer adherence to self-care behaviors. Hierarchical regression analyses showed that glucose testing CBs predicted blood glucose control and adherence to treatment above and beyond a number of other constructs including diabetes knowledge. Addressing CBs in diabetes education, in particular targeting those concerning glucose testing, could improve the adherence to treatment and thereby the long-term health of people with diabetes.

Introduction

Many patients, especially during adolescence, do not fully adhere to the diabetes treatment and, as a result, suffer adverse health consequences [1, 2]. A tight metabolic control is critical, as it has been shown to prevent or at least delay diabetes complications [3]. Adolescents have particular difficulty achieving glucose control, as they usually attain higher average glycohaemoglobin levels than adults, despite similar treatments [4]. This is, in part, due to increasing insulin resistance during puberty [5] and in part due to a lack of adherence to the multifaceted treatment regimen [6]. Although knowledge about the disease and its management is important, it is usually not the most crucial factor in non-adherence as the adolescents are usually well informed about their disease [7, 8]. A number of psychosocial constructs including self-efficacy or perceived competence and perceived treatment effectiveness have been found to be associated with better adherence to treatment [9–11]. We propose that a certain type of beliefs—compensatory beliefs (CBs)—may be another important factor hindering adolescents in adhering to their treatment regimen, especially beliefs about glucose testing.

Compensatory beliefs

CBs are convictions that the negative effects of one behavior can be compensated for by engaging in another behavior [12, 13]. For example, dieters may say to themselves: ‘I can eat this piece of cake now because I will be exercising later.’ According to the CBs model [14], when being faced with a temptation at odds with one’s goals (e.g. stay healthy or lose weight), activating CBs is one

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Compensatory beliefs associated with metabolic control

Glucagon testing adherence and with poorer metabolic control in adolescents above and beyond other constructs known to impact metabolic control and treatment adherence such as diabetes knowledge, perceived treatment effectiveness and perceived competence [15–17].

Methods

Participants

The participants were recruited from the outpatient population of the Diabetes Clinic at the Montreal Children’s Hospital. The measures were administered to 152 adolescents (43.9% male) between 12 and 18 years of age who had been diagnosed with type 1 diabetes for at least 1 year. All the adolescents and their parents who had an appointment at the clinic during the duration of the study were asked to participate, only five refused. Out of the 152 participants who agreed to participate in the study, 28 did not return the questionnaires and 10 had 5% or more of the data missing and therefore were excluded from the analyses. The analyses are thus based on 114 participants (75%). Excluded participants did not differ from included participants in age, gender or disease duration. However, they showed poorer metabolic control with a mean glycosylated hemoglobin (HbA1c) of 9.58% [standard deviation (SD) = 1.53] compared with 8.85% (SD = 1.29) among the included participants ($t$(139) = −2.67, $P = 0.009$). Also, the parental level of education was lower in the non-respondent group, with 21% of the mothers being university graduates in the non-respondent group versus 40% in the respondent group. Similarly, 59.1% of the fathers in the non-respondent group had a high school degree or less compared with 34.6% in the respondent group. The mean age of the sample of participants used in the analyses was 15 years old with an average of 6 years of disease duration. Only 10% of the sample was using the pump. Because their results did not differ from those not using the pump, they were included in the analysis.

Procedure

Potential participants and their families were approached at the Diabetes Clinic at the Montreal Children’s Hospital.
Children’s Hospital when they came for their regular appointments. Assent was obtained from the adolescents and consent from a parent for all participants. The adolescents filled out the research questionnaires while waiting at the clinic while the parents filled out a brief demographics questionnaire. If the participant did not have time to finish, they were given a stamped return envelop and asked to fill it out and send it back as soon as possible. Both parents and adolescents were instructed of the importance of filling out the questionnaires privately. Once the participants finished filling out the questionnaires, they were given a debriefing explaining the concept of CBs as well as a movie pass in appreciation for their time.

Medical records were reviewed in order to access the glycosylated hemoglobin (HbA1c) test results.

Measures

**Glucose testing CBs**

To develop the items, we first drafted a pool of potential items of a wide range of CBs from the treatment guidelines of the Canadian Diabetes Association and in consultation with members of the Diabetes Team of the Montreal Children’s Hospital (doctors, nurses, nutritionists, psychologist, social workers, etc.) concerning the accuracy, wording and completeness of the item pool. The second phase consisted of piloting the item pool with the adolescents (n = 6) from the clinic to obtain their feedback. Finally, the item pool was administered to a sample of adolescents (n = 152, the present sample) to evaluate the scale’s structure through factor analysis. Upon examination of the eigenvalues and the screeplot, we found one factor with an eigenvalue of 6.87, after which subsequent eigenvalues showed a sharp drop (next eigenvalue: 3.90), then leveling off to a plateau for the next factors. We are therefore focusing our analysis on this first factor. All items loading high on this factor are items related to glucose testing CBs. The factor is highly reliable (internal consistency α = 0.81). The six CBs are ‘I do not have to test my glucose regularly if my meals are carefully planned by my parents.’, ‘Being able to feel my glucose level can make up for not testing it regularly.’, ‘It is OK not to test my glucose if I did not eat any sweets beforehand.’, ‘Testing my glucose regularly is not that important if I eat the same things every day.’, ‘Following a meal plan can make up for not testing my glucose regularly’ and ‘It is OK not to test my glucose as long as I do not eat any sweets afterwards’. For each glucose testing CB, participants are being asked how much they agree or disagree with each of six CBs related to glucose testing using a five-point Likert scale ranging from 1 ‘totally disagree’ to 5 ‘totally agree.’

**Diabetes knowledge**

Knowledge was assessed with the Diabetes Knowledge Scale [15], which contains 23 items assessing general diabetes knowledge and insulin-specific knowledge. The alpha coefficients for both subscales have been found to be >0.70 [15]. The scores on the scale increased after receiving diabetes-specific education, supporting the content validity of the measure. Even though the psychometrics of this scale were tested on a sample of adults, each item was found to be at a Grade 6 reading level making it appropriate for use with the adolescents. The internal consistency in our sample was α = 0.74.

**Perceived competence**

A general sense of perceived competence was measured using an abbreviated version (four items) of the Generalized Perceived Competence Scale [17]. It involved judging how capable they felt in dealing with specific situations on a scale going from 1 ‘Strongly disagree’ to 5 ‘Strongly agree’. The alpha in the present sample was 0.61, which is respectable given the small number of items. The scale has been reported to predict adherence to treatment in diabetes [17].

**Illness representation—treatment effectiveness**

Perceived treatment effectiveness was assessed using the treatment effectiveness subscale of the Illness Representations Questionnaire [18]. The subscale is further divided into the treatment effectiveness to control glucose and the treatment effectiveness for prevention of complications subscales. Adolescents had to assess how important each of the treatment recommendations are in controlling...
glucose and preventing complications, from 0 ‘not at all important’ to 4 ‘Extremely important’. These subscales have good internal consistency (treatment effectiveness to control $\alpha = 0.67$; treatment effectiveness to prevent $\alpha = 0.70$ in our sample) and have demonstrated validity in predicting self-care and emotional well-being in adolescents [18].

**Relationship to treatment adherence**

*Physiological marker of treatment adherence*

Glycosylated hemoglobin (HbA$_{1c}$) levels were used as indicators of glycemic control. Blood results at the time of the visit and metabolic stability over time (calculated as the SD of the participant’s five past HbA$_{1c}$ glucose measures in the past year including the one at the time of the visit) were used as outcome variables.

*Self-reported treatment adherence*

Self-care behaviors were assessed using the Summary of Diabetes Self-Care Activities measure [6, 19]. It consists of 11 items that assess areas of diabetes self-management such as diet ($\alpha = 0.88$), exercise ($\alpha = 0.60$) and blood glucose testing ($\alpha = 0.52$). The scale was developed with adults, but has been previously adapted for adolescents with type 1 diabetes [20], which is the version used in the present study.

**Results**

The mean score for glucose testing CBs was 1.41 (SD = 0.62), indicating that overall the adolescents disagreed with the CB statements. However, 57.4% of the sample did not fully disagree with one or more of the glucose testing CB statements, i.e. showed some level of endorsement of the maladaptive CBs. Table I presents the means, SDs and alpha reliabilities for all measures, as well as the bivariate correlations with the mean of the glucose testing CBs. Age, age at diagnosis and disease duration were not related to the glucose testing CB scores. Consistent with the literature, younger age at diagnosis ($r = -0.28$, $P = 0.005$) and longer disease duration ($r = 0.29$, $P = 0.003$) were related to higher HbA$_{1c}$ results and therefore poorer metabolic control.

In accordance with our predictions, higher diabetes knowledge was related to a lower endorsement of glucose testing CBs ($r = -0.26$, $P = 0.006$). The size of the correlations is moderate demonstrating that the glucose testing CB scale measures a construct above and beyond knowledge. Moreover, glucose testing CBs correlated with metabolic control (HbA$_{1c}$ test) even after controlling for knowledge ($r = -0.20$, $P = 0.05$). As expected, higher generalized perceived competence was correlated with a lower endorsement of glucose testing CBs ($r = -0.24$, $P = 0.009$).

**Relation to treatment adherence**

*Self-reported treatment adherence*

Even though the full Summary of Diabetes Self-Care Activities measure was used, we are only reporting the glucose testing frequency results,
which are most relevant to glucose testing CBs. Higher participant endorsement of glucose testing CBs was associated with lower adherence to glucose testing \((r = -0.49, P < 0.001)\).

**Metabolic control**

According to the Canadian Diabetes Association guidelines [21, 22], the recommended HbA1c target for people with diabetes is <7%. On average, metabolic control in our sample was 8.85% (see Table II for descriptive statistics and correlations). As predicted, there was a positive correlation between endorsement of glucose testing CBs and HbA1c test results \((r = 0.20, P = 0.03)\), meaning a higher endorsement of glucose testing CBs was associated with poorer metabolic control. A higher endorsement of glucose testing CBs was also associated with less stable blood glucose over time (as assessed by the SD of five past HbA1c glucose measures) \((r = 0.18, P = 0.05)\).

**Regression analyses: treatment adherence**

Regression analyses were conducted to examine the association between glucose testing CBs and treatment adherence controlling for gender, age and age of diagnosis in all analyses as suggested by Johnson and Meltzer [22]. The criterion variable for the first model was the frequency of testing one’s glucose and for the second model the blood glucose levels at the time of the visit. The results are presented in Table II.

**Table II. Summary of hierarchical regression analyses to predict metabolic control and glucose testing**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>(\beta)</th>
<th>(R^2) change</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion: glucose testing frequency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.04</td>
<td>0.03</td>
<td>(F(3, 101) = 0.906, P = 0.441)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at diagnosis</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td>0.23</td>
<td>(F(5, 96) = 5.86, P = 0.000)</td>
</tr>
<tr>
<td>Diabetes knowledge</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment effectiveness to control glucose</td>
<td>0.30*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment effectiveness to prevent</td>
<td>-0.29*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived competence</td>
<td>0.26**</td>
<td>0.10</td>
<td>(F(1, 95) = 15.14, P = 0.000)</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
<td>0.40**</td>
<td></td>
</tr>
<tr>
<td>Glucose testing CBs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Criterion: metabolic control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.04</td>
<td>0.08</td>
<td>(F(3, 93) = 2.78, P = 0.046)</td>
</tr>
<tr>
<td>Age</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at diagnosis</td>
<td>-0.33**</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td>0.19</td>
<td>(F(5, 88) = 4.57, P = 0.001)</td>
</tr>
<tr>
<td>Diabetes knowledge</td>
<td>-0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment effectiveness to control glucose</td>
<td>-0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment effectiveness to prevent</td>
<td>0.30*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived competence</td>
<td>-0.13</td>
<td>0.03</td>
<td>(F(1, 87) = 4.05, P = 0.047)</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
<td>0.23**</td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the 0.05 level; **Significant at the 0.01 level.
Regression model for testing glucose level

Demographic variables were entered in the first step, followed by all psychological measures significantly associated with the glucose testing CBs (diabetes knowledge, treatment effectiveness to control glucose, treatment effectiveness to prevent complications and perceived competence) and finally glucose testing CBs. For regularly testing one’s glucose level, significant variables in this model included general perceived competence, treatment effectiveness to prevent complications and glucose testing CBs. Glucose testing CBs shared a significant proportion of variance with testing one’s glucose above and beyond all other variables in the model, which is a strong and interesting finding.

Regression model for metabolic control

Demographic variables were entered in the first step, followed by all psychological measures significantly associated with the glucose testing CBs (diabetes knowledge, treatment effectiveness to control glucose, treatment effectiveness to prevent complications and perceived competence) and finally glucose testing CBs. The results of the first regression model showed that glucose testing CBs shared a significant proportion of variance with metabolic control above and beyond all other variables in the model. The only other variable that did share a significant proportion of variance for metabolic control was age at diagnosis.

In sum, the regression analyses showed that holding glucose-related CBs are associated with poorer metabolic control and poorer diabetes self-care activity as indicated by testing one’s glucose level above and beyond other variables that in the past have been shown to be related to metabolic control and treatment adherence.

Discussion

The goal of this research was to assess whether holding glucose testing CBs was associated with treatment adherence as indicated by metabolic control and blood glucose testing in adolescents with type 1 diabetes. As expected, a higher endorsement of glucose testing CBs was related to lower adherence to treatment, both in terms of blood glucose control and blood glucose testing above and beyond diabetes knowledge and other socio and cognitive constructs that in prior research have been shown to be predictors of metabolic control and treatment adherence. Most importantly, our correlative findings show that believing one can compensate for not testing glucose levels was associated with less regularly checking one’s glucose levels and with poorer metabolic control.

This finding warrants longitudinal research to establish the direction of the relationship, i.e. whether indeed—as we would propose—holding CBs plays a causal role in lowering treatment adherence. If this would indeed be shown in a longitudinal design, it would appear pertinent to assess and address glucose testing CBs in diabetes education. To do so, the six-item glucose testing CBs scale could be used in clinical settings by members of diabetes teams. The scores on the scale could help guide treatment plans in therapy by psychologists, nutritionists, social workers, nurses or physicians. In other words, the scores, if high, could suggest targeting glucose testing CBs in diabetes education. For example, specifically targeting these incorrect glucose testing CBs through cognitive restructuring could be very helpful.

A limitation of this study and this type of research in general [23] is the fact that non-responders had a significantly worse metabolic control than responders. The sample may therefore be skewed in favor of adolescents who manage their diabetes better and use less CBs. Possible explanations are that both adherence to treatment and successful participation in the study require similar organizational skills [24]. Another possibility is that adolescents who have difficulties controlling their glucose might feel less inclined to confront themselves with questions regarding their diabetes self-management [24].
Including CBs related to glucose testing in diabetes education could improve the adherence to treatment and thereby the long-term health of people with diabetes.

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Conflict of interest statement

None declared.

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