Journal of Pediatric Psychology, 2023, **00**, 1–9
https://doi.org/10.1093/jpepsy/jsad057
Original Research Article

OXFORD

SAI-CH-6: Development of a Short Form of the State Anxiety Inventory for Children At-Risk for Type 1 Diabetes

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Abstract

Objective: To develop a reliable and valid short form of the State Anxiety Subscale of the State-Trait Anxiety Inventory for Children (STAI-CH) in the Environmental Determinants of Diabetes in the Young (TEDDY) study.

Methods: A Development Sample of 842 10-year-old TEDDY children completed the STAI-CH State Subscale about their type 1 diabetes (T1D) risk. The best 6 items (three anxiety-present and three anxiety-absent) for use in a short form (SAI-CH-6) were identified via item-total correlations. SAI-CH-6 reliability was examined in a Validation Sample ($n = 257$) of children who completed the full 20-item STAI-CH State Subscale and then again in an Application Sample ($n = 2,710$) who completed only the SAI-CH-6. Expected associations between the children's SAI-CH-6 scores and country of residence, sex, T1D family history, accuracy of T1D risk perception, worry about getting T1D, and their parents' anxiety scores were examined.

Results: The SAI-CH-6 was reliable ($\alpha = 0.81–0.87$) and highly correlated with the full 20-item STAI-CH State Subscale (Development Sample: $r = 0.94$; Validation Sample: $r = 0.92$). SAI-CH-6 scores detected significant differences in state anxiety symptoms associated with T1D risk by country, T1D family history, accuracy of T1D risk perception, and worry about getting T1D and were correlated with the child's parent's anxiety.

Conclusion: The SAI-CH-6 appears useful for assessing children's state anxiety symptoms when burden and time limitations prohibit the use of the STAI-CH. The utility of the SAI-CH-6 in older children with and without chronic conditions needs to be assessed.

Keywords: children; genetic risk; state anxiety; type 1 diabetes.

Introduction

Anxiety is commonly experienced by adults and children and is generally conceptualized as being either trait-like (i.e., a stable state of arousal and worry that is characteristic of one's personality) or state-dependent (i.e., a temporary and immediate response to a perceived threat that goes away when the threat is removed). Trait anxiety is common in children who have chronic health conditions (Pao & Bosk, 2011) and appears to be associated with parent anxiety (Lawrence et al., 2019). Girls often score higher on measures of trait anxiety than boys (McLaughlin & King, 2015; Olatunji & Cole, 2009; Van Oort et al., 2009), although sex differences may not be found with state anxiety (Spielberger et al., 1973).

The State-Trait Anxiety Inventory for Adults™ (STAI-AD) is one of the most commonly used questionnaires to assess symptoms of state and trait anxiety (Spielberger et al., 1973). The STAI-AD consists of 40 items (20 items assess state anxiety and 20 items assess trait anxiety). Since the STAI-AD is rather long and time-consuming to complete, shortened versions have been developed to reduce the burden (Chell et al., 2016; Chlan et al., 2003; Marteau & Bekker, 1992; Tluczek et al., 2009).

A child version of the State-Trait Anxiety Inventory™ (STAI-CH) also comprises 20 items assessing state anxiety and 20 items assessing trait anxiety (Spielberger et al., 1973). Each item on the STAI-CH State Anxiety Subscale consists of the stem "I feel" followed by one of three options describing a target emotion (e.g., I feel: very calm, calm, or not calm). As is the case with the STAI-AD, both anxiety-absent (e.g., calm) and anxiety-present (e.g., nervous) terms are used. The STAI-CH is one of the most commonly used questionnaires to assess anxiety in pediatric populations (Lazor et al., 2017; Topcu et al., 2016) including children with chronic conditions such as type 1 diabetes (T1D; Duru et al., 2016; Hilliard et al., 2011; Rechenberg et al., 2018).

There have been few attempts to develop a shortened version of the STAI-CH. Apell et al. (2011) used a 6-item version of the STAI-AD without consideration of whether those 6 items were appropriate for children (e.g., children's understanding of the items, reliability, and validity of the items in a child sample). Their sample size was very small ($N = 16$) and 44% of children needed help from their parents to complete it. Nilsson et al. (2012) conducted a pilot study using the

Received: April 28, 2023. **Revised:** August 12, 2023. **Accepted:** August 16, 2023
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Talking Mats method, which comprises a pictorial framework based on three sets of picture symbols (i.e., topic, scale, options) to create a short version of the STAI-CH. Although this pilot study demonstrated promising results, the sample size was also small ($N = 42$) and limited to children who spoke Swedish (Nilsson et al., 2012). Li and Lopez (2007) subjected a Chinese version of the STAI-CH to exploratory factor analysis to identify the best 10 items for use in a short form (Li & Lopez, 2007). The 10-item version exhibited good reliability and a strong correlation between the 10-item total score and the full 20-item STAI-CH State Anxiety Subscale score in their sample of 112 children. This short form was used in a subsequent study to explore post-operative anxiety in Chinese children (Chieng et al., 2013).

T1D is one of the most common chronic diseases of childhood (Camp-Spivey et al., 2022) and is increasing worldwide (Maahs et al., 2010). T1D destroys the insulin-producing pancreatic beta cells, resulting in exogenous insulin replacement by injection or an insulin pump for survival. Both genetic factors associated with T1D and the onset of the autoimmune process can now be detected before T1D onset (Roizen et al., 2015; Zajec et al., 2022). However, since there is no means to prevent T1D, efforts to identify individuals at genetic risk for T1D are controversial (Johnson, 2011).

Numerous studies have assessed participant anxiety associated with T1D-related genetic or autoantibody testing (Johnson, 2011; Johnson et al., 2017; Roth et al., 2015). However, these studies have focused almost exclusively on parents of children at increased risk for T1D. Hood et al. (2006) used psychometric analyses to reduce the 20-item STAI-AD State Anxiety Subscale to 6 items (SAI-AD-6; three anxiety-present and three anxiety-absent) for use with parents of children at risk for developing T1D. The SAI-AD-6 has proved useful in numerous studies of parent anxiety associated with a child's T1D risk (Baxter et al., 2012; Johnson et al., 2011; Johnson et al., 2017; Melin et al., 2022; Roth et al., 2015; Smith et al., 2014; Smith et al., 2021). These studies replicated the SAI-AD-6's reliability and reported a number of important findings related to parent anxiety about a child's T1D risk: mothers exhibit higher scores on the SAI-AD-6 than fathers; parents from the United States report higher scores than mothers from Sweden or Finland; parents of children who have a first-degree relative with T1D report higher scores than parents from the general population with no T1D history; parents of children who are autoantibody positive report more anxiety than parents of children at increased genetic risk for T1D but who have not developed autoantibodies; and parents with accurate perceptions of their child's T1D risk report more anxiety than parents who underestimate their child's risk. Hood and colleagues (2006) also successfully estimated the 20-item SAI-AD from the SAI-AD-6 for TEDDY parents with children at increased risk for T1D, permitting their results to be placed in the context of the larger literature using the full 20-item SAI-AD.

Missing from this literature is an assessment of the child's own anxiety about their T1D risk. Two early studies used the STAI-CH with children who had tested positive for T1D-related autoantibodies (Johnson et al., 1990; Johnson & Tercyak, 1995) but their sample sizes were very small. The Environmental Determinants of Diabetes in the Young (TEDDY) study seeks to identify environmental triggers of T1D in children at increased genetic risk for T1D. TEDDY provides a unique opportunity to assess the child's anxiety about their own T1D risk in a large international sample of at-risk children. The SAI-AD-6 has been used to monitor parent anxiety about the child's T1D risk throughout the TEDDY study. However, no short form of the State Anxiety Subscale of the STAI-CH has been developed. Consequently, the purpose of the current study was to develop a shortened version of the State Anxiety Subscale from the STAI-CH using standard psychometric methodology for use in TEDDY. Similar to Hood and colleagues (2006), our approach was to identify the three best anxiety-present and the three best anxiety-absent items from the STAI-CH State Anxiety Subscale for use in a 6-item short form, to assess the short-form's reliability in comparison to the full 20-item State Anxiety Subscale's reliability, and to estimate the 20-item State Anxiety Subscale score from 6-item short form. We developed validity tests based on prior findings with TEDDY parents which included the following hypotheses: (1) girls will report more anxiety about their own T1D risk than boys (in TEDDY, mothers report more anxiety about their child's T1D risk than fathers); (2) children from the United States will report more anxiety about their T1D risk than those from Finland and Sweden where T1D is more common (these country differences were found among TEDDY parents); (3) children with a parent or sibling with T1D will report more anxiety than those with no family history of T1D (TEDDY parents with T1D in the family report more anxiety about their child's T1D risk than parents with no family history of T1D); (4) children with accurate perceptions of their own T1D risk will report more anxiety than those underestimating their risk (TEDDY parents with accurate perceptions of the child's T1D risk report more anxiety than those who underestimate the child's risk); (5) children who report worrying about getting T1D will have higher state anxiety scores than those who say they do not worry at all; and (6) children's state anxiety scores will correlate with their parents' SAI-AD-6 scores.

Methods

The TEDDY Study

The TEDDY study seeks to identify environmental triggers of T1D autoimmunity or onset in genetically at-risk children. Between 2004 and 2010, more than 8,600 families with infants at high genetic risk for T1D were recruited from study centers in the United States, Finland, Germany, and Sweden; all children joined TEDDY before 4.5 months of age. Study visits occurred every 3 months during the first 4 years of the child's life, and every 6 months thereafter for those children who had not developed islet autoantibodies until the child reached 15 years of age or developed T1D. Every 3-month study visits were maintained for those children who develop islet autoantibodies. A variety of data are collected at study visits, including biological samples (e.g., blood, saliva); records of the child's diet, illnesses, and life stressors; and questionnaires assessing parent and child psychosocial functioning. All blood samples are analyzed for the islet autoantibodies associated with the development of T1D. Comprehensive details about the TEDDY protocol are described elsewhere (The Teddy Study Group, 2007).

TEDDY was funded by the National Institutes of Health and ethics review boards in all four countries approved the study. Written informed consent was obtained from all

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parents of the participating children. Child assent was obtained when the child reached 10 years of age.

T1D Risk Communication in TEDDY

TEDDY parents were informed of their child's increased genetic risk for T1D at the time of study enrollment. Efforts to communicate the child's T1D risk to the parent(s) were extensive and were repeated throughout the study (Johnson et al., 2017; Swartling et al., 2016). Any increase in T1D risk associated with a child's positive islet autoantibody test result was also communicated to the parent(s). When children turned 2 years of age, parents received a book with pictures explaining TEDDY with the intention that its use by parents would prepare their children for study visits and blood draws. When children were 5–7 years of age, a second book that further explained the purpose and procedures of TEDDY was provided to the families.

Prior to the 10-year visit, a third book containing more detailed information about the purpose of TEDDY, genetic risk, islet autoantibodies, and T1D was given to TEDDY families. At the 10-year TEDDY study visit, children completed several questionnaires to assess their understanding of their risk for developing T1D and anxiety about their T1D risk.

Study Samples

Development Sample

The Development Sample consisted of 842 10-year-old TEDDY children who completed the 20-item STAI-CH State Anxiety Subscale between December 2014 and September 2016. This sample was used to identify the best items for use in a 6-item short form using standard psychometric methodology.

Validation Sample

An additional 257 10-year-old TEDDY children completed the 20-item STAI-CH State Anxiety Subscale between October 2016 and January 2017 and were not used to select items for a 6-item short form. Consequently, children's data were used to validate the results derived from the Development Sample.

Application Sample

The Application Sample consisted of 2,710 10-year-old TEDDY children who were given only the SAI-CH-6 between February 2017 and November 2020. Children's data were used to examine the consistency of reliability and validation tests conducted with the Development and Validation Samples.

Measures

Sociodemographic Characteristics

Country of residence; child sex; whether the child has a mother, father, or sibling with T1D; mother's age at the child's birth; and child's ethnic minority status were collected at the beginning of the study. Ethnic minority status in the United States was defined as yes if the mother was not born in the United States, the mother's first language was not English, or the child was a member of an ethnic minority group (e.g., African American, Hispanic). For the European countries, ethnic minority status was defined as yes if the mother's country of birth or the mother's first language was other than that of the TEDDY country in which the child resides. The parents' marital status (parents married or living with someone; yes/no) and parents' education level (three groups: primary education, some trade school, and college/university or higher) were collected at the child age 9-month visit.

Child Anxiety About T1D Risk

The 20-item STAI-CH State Anxiety Subscale was used to assess the child's anxiety about his or her own risk for T1D in both the Developmental and Validation Samples at the child's 10-year-old study visit. The STAI-CH is available in all TEDDY languages (English, Spanish, Finnish, German, Swedish) and did not need to be translated. The child read the following stem and responded accordingly: "When you think about your risk of getting diabetes, how do you feel?" Children were encouraged to skip items they did not understand. The 10 anxiety-absent items are reversed scored so that a higher total score indicates higher state anxiety. The SAI-CH-6 (three anxiety-present items and three anxiety-absent items) derived from the Development Sample used the same stem: "When you think about your risk of getting diabetes, how do you feel?"

Child's Worry About Developing T1D

At the child age 10-year study visit, all children completed a questionnaire that included the following item: "Do you worry about getting diabetes? (Pick one answer) I never worry; I worry sometimes; I worry a lot."

Child's Risk Perception Accuracy

At the child age 10-year study visit, all children answered the following item: "Risk is the chance that something may or may not happen. What do you think about your risk of getting diabetes? (Pick one answer) I think I have: a smaller risk of getting diabetes than my friends who are not in TEDDY; the same risk of getting diabetes as my friends who are not in TEDDY; a higher risk of getting diabetes than my friends who are not in TEDDY; I am not sure about my risk of getting diabetes." Children who chose the higher-risk option were considered to have an accurate perception of their T1D risk.

Parent Anxiety About Child's T1D Risk

The SAI-AD-6 (Hood et al., 2006) was used to assess the parent's anxiety about their child developing T1D. Similar to the STAI-CH, the STAI-AD is available in all TEDDY languages (English, Spanish, Finnish, German, and Swedish) and did not need to be translated. Parents read the following stem: "When you think about your child's risk for developing diabetes, you feel:" followed by three anxiety-present items and three anxiety-absent items. Anxiety-absent items were reverse scored so that higher scores indicate higher state anxiety. Parent anxiety was measured annually; parent data collected closest to the child age 10-year study visit were used in the current analyses.

Data Analytic Plan

Independent sample *t*-test and analysis of variance (for interval data) and chi-square (for categorical data) were used to test for possible differences within and between the three study samples (i.e., Development, Application, and Validation). Standardized effect size to describe the differences in scores between groups within samples were measured as Cohen's *d* (2 groups) and Cohen's *f* (>2 groups) with effect

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size <0.20 interpreted as negligible, 0.2–0.5 as small, 0.5–0.8 as medium, and >0.8 as large.

The Development Sample was used to identify the best six items, three anxiety-absent and three anxiety-present, for use in the SAI-CH-6. First, the Development Sample was restricted to those children who completed ≥10 items of the 20-item STAI-CH State Anxiety Subscale. Next, items skipped by ≥20% of children in any country were dropped from further consideration. Item-total scale score correlations were then calculated for the remaining items. The three anxiety-absent and the three anxiety-present items with the highest item-total correlation were selected for inclusion in the SAI-CH-6. Coefficient α was used to assess the reliability of the SAI-CH-6 in comparison to the 20-item STAI-CH State Anxiety Subscale score.

To make SAI-CH-6 scores comparable to the STAI-CH State Anxiety Subscale scores, a linear regression model was used to estimate the 20-item STAI-CH State Anxiety Subscale score from the SAI-CH-6 score. This permitted SAI-CH-6 scores to be compared to the larger literature which typically uses the 20-item STAI-CH State Anxiety Subscale score. Comparisons were made using both the 20-item STAI-CH State Anxiety Subscale score and the SAI-CH-6 score on a variety of factors that might be expected to differ on this measure of anxiety: country, child sex, whether the child had a T1D first-degree relative, how worried the child was about getting diabetes, and the child's accuracy about their risk for T1D.

Correlations between the child's SAI-CH-6 score and their parents' STAI-AD-6 scores were conducted. Next, the Validation Sample was used to examine whether the findings derived in the Development Sample could be replicated in this separate independent sample. Finally, the Application Sample was used as a further test of whether the SAI-CH-6 findings from the Development and Validation Samples could be replicated.

Results

Descriptive Statistics

Table I provides the sociodemographic characteristics of the three study samples. The samples differed only by country (χ^2 (6, $N = 3,809$) = 87.52, $p < .0001$) and whether the child had a first-degree relative with T1D (χ^2 (2, $N = 3,809$) = 8.35, $p < .02$). Sweden was under-represented in the Development Sample because there was a delay in institutional ethics board approval of the child questionnaires to be given at 10 years of age. Children with a first-degree relative with T1D were slightly more common in the Validation Sample.

Development Sample

A total of 64 children (7.6%) were removed from the Development Sample because they did not complete ≥10 STAI-CH State Anxiety Subscale items. A total of five STAI-CH items (three anxiety-absent and two anxiety-present) were dropped because ≥20% of the children skipped that item; this frequency of skipped items occurred only in Sweden. The item-total score correlations were then examined for the remaining 15 items. The three anxiety-present and the three anxiety-absent items with the highest item-total correlations were selected; these data are presented in Table II for the total sample and by country. For the total sample, all item-total correlations were ≥0.71 and no country had an item-total correlation <0.61.

Coefficient α was then calculated for those children who completed ≥50% of the items on both the SAI-CH-6 and the STAI-CH State Anxiety Subscale ($N = 782$; missing items were replaced by the mean of the non-missing items), yielding an $\alpha = 0.87$ for the SAI-CH-6 and an $\alpha = 0.94$ for the STAI-CH State Anxiety Subscale. The SAI-CH-6 total score correlated 0.94 with the STAI-CH State Anxiety Subscale score, with correlations ≥0.92 in all countries.

Table I. Characteristics of TEDDY Participants (N = 3,809)

Variable	Development sample, total $N = 842$	Validation sample, $N = 257$	Application sample, $N = 2,710$
Time Frame Questionnaires completed	12/14–9/16	10/16–1/17	2/17–11/20
Country,* *n* (%)			
United States	325 (38.6)	84 (32.7)	1214 (44.8)
Finland	300 (35.6)	72 (28.0)	588 (21.7)
Germany	46 (5.5)	21 (8.2)	126 (4.7)
Sweden	171 (20.3)	80 (31.1)	782 (28.9)
Child sex: female, *n* (%)	445 (52.9)	125 (48.6)	1318 (48.6)
Child's ethnic minority: yes, *n* (%)	102 (12.5)	30 (12.2)	379 (14.5)
Child has a first-degree relative with T1D:* yes, *n* (%)	102 (12.1)	44 (17.1)	301 (11.1)
Parents marital status, *n* (%)			
Married or living together	696 (82.9)	221 (86.3)	2311 (85.7)
Not married or not living together	144 (17.1)	35 (13.7)	387 (14.3)
Mother's education, *n* (%)			
Basic primary	93 (11.1)	29 (11.3)	335 (12.4)
Trade school or some college	196 (23.3)	58 (22.6)	600 (22.2)
Bachelor's degree or higher	551 (65.6)	170 (66.2)	1767 (65.4)
Father's education, *n* (%)			
Basic primary	154 (18.3)	47 (18.3)	540 (20.0)
Trade school or some college	216 (25.7)	59 (23.0)	647 (24.0)
Bachelor's degree or higher	470 (56.0)	151 (58.8)	1515 (56.1)

Note. T1D = type 1 diabetes.
* Samples significantly different based on chi-square difference tests, $p < .05$.

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In an effort to make SAI-CH-6 scores comparable to STAI-CH State Anxiety Subscale scores, a linear regression model was used to estimate the 20-item STAI-CH State Anxiety Subscale score from the SAI-CH-6 score, yielding the following equation: STAI-CH State Anxiety Subscale score-$= 6.472 + 2.636$ (SAI-CH-6) with $R = 0.94$ and $R^2 = 0.89$. Table III provides the estimated means, standard deviations, and ranges calculated from the SAI-CH-6 using this equation with the actual means, standard deviations, and ranges derived from the 20-item STAI-CH State Anxiety Subscale score. The differences between the estimated and actual means are small and not biased in a particular direction. The standard deviations of the estimated scores are somewhat smaller and the ranges are somewhat truncated compared to those derived from the actual STAI-CH State Anxiety Subscale scores.

Next, comparisons were made using both the 20-item STAI-CH State Anxiety Subscale score and the estimated SAI-CH-6 State Anxiety Subscale score on a variety of characteristics that might be expected to differ: country, child sex, whether the child had a first-degree relative with T1D, how worried the child was about getting T1D, and the child's accuracy about their T1D risk; mean scores, p values, and effect sizes are provided in Table IV. Girls had slightly higher anxiety scores than boys, but not significantly so ($t(1, 780) = -1.83$; $p = .07$), children from the United States had higher scores than those from Europe ($F(3, 778) = 7.12$; $p < .001$), children with a first-degree relative with T1D had higher scores than those without a T1D first-degree relative ($t(1, 780) = -3.03$; $p = .003$), and those who said they worried about getting T1D had higher scores than those who said they did not worry at all ($t(1, 770) = -14.84$; $p < .0001$). However, those who were accurate about their T1D risk did not have significantly higher anxiety scores on the STAI-CH State Anxiety Subscale than those who were not accurate or who were unsure about their risk ($F(2, 768) = 1.31$; $p = .27$). These findings were replicated using state anxiety scores estimated from the SAI-CH-6.

The correlations between the children's scores on the STAI-CH State Anxiety Subscale and mothers' and fathers' STAI-AD-6 scores in the Development Sample were 0.16 and 0.14 (ps $< .001$), respectively. Similarly, the correlations between the children's SAI-CH-6 scores and mothers' and fathers' STAI-AD-6 scores were 0.13 ($p < .001$) and 0.12 ($p < .002$), respectively.

Table II. The Three Anxiety-Present and the Three Anxiety-Absent Items With the Highest Item-Total Correlations From the State Anxiety Subscale of the STAI-CH[a]

Item	Overall	United States	Finland	Germany	Sweden
Anxiety-present item 9	0.73	0.77	0.72	0.65	0.64
Anxiety-present item 11	0.70	0.74	0.71	0.61	0.61
Anxiety-present item 15	0.73	0.73	0.76	0.69	0.71
Anxiety-absent item 14	0.75	0.76	0.77	0.78	0.71
Anxiety-absent item 17	0.75	0.76	0.83	0.62	0.63
Anxiety-absent item 12	0.71	0.70	0.76	0.72	0.68

Note. Mind Garden, Inc. granted permission for us to share the actual item numbers from the STAI.

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Validation Sample

There were 241 children in the Validation Sample with ≥3 items on the SAI-CH-6, yielding a coefficient α of 0.84 (Table V), slightly lower than that of the Development Sample (0.87). Using the regression equation developed from the Development Sample (i.e., STAI-CH State Anxiety Subscale score $= 6.472 + 2.636$ [SAI-CH-6]), each child's STAI-CH State Anxiety Subscale score was estimated from that child's SAI-CH-6 score in the subsample of 203 children who had ≥3 items on the SAI-CH-6 and ≥10 items on the STAI-CH State Anxiety Subscale (missing items were replaced by the mean of the non-missing items). The State Anxiety Subscale score estimated from the SAI-CH-6 correlated highly with the actual STAI-CH State Anxiety Subscale score, $r = 0.92$, with correlations ≥0.88 by country. Table III provides estimated and actual means, standard deviations, and ranges for the Validation Sample. Similar to the Development Sample, the differences between the estimated and actual means are small, with standard deviations of the estimated scores somewhat smaller and the ranges of the scores somewhat truncated compared to those derived from the actual STAI-CH State Anxiety Subscale scores.

Table III. Country Comparison of Estimated Means, Standard Deviations, and Ranges Derived From the SAI-CH-6 With the Actual Means, Standard Deviations, and Ranges for the 20-Item STAI-CH[a] State Anxiety Subscale for the Development and Validation Samples

	Development sample ($N = 782$)				Validation sample ($N = 203$)			
	Mean (*SD*)		Range of scores[b]		Mean (*SD*)		Range of scores[b]	
Country	Estimated from SAI-CH-6	STAI-CH State Anxiety Subscale[c]	Estimated from SAI-CH-6	STAI-CH State Anxiety Subscale[c]	Estimated from SAI-CH-6	STAI-CH State Anxiety Subscale[c]	Estimated from SAI-CH-6	STAI-CH State Anxiety Subscale[c]
Overall	32.35 (7.74)	32.35 (8.23)	31.63	40.00	32.08 (7.21)	32.48 (7.84)	31.63	37.00
United States	33.54 (8.09)	33.90 (8.82)	31.63	40.00	33.38 (7.48)	34.22 (8.47)	31.63	37.00
Finland	31.29 (7.53)	30.83 (8.00)	31.63	40.00	31.49 (7.64)	31.51 (8.32)	26.36	30.00
Germany	33.06 (8.13)	32.59 (8.06)	26.36	28.00	31.28 (6.53)	31.94 (7.24)	21.09	26.00
Sweden	31.57 (6.98)	31.76 (6.88)	26.36	31.00	31.43 (6.72)	31.62 (6.70)	26.36	29.00

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[b] Calculated as range = highest score − lowest score.

[c] Estimated STAI-CH State Anxiety Subscale score $= 6.472 + 2.636$ (SAI-CH-6).

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Table IV. Mean Difference Tests for TEDDY Variables on the STAI-CH[a] State Anxiety Subscale and the SAI-CH-6 for the Development, Validation, and Application Samples

Variable	Development sample, $N = 782$				Validation sample, $N = 203$				Application sample, $N = 2{,}614$	
	STAI-CH State Anxiety Subscale mean	*p* value Effect size	Estimated mean from SAI-CH-6[b]	*p* value Effect size	STAI-CH State Anxiety Subscale mean	*p* value Effect size	Estimated mean from SAI-CH-6[b]	*p* value Effect size	Estimated mean from SAI-CH-6[c]	*p* value Effect size
Country										
United States	33.90	<.0001 0.15	33.54	.002 0.12	34.22	.17 0.10	33.38	.35 0.04	35.37	<.0001 0.23
Finland	30.83		31.29		31.51		31.49		31.20	
Germany	32.59		33.06		31.94		31.28		34.66	
Sweden	31.76		31.57		31.62		31.43		33.00	
Sex										
Male	31.78	.07 0.13	31.80	.06 0.14	32.20	.61 0.07	31.82	.60 0.07	33.69	.56 0.02
Female	32.86		32.84		32.77		33.35		33.86	
First-degree relative with T1D										
Yes	34.74	.003 0.33	34.82	.0009 0.37	34.29	.13 0.28	32.68	.59 0.10	34.70	.02 0.14
No	32.02		32.01		32.10		31.95		33.66	
Risk perception accuracy										
Yes	32.77	.27 0.03	32.63	.13 0.05	33.10	.13 0.11	33.48	.06 0.14	34.60	.000 0.07
No	31.66		31.55		30.79		30.52		33.17	
Not sure	32.60		32.80		33.19		32.03		33.63	
Worry about getting T1D										
Yes	36.45	<.0001 1.07	35.86	<.0001 0.94	35.88	<.0001 0.79	34.84	<.0001 0.68	37.11	<.0001 0.97
No	28.68		29.22		30.08		30.13		30.81	

[a] Copyright © 1970 by Charles D. Spielberger. State-Trait Anxiety Inventory for Children™ requires license purchase and is a trademark of Mind Garden, Inc.
[b] Estimated STAI-CH State Anxiety Subscale score = 6.472 + 2.636 (SAI-CH-6) calculated using Development Sample.
[c] Estimated STAI-CH State Anxiety Subscale score = 6.556 + 2.636 (SAI-CH-6) calculated using combined Development and Validation Samples.

Table V. Coefficient Alphas for the SAI-CH-6

Country	Development sample, $N = 790$	Validation sample, $N = 241$	Application sample, $N = 2{,}614$
Overall	0.87	0.84	0.81
United States	0.88	0.84	0.83
Finland	0.89	0.87	0.80
Germany	0.84	0.80	0.76
Sweden	0.83	0.82	0.79

Comparisons were again made using both the 20-item State Anxiety Subscale score from the STAI-CH and the estimated STAI-CH State Anxiety Subscale score from the SAI-CH-6 on the country, child sex, whether the child had a T1D first-degree relative, how worried the child was about getting T1D, and the child's accuracy about their T1D risk (Table IV). The power to detect differences was reduced given the smaller sample size. Using the 20-item STAI-CH State Anxiety Subscale score as the outcome variable, there were no significant differences in anxiety scores based on country ($F(3, 199) = 1.68$; $p = .17$), child sex ($t(1, 201) = -0.51$; $p = .61$), accuracy about T1D risk ($F(2, 192) = 2.10$; $p = .13$), or whether or not the child had a first-degree relative with T1D ($t(1, 201) = -1.50$; $p = .13$) for the Validation Sample, although the pattern of results mimicked that found with the Developmental Sample. Similar to the children in the Development Sample those who said they worried about getting T1D had higher STAI-CH scores than those who said they did not worry at all ($t(1, 200) = -5.54$; $p < .0001$). Most importantly, these results were replicated using State Anxiety Subscale scores estimated from the SAI-CH-6.

The correlations between the children's scores on the State Anxiety Subscale of the STAI-CH and their mothers' and fathers' SAI-AD-6 scores were 0.13 and 0.14 (ps = .06), respectively. The correlations between the children's SAI-CH-6 scores and their mothers' and fathers' SAI-AD-6 scores were 0.21 ($p = .09$) and 0.14 ($p = .06$), respectively.

Application Sample

There were 2,614 children in the Application Sample with ≥3 items on the SAI-CH-6, yielding a coefficient α of 0.80 (Table V), slightly lower than that of the Development (0.87) and Validation (0.83) Samples. Since both the Development and Application Samples completed the STAI-CH State Anxiety Subscale, we combined the samples to take advantage of the larger sample size in an effort to calculate the most robust regression equation estimating the 20-item STAI-CH State Anxiety Subscale score from the SAI-CH-6 score. The combined Development and Validation Samples consisted of 985 children who had ≥3 items on the SAI-CH-6 and ≥10 items on the STAI-CH State Anxiety Subscale (missing items were replaced by the mean of the non-missing items), yielding

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the following equation: Estimated STAI-CH State Anxiety Subscale score = 6.556 + 2.636 (SAI-CH-6). This equation was used to estimate the STAI-CH State Anxiety Subscale score from the SAI-CH-6 score in the Application Sample. Table IV provides the estimated means and standard deviations for the Application Sample.

Comparisons were again made using the estimated STAI-CH State Anxiety Subscale scores derived from the SAI-CH-6 score on: country, child sex, whether the child had a first-degree relative with T1D, how worried the child was about getting T1D, and the child's accuracy about their T1D risk (Table IV). There were no significant differences in SAI-CH-6 scores between girls and boys ($t(1, 2{,}612) = -0.58$; $p = .56$). There were significant differences by country, whether or not the child had a first-degree relative with T1D, risk perception accuracy, and worry about getting T1D: children from the United States had higher scores than children from Finland or Sweden ($F(3, 2{,}610) = 48.87$, $p < .0001$) and children who had a first-degree relative with T1D had higher scores than those without a T1D first-degree relative ($t(1, 2{,}612) = -2.33$, $p < .02$). Children who were accurate about their T1D risk had higher anxiety scores than those who were not accurate ($F(2, 2{,}587) = 8.14$; $p < .001$), and those who said they worried about getting T1D had higher SAI-CH-6 scores than those who said they did not worry at all ($t(1, 2{,}586) = -24.65$; $p < .0001$).

The correlations between the children's scores on the SAI-CH-6 and mothers' and fathers' SAI-AD-6 scores in the Application Sample were 0.12 and 0.10 ($ps < .0001$), respectively.

Discussion

Based on our prior success of developing a 6-item short form of the STAI-AD State Anxiety Subscale for use with parents in large-scale studies of children at risk for T1D, we sought to develop a similar, 6-item short form of the STAI-CH State Anxiety Subscale for use with children at risk for T1D who are participating in large scale, longitudinal or epidemiological studies like TEDDY. The SAI-CH-6 proved to be highly reliable in this large international sample of 10-year-old children from the TEDDY study and correlated strongly with the 20-item STAI-CH State Anxiety Subscale.

Most of our validity tests using the SAI-CH-6 were also supported and mimicked the findings obtained when the 20-item STAI-CH State Anxiety Subscale was used. Children from the United States had higher anxiety scores on the SAI-CH-6 than European children, children with a first-degree T1D relative had higher anxiety scores than children without a family history of T1D, children who were accurate about their T1D risk had higher anxiety scores than those with inaccurate risk perceptions, and children who reported that they worried about developing T1D had higher scores than children who indicated they did not worry at all. For the validity tests, the effect sizes were generally small. The exception was the very large effect size associated with the SAI-CH-6 scores and the measure of worry about getting T1D, which assesses the same construct.

We did not find that 10-year-old girls had higher anxiety scores than same-aged boys about their own T1D risk, despite the fact that mothers of at-risk children consistently report greater anxiety about a child's T1D risk than fathers (Johnson, 2011; Johnson et al., 2017). One potential explanation for this lack of sex difference is the extensive support provided to TEDDY participants across 10 years of TEDDY study visits. This regular interaction with TEDDY staff may have mitigated any sex differences. It is also possible, that sex differences are less common when the focus is on this specific threat: the risk of getting T1D. Consistent with this interpretation, the manual for the STAI-CH only reports sex differences for trait anxiety, but not state anxiety (Spielberger et al., 1973).

As predicted, we found significant correlations between the SAI-CH-6 and the child's parents' SAI-AD-6, although the correlations were low. We suspect that parents may have attempted to contain their anxiety about their child's T1D risk in an effort to minimize the child's own anxiety about developing T1D. In addition, the amount of support and education provided by TEDDY may have mitigated the impact of parent anxiety on child anxiety. In contrast, parents may be more willing to express their worries when they think anxiety can be helpful (e.g., don't walk alone at night, wear a bike helmet in case you are in a crash).

Strengths of the current study include its large international sample, use of standard methods for establishing the psychometric properties of the SAI-CH-6, and availability of the SAI-CH-6 in English, Swedish, Finnish, and German. It is noteworthy that five of the items selected for inclusion in the SAI-CH-6 were also included in Li and Lopez's (2007) 10-item short form developed from the Chinese version of the STAI-CH State Anxiety Subscale. This adds further support to the potential usefulness of the SAI-CH-6 with international samples. Given the large sample size of 985 children from the Development and Validation Samples who completed the full 20-item STAI-CH State Anxiety Subscale, we were able to identify a regression equation that could be used to estimate the STAI-CH State Anxiety Subscale score using the SAI-CH-6. This may prove useful to those interested in placing SAI-CH-6 results in the context of the larger literature which uses the full 20-item State Anxiety Subscale.

Study limitations include a restricted sample age of 10-year-old children and only children who are at risk for T1D. Future research should focus on establishing the psychometric properties of the SAI-CH-6 in children with and without chronic conditions across a wider age range. Information is certainly lost when moving from a well-developed 20-item questionnaire to a 6-item short form. However, the longer questionnaire has its own shortcomings in terms of time, participant burden, and likelihood of completion. The SAI-CH-6 offers a psychometrically robust measure of state anxiety that may be useful in large epidemiological or longitudinal studies where a briefer measure may yield better completion rates, lower participant burden, and greater ease of administration.

Although the SAI-CH-6 was developed for use in a large epidemiological study, efforts are currently underway to expand screening to identify individuals at risk for T1D to the general population (Sims et al., 2022; e.g., The Autoimmunity Screening for Kids in Colorado [Alonso et al., 2020; Steck et al., 2022], Fr1da in Germany [Raab et al., 2016], Australian General Population Screening Program, EarLy Surveillance for Autoimmune Diabetes in the United Kingdom [Quinn et al., 2022], Israeli Pediatric General Population for Detection of Presymptomatic T1D [Sims et al., 2022]). The American Diabetes Association recently endorsed screening for T1D risk for first-degree relatives of individuals with T1D (ElSayed et al., 2023). JDRF's T1Detect program is

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an example of a screening program that is open to anyone who is interested in screening for T1D autoantibodies (JDRF, 2023). Individuals register with JDRF on their website and are then mailed an at-home screening kit that is then mailed to a commercial laboratory. Guidelines for monitoring individuals who screen positive for T1D autoantibodies are forthcoming including recommendations for screening for anxiety symptoms. The intent of the guidelines is to provide recommendations to general healthcare providers who are not likely to have expertise in T1D autoantibody seroconversion to T1D. Although no specific questionnaires are endorsed in the guidelines, providers may choose to use the SAI-AD-6 and the SAI-CH-6 as brief measures to identify those who may need additional psychosocial support.

Author Contributions

Kimberly A. Driscoll (Conceptualization [equal], Project administration [equal], Writing—original draft [equal], Writing—review & editing [equal]), Jessica Melin (Conceptualization [equal], Project administration [equal], Writing—original draft [equal], Writing—review & editing [equal]), Kristian Lynch (Conceptualization [equal], Data curation [equal], Formal analysis [equal], Investigation [equal], Methodology [equal], Writing—original draft [equal], Writing—review & editing [equal]), Laura Smith (Conceptualization [equal], Methodology [equal], Project administration [equal], Writing—original draft [equal], Writing—review & editing [equal]), and Suzanne Bennett Johnson (Conceptualization [equal], Funding acquisition [equal], Investigation [equal], Methodology [equal], Project administration [equal], Writing—original draft [equal], Writing—review & editing [equal])

Funding

The TEDDY study was funded by U01 DK63829, U01 DK63861, U01 DK63821, U01 DK63865, U01 DK63863, U01 DK63836, U01 DK63790, UC4 DK63829, UC4 DK63861, UC4 DK63821, UC4 DK63865, UC4 DK63863, UC4 DK63836, UC4 DK95300, UC4 DK100238, UC4 DK106955, UC4 DK112243, UC4 DK117483, U01 DK124166, and U01 DK128847 and contract no. HHSN267200700014C from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), National Institute of Allergy and Infectious Diseases (NIAID), Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD), National Institute of Environmental Health Sciences (NIEHS), Centers for Disease Control and Prevention (CDC), and JDRF. This work is supported in part by the NIH/NCATS Clinical and Translational Science Awards to the University of Florida (UL1 TR000064) and the University of Colorado (UL1 TR002535). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Conflicts of interest

None declared.

Data Availability

The datasets generated and analyzed during the current study will be made available in the NIDDK Central Repository at https://repository.niddk.nih.gov/studies/teddy.

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