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Validation of the Abdominal Pain Index Using a Revised Scoring Method

Kelsey T. Laird,[1] MS, Amanda L. Sherman,[1] MS, Craig A. Smith,[1] PhD, and Lynn S. Walker,[2] PhD

[1]Department of Psychology and Human Development, Vanderbilt University and [2]Department of Pediatrics, Vanderbilt University

Correspondence concerning this article should be addressed to Lynn S. Walker, PhD, Division of Adolescent and Young Adult Health, Vanderbilt University School of Medicine, 2146 Belcourt Avenue, Nashville, TN 37212, USA. E-mail: lynn.walker@vanderbilt.edu

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Abstract

Objective Evaluate the psychometric properties of child- and parent-report versions of the four-item Abdominal Pain Index (API) in children with functional abdominal pain (FAP) and healthy controls, using a revised scoring method that facilitates comparisons of scores across samples and time. **Methods** Pediatric patients aged 8–18 years with FAP and controls completed the API at baseline ($N = 1,967$); a subset of their parents ($N = 290$) completed the API regarding the child's pain. Subsets of patients completed follow-up assessments at 2 weeks ($N = 231$), 3 months ($N = 330$), and 6 months ($N = 107$). Subsets of both patients ($N = 389$) and healthy controls ($N = 172$) completed a long-term follow-up assessment (mean age at follow-up = 20.21 years, $SD = 3.75$). **Results** The API demonstrated good concurrent, discriminant, and construct validity, as well as good internal consistency. **Conclusion** We conclude that the API, using the revised scoring method, is a useful, reliable, and valid measure of abdominal pain severity.

Key words: abdominal pain; chronic pain; pain severity; parent report; pediatric pain.

Validation of the Abdominal Pain Index

Chronic pain, defined as pain that occurs constantly or recurs frequently, represents a major clinical, social, and economic problem. Indeed, it has been identified as one of the most widespread and difficult problems in medicine (Latham & Davis, 1994). Recent studies suggest that 20–30% of children (Perquin et al., 2000; Roth-Isigkeit, Thyen, Stoven, Schwarzenberger, & Schmucker, 2005) and 30% of adults report experiencing chronic pain (Johannes, Le, Zhou, Johnston, & Dworkin, 2010). Advances in our understanding and treatment of chronic pain depend on the availability of psychometrically sound tools to assess changes in pain over time. Pain intensity is perhaps the most obvious parameter in the assessment of pain. A variety of self-report and behavioral measures have been developed and validated for assessing pain intensity in children and adults (McGrath et al., 2008; Turk et al., 2003). However, assessment of pain intensity alone is inadequate for assessing chronic or recurrent pain conditions, as pain intensity typically varies across pain episodes. Moreover, the frequency and duration of pain are important in characterizing chronic and recurrent pain.

Abdominal pain is one of the most common types of recurrent pain in childhood (Perquin et al., 2000; Roth-Isigkeit et al., 2005), and pediatric functional abdominal pain (FAP) prospectively predicts abdominal pain-related functional gastrointestinal disorders (FGIDs), such as irritable bowel syndrome (IBS), as well as non-abdominal chronic pain, such as back pain and headaches (Gieteling, Bierma-Zeinstra, Passchier, & Berger, 2008; Walker, Sherman, Bruehl, Garber, & Smith, 2012). To our knowledge, the Abdominal Pain Index (API; Walker, Smith, Garber, & Van Slyke, 1997) is the only instrument that can be scored as a composite measure of overall abdominal pain severity composed of pain frequency, intensity, and duration. Self-report and parent-proxy-report versions of the API are available. The purpose of this article is to describe the validation of the four-item API using the revised scoring method reported in recent publications (Sherman, Bruehl, Smith, & Walker, 2013; Walker et al., 2012). The revised scoring method is more easily interpreted than the original scoring method and facilitates comparisons across samples and time.

The API was developed by Walker and colleagues to characterize the pain experience of youth with recurrent or chronic abdominal pain (Walker et al., 1997). It has been used by several investigators (Boyer et al., 2006; Campo et al., 2004; Greco, Freeman, & Dufton, 2007; Kaminsky, Robertson, & Dewey, 2006; Robins, Smith,

Glutting, & Bishop, 2005; van der Veek, Derkx, Benninga, Boer, & de Haan, 2013; van der Veek, Derkx, de Haan, Benninga, & Boer, 2010, 2012; van der Veek et al., 2014). The API assesses characteristics of abdominal pain during the previous 2 weeks including the number of days with pain, number of pain episodes per day, typical pain episode duration, and typical pain intensity. The original scoring method entailed computing a composite score in which the rating of each pain characteristic was converted to a standard score, and these scores were summed to yield an index of abdominal pain severity (Walker et al., 1997). This approach allowed the relative severity of pain among participants to be compared at any particular time point. However, standard scores are derived from standard deviations of scores within a particular sample and have a mean that is artificially set to zero and a standard deviation that is artificially set to one. This method prohibits comparison of scores across samples that differ in either their mean or their variance. As research on recurrent and chronic abdominal pain expands to include more geographic locations, cultures, and settings, it has become important to be able to compare pain severity scores across populations. Furthermore, understanding of any recurrent pain condition requires assessment over time. While the original scoring method allowed comparison of individual change scores across time, standardization of scores at each assessment period prohibited the detection of cohort trends over time.

In the present article, we describe and evaluate the psychometric properties of the API using a scoring method that we developed to allow comparison across samples and time in recent studies (Rippel et al., 2012; Sherman et al., 2013; Walker et al., 2012).

Method

Participants

Participants were 867 children with FAP and 1,100 healthy controls. Of the child participants with FAP, 290 had a parent who also participated. These data were collected as part of a comprehensive evaluation of health outcomes of pediatric patients with FAP. Other aspects of the evaluation have been reported elsewhere (Dengler-Crish, Horst, & Walker, 2011; Sherman et al., 2013; Walker, Dengler-Crish, Rippel, & Bruehl, 2010; Walker et al., 2012). FAP participants in the baseline evaluation were consecutive new patients, aged 8–18 years, who presented to the pediatric gastroenterology clinic of a tertiary care center for evaluation of abdominal pain between 1993 and 2004 (Baber, Anderson, Puzanovova, & Walker, 2008; Walker, Garber, Smith, Van Slyke, & Claar, 2001; Walker et al., 1997). Patients were eligible for participation in the baseline evaluation if they lived with parent(s) or parent figure, reported abdominal pain of at least 3 months duration, had no history of chronic illness or disability, and had no organic disease diagnosis for abdominal pain from the referring physician. Participants were eligible for the subsequent long-term follow-up study of health outcomes if they were aged ≥12 years, at least 4 years had elapsed since initial study enrollment, no evidence of significant organic disease was found in the medical evaluation at the tertiary care clinic, and they reported no major chronic disease (e.g., inflammatory bowel disease, multiple sclerosis) at follow-up. Of the FAP patients who participated in the baseline study, 760 met criteria for age and long-term follow-up interval. Of these, 261 (34%) could not be reached, 60 (8%) declined to participate, and 40 (5%) indicated interest in participation but did not keep their appointment or could not be scheduled during the study period. Finally, three were excluded because of self-reported onset of chronic disease during the follow-up interval. Thus, of the 760 former patients who met eligibility criteria, 396 (52%) participated in the long-term follow-up interviews.

Healthy children were recruited from public schools in metropolitan Nashville and an adjacent rural county between 1997 and 2004. To be eligible for participation as a healthy child, children had to report no abdominal pain in the month preceding screening, report nonabdominal pain on no more than 2 days in the past week, score below the sample median for healthy children on the Children's Somatization Inventory (CSI; Walker, Beck, Garber, & Lambert, 2009), and have no chronic illness. Healthy children who subsequently developed an FGID at follow-up ($N = 13$) were excluded from the analysis. Recruitment for the follow-up study involved sending letters to healthy children and their parents ($n = 343$) with a card to return if they did not wish to be contacted; 3 declined further contact, leaving 340 potential participants. Of these, 110 (32%) could not be reached by telephone, 20 (6%) declined to participate, and 23 (7%) did not keep their appointment for the follow-up study or could not be scheduled. Thus, the final follow-up sample for the healthy comparison group included 187 persons.

The analyses reported here are based on baseline data ($N = 1{,}967$) and long-term follow-up ($N = 396$) data from participants with FAP and controls. Data from parents were available at baseline only. Subsets of participants with FAP completed short-term follow-up assessments at 2 weeks ($N = 308$), 3 months ($N = 420$), and 6 months ($N = 122$) after the baseline assessment. Because not all measures were administered to all participants at each time point, the number of participants is reported with each analysis.

Procedure

Baseline

An interviewer administered questionnaires to pediatric patients in a private room at the clinic before the medical evaluation. Parents completed questionnaires independently at the same time. Medical records were reviewed for results of the medical evaluation. Details regarding baseline assessment procedures have been presented elsewhere (Walker et al., 1997, 2001).

Follow-Up

Participants were contacted by telephone several years after baseline (range = 4–21 years, mean = 8.73 years). Trained interviewers administered the API and assessed the symptom criteria for FGIDs using a structured interview. Interviewers were unaware of the baseline status (FAP, control) of participants they interviewed. Parental consent was obtained for participants <18 years of age. The institutional review board approved all procedures.

Measures

Baseline Measures

Abdominal Pain Severity. The API assesses characteristics of abdominal pain that a child has experienced during the previous 2 weeks (Appendix). The frequency of abdominal pain episodes during the previous 2 weeks is rated on a 6-point scale ranging from *not at all* (0) to *every day* (5). The typical daily frequency of abdominal pain episodes is assessed on a 6-point scale ranging from *none* (0) to *constant during the day* (5). The typical duration of pain episodes is rated on a 9-point scale ranging from *none* (0) to *all day* (8). The typical intensity of abdominal pain in the past 2 weeks is rated on an 11-point scale ranging from *no pain* (0) to *the most pain possible* (10). The revised scoring method creates a raw (non-normalized) composite score using a procedure previously reported (Rippel et al., 2012; Sherman et al., 2013; Walker et al., 2012). This scoring

method uses the four items of the API[1] to calculate a composite score as follows: (1) items that are not already on a 6-point scale are converted to a scale ranging from 0 to 5, (2) the mean of all four items is taken to achieve a score ranging from 0 to 5, and (3) to put this measure on the same scale as other self-reported measures of pain characteristics (Walker, Smith, Garber, & Claar, 2005; Walker et al., 1997), this mean is converted to a 5-point scale to yield a mean ranging from 0 to 4 (Appendix).

Somatic Symptoms. The CSI (Walker et al., 2009) assesses the severity of 35 somatic symptoms (e.g., headaches, low energy, dizziness, chest pain). Participants rate how much they were bothered by each symptom during the past 2 weeks using a 5-point scale ranging from *not at all* (0) to *a whole lot* (4). Subscale scores are computed for gastrointestinal (GI) symptoms (9 items, e.g., abdominal pain, nausea, constipation, diarrhea, bloating) and non-GI symptoms (26 items, e.g., dizziness, back pain, headaches, sore muscles) by averaging the relevant items for each subscale. Both subscales had good internal consistency; as previously reported for this sample, Cronbach alpha coefficients were .78 and .82 for the GI and non-GI symptom subscales, respectively (Walker et al., 2012). A parent-report form of the CSI was administered to parents regarding their child's somatic symptoms. Cronbach alpha coefficients for the parent report version have been previously reported as .70 and .82 for the GI and non-GI symptom subscales, respectively (Walker et al., 2012).

Pain Threat. The Pain Beliefs Questionnaire (PBQ; Walker et al., 2005) assesses children's pain appraisals (Lazarus & Folkman, 1984; Smith & Lazarus, 1990). The Primary Appraisal subscale (20 items) assesses the degree to which pain is perceived as threatening to one's well-being (e.g., "My stomach aches mean I have a serious illness"). Two additional subscales assess one's perceived ability to cope with pain. The Primary Appraisal subscale was used for the present study in analyses evaluating the validity of the API; we expected that the API composite score would be highly correlated with perceived pain threat as measured by the Primary Appraisal subscale of the PBQ. For each item on the PBQ, respondents indicate how true the statement is using a 5-point rating scale ranging from *not at all true* (0) to *very true* (4). The pain threat subscale was computed by averaging items pertaining to that subscale. Parents completed a parent-report version of the PBQ to rate their perceptions of their children's pain threat. Reliability and sensitivity to treatment have been documented for the PBQ (Anderson, Acra, Bruehl, & Walker, 2008; Langer et al., 2007; Levy et al., 2010; Lipsitz, Gur, Albano, & Sherman, 2011; Walker, Baber, Garber, & Smith, 2008; Walker et al., 2005). In this study, the Cronbach alpha coefficient for the pain threat subscale was .88. The Cronbach alpha for the corresponding parent report subscale was .83.

Functioning. The Functional Disability Inventory (FDI; Claar & Walker, 2006; Walker & Greene, 1991) assesses self-reported difficulty in physical and psychosocial functioning owing to physical health during the past 2 weeks. Responses to each of 15 items are scored on a 5-point scale, ranging from *no trouble* (0) to *impossible* (4). Items were averaged to compute a composite score. The Cronbach alpha coefficient for the FDI was .90.

Negative Affect. The self-report Children's Depression Inventory (CDI; Kovacs, 1992) was used to assess the severity of negative affect. For each of 26 items, participants are presented with three statements and asked to select the one that best described how they felt during the past 2 weeks. The items were averaged, and the resulting scale score was converted to a 0–4 scale to be consistent with other measures used in this study. The Cronbach alpha coefficient was .86.

Socioeconomic Status. The Hollingshead Four-Factor Index of Socioeconomic Status (Hollingshead, 1975) is a measure of a family's socioeconomic status (SES). It is based on four domains: marital status, retired/employed status, educational attainment, and occupational prestige. Parents completed this measure at baseline.

Follow-Up Measures

All baseline measures described above also were administered at long-term follow-up. Two additional measures, not yet published and therefore not administered at baseline, were administered at long-term follow-up. These measures assessed symptom criteria for FGIDs and chronic pain, as described below.

Functional Gastrointestinal Disorders. The Rome III Diagnostic Questionnaire for FGIDs (Drossman, 2006) was developed by the Rome Foundation Board to assess symptoms associated with the diagnostic criteria for FGIDs. We administered 24 items that assessed symptom criteria for several FGIDs associated with abdominal pain, including IBS, functional dyspepsia, abdominal migraine, and FAP. Participants' responses were scored according to the pediatric Rome criteria (for participants <18 years of age) or the adult Rome criteria (for participants aged ≥ 18 years). Participants with follow-up data received a score indicating the presence or absence of at least one type of FGID.

Chronic Pain. The Persistent Pain Questionnaire (PPQ; Bruehl, France, France, Harju, & al'Absi, 2005) was designed to provide a structured assessment of history and location of any chronic pain. The PPQ lists the standard nine body locations (including the abdomen) described by the International Association for the Study of Pain, and asks the respondent to indicate whether he/she has ever had pain in that location "daily or almost every day that continued for three months or longer." The PPQ was modified for this study to assess current chronic pain, defined as pain experienced in the past 3 months. For each site of current chronic pain, respondents rated the intensity of their pain on a 0–100 scale (anchored from "*no pain at all*" to "*the worst pain possible*"). The severity of nonabdominal chronic pain at follow-up was defined as the number of nonabdominal current chronic pain sites rated ≥ 30. The intensity of abdominal pain at follow-up was defined as the participant's intensity rating for the abdomen item. For participants <18 years of age at follow-up, parents completed the PPQ indicating their child's current chronic pain across all nine body locations.

Results

Demographic Characteristics

The baseline sample comprised 867 children and adolescents with FAP and 1,100 healthy children and adolescents between the ages of

[1] Because the maximum intensity of pain item is highly correlated with the typical intensity of pain, and because of a need to keep assessments as brief as possible at intake, only the first four items of the API (which previously included a maximum pain intensity item) were administered at baseline. At long-term follow-up, the correlation between API scores including and not including the 5th item was .99 ($p < .001$, $N = 561$). We are therefore confident that omitting the fifth item does not significantly reduce the quality of information provided by the API.

7 and 18 years (1,967 children and adolescents in total). The average age of participants at baseline was 11.31 ($SD = 2.19$). The majority of participants were White (90.29%) and female (56.74%). A minority of participants were Black (2.64%), Hispanic (1.37%), Asian (0.61%), another race (1.83%), or did not report their race (3.25%). The average age of participants at follow-up was 20.21 years ($SD = 3.75$). We used ROME III criteria to assess how many of the participants who had FAP at baseline met symptom diagnostic criteria for a FGID at long-term follow-up. One hundred fifty-three (39.33%) of the participants who had FAP at baseline met criteria for one or more FGIDs at long-term follow-up. Of those, 71.24% met criteria for IBS, 50.33% met criteria for functional dyspepsia, 7.19% met criteria for abdominal migraine, and 1.31% met criteria for FAP syndrome.

Child-Reported API Score

Descriptive Statistics

Baseline means and standard deviations on the API by sex and group (FAP vs. Control) are presented in Table I. In the combined sample of FAP patients and controls, child-reported API scores were significantly higher for girls than for boys, $F(1, 1{,}964) = 66.73$, $p < .001$. The Cohen's d, indicating the difference between these two means in standard deviation units, was 0.37. This difference was significant in both children with FAP ($F(1, 864) = 28.86$, $p < .001$, Cohen's $d = 0.37$), and healthy controls ($F(1, 1{,}098) = 34.98$, $p < .001$, Cohen's $d = 0.36$).

Baseline API scores by age, sex, and group are presented in Table I. In the combined baseline sample of FAP patients and controls ($N = 1{,}967$), age had a small but significant correlation with API score ($r = .17$, $p < .001$); older children had higher API scores. This relation held both for children with FAP ($r = .16$, $p < .001$, $N = 867$) and healthy controls ($r = .09$, $p = .002$, $N = 1{,}100$; the strength of this relation was not significantly different in children with FAP vs. controls, $t(3) = 0.77$, $p = .442$). The relation between age and API score also held among both girls ($r = .22$, $p < .001$, $N = 1{,}116$) and boys ($r = .08$, $p = .018$, $N = 850$), although the strength of the relation was significantly greater in girls ($t(3) = -2.87$, $p = .004$).

Table I. Baseline API Scores by Age, Sex, and Group

Group	*N*	Mean	*SD*	Range	10%	90%
FAP						
Male						
Childhood	138	1.64	0.91	0.00–4.00	0.00	2.98
Early adolescence	163	1.74	0.77	0.00–3.90	0.83	2.72
Late adolescence	47	2.00	0.87	0.00–3.68	0.85	3.31
Female						
Childhood	202	1.85	0.83	0.00–4.00	0.76	2.84
Early adolescence	223	2.17	0.85	0.00–4.00	1.15	3.38
Late adolescence	93	2.23	0.91	0.00–4.00	1.32	3.70
Healthy controls						
Male						
Childhood	227	0.69	0.90	0.00–4.00	0.00	1.98
Early adolescence	257	0.80	0.87	0.00–3.40	0.00	2.10
Late adolescence	18	0.52	0.72	0.00–1.98	0.00	1.91
Female						
Childhood	272	0.94	0.93	0.00–4.00	0.00	2.37
Early adolescence	306	1.15	0.88	0.00–3.88	0.00	2.31
Late adolescence	20	1.47	1.05	0.00–3.68	0.00	3.14

Note. Childhood = 8–10 years of age; early adolescence = 11–14 years; late adolescence = 15–18 years.

SES as indicated by the Hollingshead Index was not significantly associated with API score ($r = .071$, $p = .180$, $N = 357$). This effect did not reach statistical significance after controlling for sex, age, and FAP status (standardized coefficient = .068; $p = .189$).

Internal Consistency

Cronbach's alpha using the revised scoring method was previously reported for 843 of the 867 children with FAP in this data set and was .75 for child report and .76 for parent proxy report (Walker et al., 2012). Cronbach's alpha for the combined sample of children with FAP and healthy controls reported here was slightly higher (.83; $N = 1{,}967$). Cronbach's alpha was .73 for children with FAP and .84 for healthy children. Cronbach's alpha for adolescent and young adult self-report at long-term follow-up in the combined sample was .87 ($N = 560$). Cronbach's alpha at long-term follow-up was .87 for the full sample, .85 for adolescents and adults who had FAP at baseline, and .88 for healthy controls.

Concurrent Validity

For the subset of FAP patients for whom parent proxy report of the API was obtained at baseline, the API showed good concurrent validity. Following convention (Cohen, 1988, 1992), we defined a large (strong) effect as a Pearson's correlation coefficient of between .4 and .6, and a moderate effect as a Pearson's correlation between .2 and .4. Pediatric patients' reports of abdominal pain severity were strongly correlated with parental reports ($r = .60$, $p < .001$, $N = 290$).

Discriminant Validity

Discriminant validity of the API was evaluated by examining the ability of the API to discriminate between children with and without FAP. The average API score of healthy control children ($N = 1{,}100$) was 0.92 ($SD = 0.91$), whereas the average score of children with FAP ($N = 867$) was 1.93 ($SD = 0.87$), a difference which was statistically significant, $F(1, 1{,}965) = 615.77$, $p < .001$, and represented a strong effect of health status (FAP vs. control) on abdominal pain severity assessed by the API, Cohen's $d = 1.13$.

Construct Validity

Construct validity of the API was evaluated by examining the correlation of the API with related self-reported constructs. Observed Pearson correlations among all self-reported variables hypothesized to correlate with the API in FAP participants at baseline are reported in Table II. We expected a strong correlation between API score and pain threat appraisal, because the severity of pain is highly

Table II. Means, SDs, and Observed Pearson Correlations Among all Self-Reported Variables Hypothesized to Correlate With the API in FAP Participants at Baseline

	API	CSI	PBQ	FDI	CDI
Somatic symptoms (CSI)	0.46				
Pain threat (PBQ)	0.56	0.52			
Functioning (FDI)	0.36	0.60	0.44		
Negative affect (CDI)	0.29	0.52	0.45	0.52	
Mean	1.93	0.67	1.92	0.75	0.70
SD	0.87	0.42	0.71	0.66	0.53

Note. API = Abdominal Pain Index; CSI = Children's Somatization Inventory; PBQ = Pain Beliefs Questionnaire; FDI = Functional Disability Inventory; CDI = Children's Depression Inventory. All correlations were significant at $p < .001$.

correlated with the degree to which an individual perceives that pain to be threatening (Lipani & Walker, 2006; Williams, Blount, & Walker, 2011). Because we expected other symptoms and disability to be influenced not only by pain severity but also by multiple unmeasured factors, we expected a moderate correlation between the API and disability, somatic symptoms, and depressive symptoms (Boyer et al., 2006; Claar & Walker, 2006; Kaminsky et al., 2006; Lipani & Walker, 2006). As predicted, greater severity of self-reported abdominal pain as indicated by the API was strongly correlated with self-reports of more severe appraisals of pain threat on the PBQ (among FAP: $r = .56$, $p < .001$, $N = 858$; among healthy controls: $r = .52$, $p < .001$, $N = 634$; among the combined sample: $r = .62$, $p < .001$, $N = 1{,}492$). API score was moderately correlated with greater self-reported disability on the FDI (FAP: $r = .36$, $p < .001$, $N = 703$; healthy: $r = .39$, $p < .001$, $N = 897$; combined sample: $r = .40$, $p < .001$, $N = 1{,}600$). API score was moderately to strongly correlated with greater somatic symptoms as indicated by the CSI (combined sample: GI: $r = .69$, $p < .001$; non-GI: $r = .38$, $p < .001$; total: $r = .51$, $p < .001$, $N = 1{,}869$). This was true in both children with FAP (GI: $r = .52$, $p < .001$; non-GI: $r = .35$, $p < .001$; total: $r = .46$, $p < .001$, $N = 859$) and in healthy children (GI: $r = .68$, $p < .001$; non-GI: $r = .54$, $p < .001$; total: $r = .59$, $p < .001$, $N = 1{,}010$). Finally, API score was moderately correlated with more self-reported negative affect on the CDI (FAP: $r = .29$, $p < .001$, $N = 851$; the CDI was not administered to healthy children).

Construct validity was further investigated at long-term follow-up by examining the relation between API score and self-reported bodily pain as measured by the PPQ, which assesses both intensity of current abdominal pain and the number of sites of nonabdominal chronic pain. These analyses used cross-sectional data at long-term follow-up, as the PPQ was not administered at baseline. We predicted that the association of API score with current abdominal pain intensity on the PPQ would be large because these instruments measure pain at the same anatomic site. We predicted that the association of API score with number of total pain sites would be moderate. The relation between API score at follow-up and intensity of abdominal pain as assessed by the PPQ at follow-up was large ($r = .51$, $p < .001$, $N = 555$). The relation between API score and number of nonabdominal sites of chronic pain as assessed by the PPQ was moderate ($r = .35$, $p < .001$, $N = 555$). These correlations were significant both in individuals with FAP (abdominal pain: $r = .50$, $p < .001$, $N = 385$; nonabdominal pain: $r = .34$, $p < .001$, $N = 385$) and in healthy individuals (abdominal pain: $r = .20$, $p = .009$, $N = 170$; nonabdominal pain: $r = .16$, $p = .034$, $N = 170$). The strength of the correlation between API scores and ratings of abdominal pain intensity on the PPQ was significantly greater for individuals with FAP than for healthy individuals, $t(3) = 4.13$, $p < .001$. The strength of the correlation between API scores and number of nonabdominal chronic pain sites was not significantly different in individuals with FAP compared with healthy individuals, $t(3) = 1.63$, $p = .103$.

Follow-Up

Test–retest reliability was investigated by assessing the strengths of the correlations between baseline API score and API score at all follow-up time points. We expected strong correlations at 2-week follow-up, but moderate correlations at long-term follow-up. As predicted, among participants with FAP, API score at baseline was strongly correlated with API score at 2 weeks ($r = .59$, $p < .001$, $N = 231$) and moderately correlated with API score at 3 months ($r = .36$, $p < .001$, $N = 330$) and 6 months ($r = .34$, $p < .001$, $N = 107$). Among participants with FAP, the correlations between API score at baseline and long-term follow-up were low but significant ($r = .20$, $p < .001$, $N = 389$). Follow-up API scores for healthy participants were only available at long-term follow-up. Among healthy controls, the correlation between API score at baseline and long-term follow-up was similarly low but significant ($r = .19$, $p = .015$, $N = 172$). In the combined sample, API baseline scores were moderately associated with API scores at long-term follow-up ($r = .38$, $p < .001$, $N = 561$).

Predictive validity was evaluated by investigating whether child-reported API scores at baseline significantly predicted whether participants in the combined sample met criteria for an FGID at long-term follow-up. Indeed, children who went on to meet criteria for a FGID as adolescents and adults had higher API scores at baseline ($M = 1.99$, $SD = 0.92$, $N = 162$) compared with children who did not go on to meet criteria for an FGID at follow-up ($M = 1.32$, $SD = 1.09$, $N = 404$, $F(1, 564) = 48.287$, $p < .001$, Cohen's $d = 0.66$). Further analyses revealed that the relation between baseline API score and presence of an FGID at long-term follow-up remained significant among children with FAP but not among healthy controls. Specifically, baseline API scores were significantly higher for children with FAP who met criteria for an FGID at long-term follow-up ($M = 2.08$, $SD = 0.86$, $N = 153$) compared with those who did not ($M = 1.89$, $SD = 0.89$, $N = 241$, $F(1, 392) = 4.44$, $p < .05$, Cohen's $d = 0.22$). By contrast, the difference in baseline API scores among healthy children who met ($M = 0.43$, $SD = 0.56$, $N = 9$) or did not meet ($M = 0.47$, $SD = 0.73$, $N = 163$) criteria for an FGID at long-term follow-up was not statistically significant ($F(1, 170) = 0.028$, $p = .867$, Cohen's $d = 0.06$).

Predictive validity was further evaluated by investigating the extent to which baseline API scores predicted pain at follow-up in the combined sample as assessed by the PPQ. Because API scores at baseline and long-term follow-up were moderately correlated, and cross-sectional correlations between the API and the PPQ were large to moderate (for abdominal pain intensity and number of chronic pain sites, respectively), we predicted a small to moderate correlation between baseline API score and abdominal pain intensity at long-term follow-up, and a small correlation between baseline API score and number of nonabdominal chronic pain sites at long-term follow-up. Greater severity of child-reported abdominal pain as assessed by the API at baseline was moderately associated with greater self-reported intensity of abdominal pain ($r = .25$, $p < .001$, $N = 558$) at long-term follow-up, and modestly associated with greater number of nonabdominal sites of clinically significant pain ($r = .19$, $p < .001$, $N = 558$) as assessed by the PPQ at long-term follow-up. The strength of these correlations was not significantly different in children with FAP compared with healthy children (abdominal pain: $t(3) = 1.13$, $p = .261$; nonabdominal pain: $t(3) = 0.07$, $p = .941$). Higher child-reported baseline API score was also moderately associated with more somatic symptoms as measured by the CSI at long-term follow-up, both in the combined sample (GI symptoms: $r = .35$, $p < .001$; non-GI symptoms: $r = .24$, $p < .001$; total: $r = .32$, $p < .001$, $N = 561$) and among children with FAP (GI symptoms: $r = .23$, $p < .001$; non-GI symptoms: $r = .13$, $p < .05$; total: $r = .19$, $p < .001$, $N = 390$), but not among healthy children (GI symptoms: $r = -.047$, $p = .54$; non-GI symptoms: $r = -.035$, $p = .64$; total: $r = -.045$, $p = .560$, $N = 172$). The strength of the correlation between baseline API score and long-term follow-up CSI total score was significantly greater among children with FAP than healthy children, $t(3) = 2.41$, $p = .016$.

Parent Proxy Report

As indicated previously, child and parent-proxy report API were significantly correlated, supporting their construct validity. Construct validity of the parent proxy report was further evaluated by investigating the relation of parent-reported API to pediatric patient-reported measures. We predicted that the relation of the parent-reported API to patient-reported measures would be similar to the observed (moderate to strong) correlations between the patient-reported API and these measures, but that the relations would be attenuated owing to reporter differences. Among children with FAP, parent-reported API score was moderately associated with child-reported pain threat ($r = .38$, $p < .001$, $N = 289$), child-reported somatic symptoms ($r = .36$, $p < .001$, $N = 285$), and child-reported disability ($r = .33$, $p < .001$, $N = 141$), and modestly correlated with child-reported depressive symptoms ($r = .19$, $p = .017$, $N = 161$). Discriminant validity could not be computed for parent proxy report because the API was not administered to parents of healthy children.

Construct validity of the parent proxy API was evaluated by investigating, in the FAP sample, the association of the parent proxy API with parent proxy reports of their child's abdominal pain, somatic symptoms, pain threat appraisal, and disability. We predicted that these correlations would be moderate to strong, similar to relations among the corresponding child self-reported measures. Indeed, greater severity of abdominal pain on the parent proxy API was strongly correlated with parent reports of more severe appraisals of pain threat on the parent proxy PBQ ($r = .59$, $p < .001$, $N = 277$), more severe somatic symptoms in their child as indicated by the parent proxy CSI ($r = .51$, $p < .001$, $N = 281$), and greater disability as indicated by the parent proxy FDI ($r = .48$, $p < .001$, $N = 139$).

Test–retest validity of the parent-proxy-report API was supported in the FAP sample by the finding that, similar to our findings with the child-report form, parent-proxy API score at baseline was strongly correlated with parent-proxy API score at 2 weeks ($r = .56$, $p < .001$, $N = 147$), but only moderately correlated with parent-proxy API score at 3 months ($r = .27$, $p < .005$., $N = 141$) and 6 months ($r = .20$ $p = .03$, $N = 114$). Parents were not administered the API at long-term follow-up.

Among children with FAP, parent-proxy API score at baseline did not significantly predict whether the child would meet criteria for an FGID at long-term follow-up, $F(1, 158) = 1.09$, $p = .297$. Parent-proxy API at baseline had a small but nonsignificant positive correlation with number of nonabdominal chronic pain sites as assessed by the self-report PPQ at long-term follow-up ($r = .14$, $p = .071$, $N = 160$), and a negligible correlation with the intensity of abdominal pain at long-term follow-up ($r = .05$, $p = .518$, $N = 160$). However, parent-proxy API at baseline did significantly yet modestly predict somatic symptoms (as assessed by the self-report CSI) at long-term follow-up ($r = .16$, $p = .038$, $N = 161$).

Discussion

This study evaluated psychometric properties of the child-report and parent-proxy-report versions of the API. The original method of scoring the API involved standardization of scores within a given sample and period, thus preventing the comparison of API scores across samples or time. Recognizing this limitation, two investigators devised unique approaches to calculating a total score for the API (Robins et al., 2005; van der Veek et al., 2010, 2012, 2013, 2014). These approaches are similar to the scoring method reported here; however, an evaluation of the psychometric properties of the API as scored using these approaches has never been published. For this study, we analyzed API data from a large longitudinal data set of children with FAP and healthy controls using a revised scoring method that facilitates comparison of scores across samples and time. Good construct, concurrent, discriminant, and predictive validity, as well as acceptable internal consistency, were found using this method.

Construct validity for the child-report version of the API was supported by the moderate to strong correlation between self-reported API score with self-reports of more severe pain threat appraisal, greater disability, more somatic symptoms, and more negative affect. Similarly, construct validity for the parent-proxy-report API was supported by the finding that greater severity of parent-reported API score was strongly correlated with parent proxy reports of more severe somatic symptoms, greater pain threat, and greater child disability. Construct validity was further supported by the moderate association between parent-proxy-report API score and child reports of somatic symptoms, primary pain appraisal, disability, and depressive symptoms among children with FAP.

Good concurrent validity was supported by a significant correlation between child-report and parent-proxy-report API scores. Discriminant validity was supported by the significantly higher child-reported API scores observed among children with FAP compared with healthy children. We found no evidence that the API discriminates based on SES, as SES was unrelated to API score in our sample.

We also found good predictive validity for the API using the revised scoring method. It is noteworthy that symptom reports as assessed by the API were moderately correlated between baseline and 6 months as well as between baseline and long-term follow-up, an average of 9 years later. This was true of both children with FAP and healthy children. Furthermore, greater severity of child-reported abdominal pain as assessed by the API at baseline was modestly but significantly associated with greater intensity of abdominal pain and greater number of clinically significant nonabdominal pain sites as assessed by the PPQ at long-term follow-up among children with FAP. Finally, greater severity of child-reported abdominal pain as assessed by the API at baseline was moderately predictive of GI symptoms as assessed by the CSI at long-term follow-up among children with FAP.

Consistent with other literature indicating a higher prevalence and severity of pain in girls versus boys, child-reported API scores were higher for girls than for boys in our sample (Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley, 2009; Perquin et al., 2000). This finding is consistent with the known higher prevalence of FAP in women than in men (Drossman et al., 1993). The fact that girls' API scores were higher than boys even in the control group makes sense in the context of a culture in which boys are socialized to minimize pain to a greater extent than girls (Zeman & Garber, 1996). API scores significantly increased with age in girls; this occurred to a lesser extent in boys. This is consistent with other studies showing that sex differences in the experience of various types of pain emerge or become greater around puberty (Fillingim et al., 2009; LeResche, Mancl, Drangsholt, Saunders, & Korff, 2005). The slight increase in API score in boys over time may reflect the more frequent experience of pain with age (Perquin et al., 2000; Roth-Isigkeit et al., 2005).

The difference between the mean API scores for children with FAP (1.93) compared with healthy children (0.92) was relatively small ($R^2 = 0.24$). Abdominal pain is very common in the general pediatric population, with 13.5–22.2% of adolescents experiencing abdominal pain at least weekly (Stanford et al., 2008). Abdominal pain in the general population can be associated with diet, acute illness, and other common factors. Thus, it is likely that the etiology for abdominal pain reported by the FAP patients differed from that for abdominal pain reported by healthy controls. Moreover,

abdominal pain scores for some FAP patients may have been relatively low because their medical evaluation was precipitated by parental fears related to a family history of organic disease such as inflammatory bowel disease rather than the severity of the child's pain. Additionally, FAP by nature is episodic, and so it is inevitable that some patients were not experiencing their usual pain severity at the time of the medical evaluation.

One limitation of this study is the relative homogeneity of our sample. Studies with more diverse samples will help determine whether our results generalize to other age-groups, ethnicities, and chronic pain populations. For example, as our participants were either healthy controls or had FAP, it is unknown whether the API is appropriate for use in children with abdominal pain due to organic causes such ulcerative colitis or Crohn's disease. A second limitation is that it was not possible to test the difference between the four-item and five-item versions of API, because only the four-item version was administered at baseline. A final limitation is that because of the high prevalence of pain in the general population, healthy children who had up to 2 days of nonabdominal pain over the past week were eligible for participation, and it is unknown whether their nonabdominal pain may have impacted the results.

We conclude that the API is a valid and reliable measure of abdominal pain in children and adolescents aged ≥8 years with FAP. We recommend using the revised scoring method described here for future research. Future studies should investigate the treatment sensitivity of the API using this revised scoring method to evaluate its appropriateness for use in clinical trials.

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Conflicts of interest: None declared.

Appendix

Abdominal Pain Index (API): Child Form

The next few questions are about your abdominal pain during the ***past 2 weeks***.

1. In the ***past 2 weeks***, how often have you had abdominal pain (stomach aches)?

_____ 0. not at all*
_____ 1. one or two days
_____ 2. three or four days
_____ 3. five or six days
_____ 4. most days
_____ 5. every day

2. In the ***past 2 weeks***, how many times a day did you usually have the pain?

_____ 0. none
_____ 1. once a day
_____ 2. two or three times a day
_____ 3. four or five times a day
_____ 4. six or more times during the day
_____ 5. constant during the day

3. In the ***past 2 weeks***, when your stomach hurt, how long did the pain last?

_____ 0. no pain
_____ 1. a few minutes
_____ 2. about half an hour
_____ 3. about an hour
_____ 4. between one and two hours
_____ 5. three or four hours
_____ 6. five or six hours
_____ 7. most of the day
_____ 8. all day (it never completely stops)

4. In the ***past 2 weeks***, when your stomach hurt, how much did it **usually** hurt?

The MOST pain possible
10
9
8
7
6
5
4
3
2
1
0
NO PAIN

*If the response to item 1 is 0 (not at all), the remaining items are automatically scored as 0. The authors grant permission for this index to be used for research purposes.

Abdominal Pain Index (API): Parent Proxy Form

The next few questions are about your child's abdominal pain during the ***past 2 weeks***.

1. In the ***past 2 weeks***, how often have your child had abdominal pain (stomach aches)?

_____ 0. not at all*
_____ 1. one or two days
_____ 2. three or four days
_____ 3. five or six days
_____ 4. most days
_____ 5. every day

2. In the ***past 2 weeks***, how many times a day did he or she usually have the pain?

_____ 0. none
_____ 1. once a day
_____ 2. two or three times a day
_____ 3. four or five times a day
_____ 4. six or more times during the day
_____ 5. constant during the day

3. In the ***past 2 weeks***, when your child's stomach hurt, how long did the pain last?

_____ 0. no pain
_____ 1. a few minutes
_____ 2. about half an hour
_____ 3. about an hour
_____ 4. between one and two hours
_____ 5. three or four hours
_____ 6. five or six hours
_____ 7. most of the day
_____ 8. all day (it never completely stops)

4. In the ***past 2 weeks***, when your child's stomach hurt, how much did it **usually** hurt?

The MOST pain possible
10
9
8
7
6
5
4
3
2
1
0
NO PAIN

*If the response to item 1 is 0 (not at all), the remaining items are automatically scored as 0. The authors grant permission for this index to be used for research purposes.

Revised Scoring Instructions for the API Total Score

Key:
API1 = item 1 rating
API2 = item 2 rating
API3 = item 3 rating
API4 = item 4 rating

Computation	Description
API3 × 5/8 = API3NEW	Item 3 is converted to a 6-point scale by multiplying its value by 5/8.
API4/2 = API4NEW	Item 4 is converted to a 6-point scale by dividing its value by 2.
(API1 + API2 + API3NEW + API4NEW)/4 = UNSCALEDMEAN.	All four items are averaged.
UNSCALEDMEAN × 4/5 = APIFINAL	This average is converted to a final composite score on a 4-point scale by multiplying it by 4/5.

Sample SPSS code for these calculations is provided below.

```
COMPUTE API3NEW = API3*5/8.
VARIABLE LABELS API3NEW 'API3 converted to a 6-point scale ranging from 0 to 5'.
EXECUTE.

COMPUTE API4NEW = API4/2.
VARIABLE LABELS API4NEW 'API4 converted to a 6-point scale ranging from 0 to 5'.
EXECUTE.

COMPUTE UNSCALEDMEAN = MEAN(API1, API2, API3NEW, API4NEW).
EXECUTE.

COMPUTE API_FINAL = UNSCALEDMEAN*4/5.
EXECUTE.

VARIABLE LABELS API_FINAL 'API final score on a 0 to 4 scale'.
EXECUTE.
```

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