Preliminary Reliability and Validity of a New Time-Sensitive ADHD Symptom Scale in Adolescents with ADHD

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Abstract

Objectives: To validate the Time-Sensitive ADHD Symptom Scale (TASS) in the assessment of symptom change during the day in adolescents with attention-deficit/hyperactivity disorder (ADHD). Methods: A total of 40 participants with ADHD aged 13 to 17 years completed 1 or 2 visits, 1 to 9 weeks apart. The TASS and the ADHD Rating Scale-IV (ADHD-RS-IV) were completed twice at each visit: at the time of the clinic visit (in-clinic assessment) and 2 to 6 hours afterwards (evening assessment). Results: Internal consistency of the TASS was high, with Cronbach’s alpha coefficients of 0.91 (in-clinic) and 0.90 (evening) for visit 1, and 0.88 (in-clinic) and 0.86 (evening) for visit 2. Pearson’s correlation coefficients between the TASS and ADHD-RS-IV were significant at both visits (P < 0.0001). Stability analyses of the TASS found no significant effect between ratings performed at different visits (P = 0.936), but there was a significant effect of the assessment time within visits (P < 0.0001). There was not a significant visit by assessment time interaction (P = 0.924). Conclusions: The TASS showed high internal consistency and high concurrent validity with the ADHD-RS-IV. Results of this preliminary study indicate that the TASS is a valid and reliable self-report scale for adolescents with ADHD.

Keywords: ADHD; adolescents; classification; psychometrics; questionnaires

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is estimated to affect approximately 8% of school-aged children, making it one of the most common psychiatric disorders of childhood.1 The persistence of ADHD into adolescence and adulthood has been well documented, with approximately 75% of adolescents and 50% to 60% of adults continuing to manifest significant symptoms of the disorder.2-4 Impairments associated with ADHD are pervasive and include academic and social dysfunction as well as problems with peer and parental relationships and emotional development.5-11 Adolescents with ADHD also have a higher risk for comorbid psychiatric disorders,12-14 low self-esteem, early-onset substance abuse,15 and cigarette smoking16 than their non-ADHD peers.

Short- and long-acting psychostimulants are commonly utilized for the treatment of adolescent ADHD.17,18 Although research has shown stimulants to be very effective in managing ADHD symptoms,2,19,20 improving academic and social functioning,2,18 and reducing the risk of developing substance use disorders,21 adolescents are similar to adults in that they require daily symptom relief for 8 to 14 hours in order to perform well in school during the day and then complete homework assignments and household chores.
at night. Recent pharmacologic advances have focused on long-acting stimulants and nonstimulants medications as these agents have a duration of effect that can extend into the evening. However, even when treated with long-acting medications, adolescents may require a supplemental dose of a short-acting stimulant in the late afternoon or early evening in order to receive adequate treatment throughout the day.

While there are several validated symptom-assessment scales for adolescents, such as the ADHD Rating Scale-IV (ADHD-RS-IV) and the Conners-Wells’ Adolescent Self-Report Scales (CASS-S), that reliably assess change in ADHD symptoms over epochs of days to weeks, there are no scales that capture symptom change within a single day. Because the assessment of change in ADHD symptoms during the day is crucial for physicians to determine appropriate medications and daily treatment regimens, there is a clear need for a valid and reliable time-sensitive ADHD symptom assessment scale for adolescents.

To address this issue, we sought to evaluate the psychometric properties of the Time-Sensitive ADHD Symptom Scale (TASS) as a self-report assessment tool to assess change of ADHD symptoms during the day in adolescents with ADHD. Although comprehensive analyses of the TASS in adolescent ADHD have not been published, the TASS was able to measure potential effects of medication through the day in adults with ADHD in a placebo-controlled trial of triple-beaded mixed amphetamine salts. The primary objectives of the current study were:

1. Evaluate the internal consistency of the TASS.
2. Examine the concurrent validity of the TASS by comparing it with the clinician-administered ADHD-RS-IV.
3. Examine the stability of the TASS over time in measuring ADHD symptoms.

**Methods**

**Study Participants**

Adolescents aged 13 to 17 years who met Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) criteria for ADHD, as determined by DSM-based clinician evaluation and the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS), were eligible to participate in the study. Adolescents with an active psychotic disorder or an inability to reliably report ADHD symptoms as determined by study investigators were excluded. Participants were recruited from responders to advertisements in local media, professional referrals for evaluation of ADHD, or patients already receiving treatment for ADHD at the study sites.

**Rating Scales**

The TASS is a time-sensitive, self-report scale designed to assess change in ADHD symptom severity over the course of a day. The scale was developed over several years of clinical examination and treatment of patients at the ADHD Program at the NYU School of Medicine and the Pediatric Psychopharmacology Research Program at the Massachusetts General Hospital. The TASS, which is derived from the ADHD-RS and the ADHD Self-Report Scale (ASRS) version 1.1 Symptom Checklist, consists of 18 items that correspond to the 18 ADHD symptom domains listed in DSM-IV-TR, with modification of the wording for each item to allow for the assessment of ADHD symptoms during the day. For example, the symptom domain “often loses things necessary for tasks or activities” becomes “how much difficulty are you having because of misplacing things?” on the TASS; the symptom domain “often fidgets with hands or feet or squirms in seat” becomes “how much are you fidgeting or squirming with your hands or feet?” on the TASS. Each item is scored on a 4-point scale as follows: 0 (none), 1 (mild), 2 (moderate), and 3 (severe); the maximum total score is 54, and the total score for both the inattentive and hyperactive/impulsive subscales is 27. Additionally, a “not applicable” response is provided as an option, as the assessment window is relatively brief and the responder may not have experienced a particular symptom during that time. Although many self-report ADHD scales, such as the ASRS v1.1 Symptom Checklist, have frequency-based metrics, the TASS was designed to be rated on a severity basis. The scale was designed in this manner because a frequency-based measure (such as how many times per day or per week) would be less appropriate to assess specific symptoms that may not occur frequently during a rating epoch in a given day. Because the TASS was intended to assess symptoms several times during the day, using a frequency-based scale would potentially create a floor effect, as ratings of the frequency of occurrence might be too low to measure change.

The clinician-administered ADHD-RS-IV is an 18-item scale that was designed to assess the frequency and severity of current ADHD symptoms and has been shown to be sensitive to drug effects in clinical trials of adolescent ADHD. Each item directly corresponds with the 18 DSM-IV-TR symptoms of ADHD and is scored on a 4-point scale (0 = none, 1 = mild, 2 = moderate, 3 = severe). A “not applicable” response was included as an option for this study to be consistent with the TASS. All study raters were required to have extensive experience in the assessment of ADHD and to complete a rater training program, details of
which have been previously described,\textsuperscript{39} in order to minimize inter-rater reliability.

**Study Design**

This study was conducted from August 2006 to August 2008 at 2 study sites: 1) the ADHD Program at the NYU School of Medicine and 2) the ADHD Clinical Trials Program at Mount Sinai School of Medicine. The study received Institutional Review Board approval by the local board at each site. The study was conducted in accordance with International Conference on Harmonization Guidelines for Good Clinical Practice and ethical principles originating in or derived from the Declaration of Helsinki. All parents and adolescents provided written informed consent and assent, respectively, prior to initiating the study.

Participants were screened for eligibility and enrolled in the study at visit 1. Eligible participants completed either 1 or 2 visits that occurred 1 to 9 weeks apart. Participants were not required to complete both visits. The TASS and ADHD-RS-IV were completed twice at each visit: 1) at the time of the participant’s clinic visit (“in-clinic” assessment); and 2) 2 to 6 hours after the in-clinic assessment (“evening” assessment). Study raters contacted participants via telephone at a prearranged time to collect the data from the evening TASS rating and to perform the evening ADHD-RS-IV rating. Participants were instructed to complete the TASS based on how they felt over the preceding few hours at all visits. For the in-clinic assessments, the ADHD-RS-IV was completed based on the preceding month at visit 1 and the interval of time between visits at visit 2; for the evening assessments, the ADHD-RS-IV was completed based on the preceding few hours.

**Statistical Analysis**

Cronbach’s alpha\textsuperscript{40} was used to assess the internal consistency of the TASS. Pearson’s correlation coefficients and the kappa coefficient of agreement were calculated to assess the concurrent validity and item-by-item agreement, respectively, between the TASS and ADHD-RS-IV. Analyses of concurrent validity and item-by-item agreement were computed using data collected from the evening assessments only as these ratings assessed the same epoch. All “not applicable” responses were considered missing data points, so total mean item scores for the TASS and ADHD-RS-IV were used when calculating concurrent validity and item-by-item agreement. To examine the change in TASS scores over time, we used a repeated-measures generalized estimating equations (GEE) model. This analysis determined if TASS scores changed between visits or between assessment time within visits. We also tested for an interaction between visit and time. Additionally, we repeated the GEE analysis with the ADHD-RS-IV scores.

**Results**

A total of 40 participants were enrolled; 45% (n = 18) completed all visits. The mean age of participants was 14.9 ± 1.5 standard deviation (SD) years; 75% of the sample was male. 67.5% identified themselves as Caucasian, 10% as African American, 12.5% as Hispanic, 5% as Asian American, 2.5% as American Indian, and 2.5% as other/mixed ethnicity. The mean socioeconomic status, as determined by the Hollingshead Four Factor Index of Social Status scale,\textsuperscript{41} was 46.8 ± 10.9 SD. Seventy percent (n = 28) were currently receiving medication for ADHD. All participants receiving medication were treated with either sustained-release psychostimulants and/or atomoxetine. All individuals who received sustained-release psychostimulants took the initial dose in the morning and 7 of them received a supplemental afternoon dose of an immediate-release psychostimulant. Additionally, 10% (n = 4) received antidepressant medications and 10% (n = 4) received anxiolytic medications for comorbid psychiatric disorders.

27.1% of the TASS ratings and 16.9% of the ADHD-RS-IV ratings had ≥ 1 item rated as “not applicable.” 20.3% of the TASS ratings and 8.5% of the ADHD-RS-IV ratings had

<table>
<thead>
<tr>
<th>Table 1. TASS and ADHD-RS-IV Means (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visit 1</strong></td>
</tr>
<tr>
<td><strong>In-clinic</strong></td>
</tr>
<tr>
<td>TASS Total Score</td>
</tr>
<tr>
<td>TASS Inattentive Score</td>
</tr>
<tr>
<td>TASS Hyperactive/Impulsive Score</td>
</tr>
<tr>
<td>ADHD-RS-IV Total Score</td>
</tr>
<tr>
<td>ADHD-RS-IV Inattentive Score</td>
</tr>
<tr>
<td>ADHD-RS-IV Hyperactive/Impulsive Score</td>
</tr>
</tbody>
</table>

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ADHD-RS-IV, ADHD Rating Scale; SD, standard deviation; TASS, Time-Sensitive ADHD Symptom Scale.
multiple items rated as “not applicable.” The mean and SD of the TASS and ADHD-RS-IV total item scores, as well as the inattentive and hyperactive/impulsive subscale scores, are reported in Table 1.

Internal consistency of TASS items was high, with Cronbach’s alpha coefficients of 0.91 (in-clinic) and 0.90 (evening) at visit 1, and 0.88 (in-clinic) and 0.86 (evening) at visit 2. Pearson’s correlation coefficients between mean item scores for the TASS and ADHD-RS-IV were significant for visit 1 (r = 0.81; P < 0.0001), visit 2 (r = 0.77; P < 0.0001), and visits 1 and 2 combined (r = 0.82; P < 0.0001). The item-by-item analysis between the TASS and ADHD-RS-IV showed moderate to high agreement for individual items at visit 1 (36.4%–65.9%) and visit 2 (72.7%–97.7%), and statistically significant kappa coefficients for all items (Table 2).

For the repeated-measures GEE analysis of the TASS, there was not a significant effect between ratings performed at different visits (P = 0.936). There was a significant effect of the assessment time within a visit on TASS scores (P < 0.0001). There was not a significant visit by time of assessment interaction (P = 0.924). For the GEE analysis of the ADHD-RS, there was a significant effect between ratings performed at different visits (P = 0.024) and for the assessment time within a visit (P < 0.046). There was not a significant visit by time of assessment interaction (P < 0.052; Table 3).

**Discussion**

The TASS showed high internal consistency and high concurrent validity with the clinician-administered ADHD-RS-IV, although the 2 scales are clearly not identical. Pearson’s correlation coefficients indicate that the shared variance is only 20% to 25%. It was not surprising that the TASS showed only moderate item-by-item agreement with the ADHD-RS-IV, as the TASS uses modified, time-specific language. There was also a moderate discrepancy in the item-by-item agreement between visits 1 and 2. Some of the discrepancy may have resulted from the effects of treatment, a change in the performance of certain items with repeat examination, or greater awareness of symptoms as they improve with treatment. In general, a ≥ 30% reduction in the total ADHD-RS-IV score is considered to represent significant clinical improvement and we expect a similar construct to apply to the TASS.

Regarding the stability of TASS scores over time, the significant differences between TASS ratings within the same day was likely due to the intraday variability in the

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**Table 2. Inter-rater Reliability of Symptom Ratings by Participants (TASS) and Raters (ADHD-RS-IV)**

<table>
<thead>
<tr>
<th>TASS Symptom Domains</th>
<th>Visit 1 % Agreement</th>
<th>Kappa</th>
<th>z-Score</th>
<th>P Value</th>
<th>Visit 2 % Agreement</th>
<th>Kappa</th>
<th>z-Score</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Failure to give close attention to details/makes careless mistakes</td>
<td>43.2</td>
<td>0.242</td>
<td>3.06</td>
<td>&lt; 0.003</td>
<td>79.5</td>
<td>0.621</td>
<td>6.06</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>2. Fidgety</td>
<td>63.6</td>
<td>0.513</td>
<td>6.47</td>
<td>&lt; 0.001</td>
<td>97.7</td>
<td>0.960</td>
<td>9.04</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>3. Difficulty sustaining attention</td>
<td>43.2</td>
<td>0.261</td>
<td>3.47</td>
<td>&lt; 0.002</td>
<td>79.5</td>
<td>0.645</td>
<td>6.48</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>4. Leaves seat when sitting is expected</td>
<td>52.3</td>
<td>0.326</td>
<td>4.02</td>
<td>&lt; 0.001</td>
<td>84.1</td>
<td>0.707</td>
<td>6.08</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>5. Difficulty concentrating</td>
<td>59.1</td>
<td>0.459</td>
<td>5.98</td>
<td>&lt; 0.001</td>
<td>72.7</td>
<td>0.617</td>
<td>6.63</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>6. Runs about or climbs</td>
<td>65.9</td>
<td>0.432</td>
<td>5.29</td>
<td>&lt; 0.001</td>
<td>77.3</td>
<td>0.617</td>
<td>6.63</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>7. Not following through on instructions or failing to finish work</td>
<td>56.8</td>
<td>0.399</td>
<td>4.90</td>
<td>&lt; 0.001</td>
<td>72.7</td>
<td>0.496</td>
<td>4.85</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>8. Difficulty playing quietly or engaging in leisure activities quietly</td>
<td>59.1</td>
<td>0.386</td>
<td>4.53</td>
<td>&lt; 0.001</td>
<td>84.1</td>
<td>0.723</td>
<td>6.99</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>9. Difficulty organizing</td>
<td>50.0</td>
<td>0.326</td>
<td>4.16</td>
<td>&lt; 0.001</td>
<td>77.3</td>
<td>0.594</td>
<td>6.13</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>10. “On the go” or driven by a motor</td>
<td>61.4</td>
<td>0.449</td>
<td>5.40</td>
<td>&lt; 0.001</td>
<td>86.4</td>
<td>0.745</td>
<td>6.23</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>11. Avoids tasks that require sustained attention</td>
<td>36.4</td>
<td>0.195</td>
<td>2.77</td>
<td>&lt; 0.01</td>
<td>79.5</td>
<td>0.647</td>
<td>7.13</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>12. Talks excessively</td>
<td>61.4</td>
<td>0.395</td>
<td>4.56</td>
<td>&lt; 0.001</td>
<td>86.4</td>
<td>0.749</td>
<td>7.00</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>13. Losing things necessary for tasks or activities</td>
<td>61.4</td>
<td>0.431</td>
<td>5.13</td>
<td>&lt; 0.001</td>
<td>84.1</td>
<td>0.718</td>
<td>6.86</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>14. Blurs out answers before questions are completed</td>
<td>61.4</td>
<td>0.367</td>
<td>4.44</td>
<td>&lt; 0.001</td>
<td>84.1</td>
<td>0.706</td>
<td>6.54</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>15. Easily distracted</td>
<td>63.6</td>
<td>0.512</td>
<td>6.31</td>
<td>&lt; 0.001</td>
<td>77.3</td>
<td>0.620</td>
<td>6.71</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>16. Difficulty waiting</td>
<td>63.6</td>
<td>0.439</td>
<td>5.12</td>
<td>&lt; 0.001</td>
<td>81.8</td>
<td>0.629</td>
<td>5.50</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>17. Forgetful in daily activities</td>
<td>45.5</td>
<td>0.265</td>
<td>3.42</td>
<td>&lt; 0.002</td>
<td>77.3</td>
<td>0.467</td>
<td>3.87</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>18. Interrupts or intrudes on others</td>
<td>59.1</td>
<td>0.403</td>
<td>4.65</td>
<td>&lt; 0.001</td>
<td>86.4</td>
<td>0.747</td>
<td>6.60</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ADHD-RS-IV, ADHD Rating Scale; TASS, Time-Sensitive ADHD Symptom Scale; SD, standard deviation.
Validation of the TASS in Adolescents with ADHD

The TASS is designed to measure symptom change over the course of days or weeks; rather, the TASS is intended to replace other validated, clinician- and self-administered ADHD scales; 3) the TASS in larger samples of adolescents with ADHD, with and without comorbidities (eg, mood disorders, anxiety disorders, or substance use disorders); and 4) the potential effect of ratings conducted later in the day, with a longer inter-epoch rating time.

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Conflict of Interest Statement
Lenard A. Adler, MD has received grant/research support from the following sources: Bristol-Myers Squibb, Chelsea Therapeutics, Eli Lilly & Company, National Institute of Drug Abuse, Ortho McNeil/Janssen/Johnson & Johnson, Pfizer Inc, and Shire Laboratories, Inc. Dr. Adler has been a speaker or on the speakers’ bureaus for the following companies: Ortho McNeil/Janssen/Johnson & Johnson and Shire Laboratories, Inc. Dr. Adler has served on the advisory board for Eli Lilly & Company, i3 Research, Major League Baseball, Mindsite, Organon, Ortho McNeil/ Janssen/Johnson & Johnson, and Shire Laboratories, Inc. Dr. Adler has consulted with Epi-Q, INC Research, Major League Baseball Players Association, and United Biosource Corporation. Dr. Adler has received royalty payments (as inventor) from the NYU School of Medicine for license

Table 3. Generalized Estimating Equations (GEE) Analysis

<table>
<thead>
<tr>
<th>Effect</th>
<th>GEE Analysis of TASS</th>
<th>GEE Analysis of ADHD-RS-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>SE</td>
</tr>
<tr>
<td>Visit</td>
<td>−0.406</td>
<td>5.07</td>
</tr>
<tr>
<td>Time</td>
<td>−6.28</td>
<td>1.56</td>
</tr>
<tr>
<td>Visit x Time Interaction</td>
<td>−0.477</td>
<td>4.97</td>
</tr>
</tbody>
</table>

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; ADHD-RS-IV, ADHD Rating Scale; SE, standard error; TASS, Time-Sensitive ADHD Symptom Scale.

efficacy of medication rather than diurnal variability of ADHD symptoms. The majority of the sample was being treated for ADHD, so a test–retest analysis could not be performed because the reduced sample size of the subset of participants not being treated for ADHD (n = 10) would have insufficient power. However, in the forthcoming validation of the TASS for adults with ADHD, there were no significant differences in TASS ratings obtained over the course of the same day in a similar GEE analysis performed with a test–retest analysis could not be performed because the reduced sample size of the subset of participants not being treated for ADHD (n = 10) would have insufficient power. However, in the forthcoming validation of the TASS for adults with ADHD, there were no significant differences in TASS ratings obtained over the course of the same day in a similar GEE analysis performed with a sample size of the same day in a similar GEE analysis performed with a sample size and somewhat short inter-epoch rating time of 2 to 6 hours. Additionally, the sample was primarily referred, the majority of whom were receiving medication for ADHD, which may raise concerns about the potential impact of referral bias and limit generalizability of the results.

The results of this preliminary analysis support the utility of the TASS as a fairly valid and reliable scale to measure fluctuations of ADHD symptoms in adolescents. These findings must be viewed with some caution based on the small sample size and somewhat short inter-epoch rating time of 2 to 6 hours. Additionally, the sample was primarily referred, the majority of whom were receiving medication for ADHD, which may raise concerns about the potential impact of referral bias and limit generalizability of the results.

The TASS is not intended to replace other validated scales, such as the ADHD-RS-IV or CASS-S, as measures of symptom change over the course of days or weeks; rather, the TASS is designed to measure symptom change over the course of a single day. Clinicians should find the TASS useful when planning and evaluating the treatment regimen of adolescents with ADHD, as it provides the assessment of symptoms that occur later in the day, when the duration of effect of even long-acting psychostimulants has been exceeded. Other potential advantages of the TASS are the ease of patient use and context-based, time-specific language. Future research should examine: 1) the sensitivity of the TASS to treatment effects; 2) the TASS compared with other validated, clinician- and self-administered ADHD scales; 3) the TASS in larger samples of adolescents with ADHD, with and without comorbidities (eg, mood disorders, anxiety disorders, or substance use disorders); and 4) the potential effect of ratings conducted later in the day, with a longer inter-epoch rating time.

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References


