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Brief youth self-report screener for tics: Can a subscale of the Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES) identify tic disorders in youth?

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Abstract

Tics are unwanted, repetitive movements and sounds that frequently present during childhood. They are typically brief and purposeless, but can create significant distress for individuals, and often co-occur with other neuropsychiatric conditions. Thus, early identification of tics is warranted. Unfortunately, tics are often misdiagnosed, and because tics may wax and wane, identification can be difficult, especially in the context of routine clinical visits. There are limited tools that can be used to reliably identify tics in clinical practice, especially in non-specialty settings. The purpose of the current study was to evaluate the performance of the Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES), a self-report scale with some support as a screening tool. In addition, the performance of a subset of questions (the MOVES-6) was evaluated for rapid screening. Participants were recruited across two study sites and included children and adolescents diagnosed with Tourette syndrome ($n = 151$) or another persistent tic disorder ($n = 10$) and community controls ($n = 74$). Results suggest both the MOVES and the MOVES-6 have high sensitivity (90% and 88%, respectively) and at least acceptable specificity (77% and 86%, respectively) compared with expert assessment of tic disorders, suggesting that both versions can identify tic disorders without high proportions of false negatives. Both versions were highly sensitive with acceptable specificity regardless of sex, race/ethnicity, and age. The MOVES and MOVES-6 show promise as a screener for tics or tic disorders, but additional research is needed, particularly in a general population setting.

Social Media 200 or Less Character Promotion:

Tic disorders can be easy to miss, but early detection is important. A 6-item youth-report screener might accurately identify many youth with potential tics.

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Keywords

Tourette syndrome; Tics; Screening

Tics are recurrent repetitive movements and/or vocalizations, often preceded by an unpleasant feeling/urge that is briefly relieved following the tic. The average age of tic onset is between 5 and 7 years, though some individuals report tics earlier in childhood (Leckman, 2002). Most tics are brief and purposeless, although they may occur in bouts or orchestrated patterns. Some tics are more complicated, resembling intentional behavior or speech. Tourette syndrome (TS), the presentation of at least two motor tics and one phonic tic for at least 1 year, has a global estimated prevalence of 0.3–0.9% in children and adolescents (Kraft et al., 2012; Scharf et al., 2015). In contrast to Tourette syndrome, tics are believed to be relatively common among youth, with cross-sectional estimates of 25% for tics to be present at some time during childhood or adolescence (Scahill et al., 2014; Snider et al., 2002) with some experts positing that the true rate of youth ever having a tic by 6^{th} grade may be as high as 79% (Black et al., 2016). Notably, tics and Tourette syndrome are generally believed to be biologically related, presenting on a continuum of severity (Claudio-Campos et al., 2021). Tics are associated with functional impairment in school, social interactions, and employment (Cloes et al., 2017; Conelea et al., 2011; Murphy et al., 2013).

As suggested by the wide range of estimates in the literature (Scharf et al., 2015), the true prevalence of tics and tic disorders among children and adolescents is unknown. Although some tics are difficult to conceal due to their intensity or frequency, many cases of tics are likely missed or not recognized. The reasons are likely multifaceted. First, many families may fail to recognize a child’s behavior to be a tic. Second, many families do not seek medical care for tics (Scharf et al., 2012). Third, many tics are misdiagnosed by healthcare providers as sequelae of other conditions such as vision problems, allergies, hyperactivity associated with attention-deficit/hyperactivity disorder (ADHD), or stereotypic movements associated with autism spectrum disorder (Huisman-van Dijk et al., 2016). Children and adolescents with tics have a greater prevalence of conditions such as ADHD, obsessive-compulsive disorder (OCD), anxiety disorders, learning disabilities, mood dysregulation, behavioral disorders (Freeman, 2007; Kurlan et al., 2002; Lewin et al., 2010; Robertson et al., 1988), and risk for future substance abuse (Virtanen et al., 2021) than their peers without tics. Finally, there is a lack of validated screening instruments for tics, especially tools that can be used in primary care/non-specialty settings. Thus, a diagnosis of a tic disorder may be missed or delayed until either the tics or a co-occurring condition becomes problematic. Given that 1) tics are often missed by healthcare providers and 2) tics are associated with increased likelihood of comorbid neuropsychiatric conditions and related impairment, it is important that tics are identified sooner so that individuals can receive treatment if needed.

Although there are several assessment tools for rating tic severity, the field lacks a validated tic screener designed for administration in primary care or non-specialty settings. Existing tools often require expertise in tics, are relatively time-intensive, and consequently, are beyond what can be administered in the context of primary (and often tertiary) office

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visits. Pediatricians are often the first (or only) clinical point of screening (Yadegar et al., 2019) for youth presenting with tics. However, many pediatricians feel underprepared or under-resourced to assess for the presence of tic disorders (Boreman et al., 2007; Marcks et al., 2004). A validated screening instrument for tic identification could allow for efficient, earlier diagnosis and the opportunity to refer to appropriate clinical treatments when needed. Furthermore, validated instruments could be used in future epidemiologic studies to better understand the prevalence of tics and tic disorders.

Performance of self-report and parent-report tic screening instruments may be influenced by potential biases including awareness of tics (Podsakoff et al., 2003) and understanding of tic symptoms/presentation. This may be particularly important in the identification of tic disorders. For example, the Diagnostic Interview Schedule for Children, 4th Edition (DISC-IV; Shaffer et al., 2000), a structured computer-assisted instrument designed to assess the criteria for mental disorders in children according to the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders, Text Revision (DSM-IV; American Psychiatric Association 2000), was used as a standardized measure to identify tic disorders in a pediatric research sample, including 181 youth with TS (Lewin et al., 2014). Notably, all participants with TS were recruited specifically through a Tourette sub-specialty clinic from which they received care (University of South Florida or University of Rochester) due to their diagnostic history of TS. Surprisingly, 53% of youth with TS and 26% of their parents did not endorse the presence of current motor tics (the first interview question). This finding suggests that screeners should not rely on a patient/parent self-identifying symptoms/behaviors explicitly defined as tics, but instead might instead focus on symptom presence consistent with tics (for example, repetitive movements such as purposeless eye blinking or throat clearing).

Few brief screeners for tics disorders (including TS) exist. One tool, the proxy-report questionnaire (PRQ; Linazasoro et al., 2006), is a brief instrument that describes tics and has parents or teachers report whether a child has ever had a tic and if they currently have a tic. The PRQ has been validated as a screening instrument for identifying tic disorders generally but has low sensitivity when relying on a single reporter (Cubo et al., 2011); the measure also requires that the individual identify the symptoms as a tic. Another measure, the Motor tic, Obsessions and compulsions, Vocal tic Evaluation Survey (MOVES; Gaffney et al., 1994) has been identified as a promising screener for tics (Martino et al., 2017). The MOVES is a 20-item self-report screener with items assessing motor tics, vocal tics, obsessions, and compulsions. Scores range from 0 to 60 (items can be rated: Never, Sometimes, Often or Always). The MOVES total score shows good sensitivity (87%) and specificity (94%) with a cutoff score of 10 when determining a diagnosis of TS (Gaffney et al., 1994). Test-retest reliability is 0.40 for the MOVES Total score (this is not unexpected given the marked fluctuation in tic symptoms and may not impact functionality as a screener, especially if the threshold scores are low for identifying youth with tic disorders). In addition, the MOVES tic score has shown to be significantly correlated (r=0.73) with the Yale Global Tic Severity Scale (YGTSS) indicating acceptable convergent validity (Gaffney et al., 1994). The MOVES has not been validated beyond the original study, and due to its length, may not be suitable for brief screening of tics (Martino et al., 2017). However, a subset of tic-focused items from the MOVES may allow for rapid screening for tics with acceptable sensitivity and specificity (referred to as the MOVES-6; see below for a

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description of the procedure). Therefore, the purpose of the current study was to examine the performance of the MOVES full scale and a subset of tic-focused items (the MOVES-6) for potential brief screenings in a sample of children with and without tic disorders across two research sites.

Materials and methods

Study sites

Data for the current study were derived from a larger cross-sectional collaborative effort funded by the Centers of Disease Control and Prevention (5U01DD000504) between the University of South Florida Rothman Center for Neuropsychiatry (USF) and the University of Rochester Pediatric Neurology Tourette syndrome Clinic (UR). The USF and UR sites each have established multi-disciplinary teams well-versed in identification and treatment of tics, TS, and related disorders, such as anxiety, OCD, and ADHD. The overarching aim of the collaboration was to examine the impact of tic disorders among individual children, families, and communities. Other results and detailed study methodology from the current project have been published elsewhere, and there is overlap in the descriptive/sample descriptions (i.e., Augustine et al., 2017; Lewin et al., 2014; Vermilion et al., 2020; Vermilion et al., 2021); however, sample sizes across the reports may vary given the different foci in sub-aims (e.g., only children who completed the MOVES are described in the present study). Research procedures at both sites were approved by respective institutional human subjects' protection boards; parents provided informed consent and youth assented prior to enrollment.

Recruitment

University of Rochester—Children with TS who had received care from the UR Pediatric Neurology outpatient clinic within the past two years were recruited during office visits as well as by mail. Study information was also made available at local Tourette Association of America (TAA) chapter events. Children ages 5–18 years with a confirmed diagnosis of TS by a UR pediatric neurologist (based on DSM-IV-TR criteria) were eligible to participate. Community control participants were recruited using flyers at local pediatric practices, community organizations, and websites, and were matched by age to participants with TS recruited at UR.

University of South Florida—Participants with a clinician-diagnosis of TS, persistent tic disorder (PTD), or tic disorder not otherwise specified, according to DSM-IV-TR criteria (American Psychiatric Association, 2000), were recruited from the normal patient flow at the USF Rothman Center for Neuropsychiatry. Information about the study was also made available at local Florida Tourette Association chapter events. No control participants were recruited at USF.

Participants

Using the populations described above, a sample of children with clinician-diagnosed TS (n = 151) or other persistent tic disorder (n = 10) and healthy controls (n = 74) were recruited at USF and UR between 2009–2012. Most participants were white (87% of the complete study

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sample), non-Hispanic (89%), and male (66%). Neuropsychiatric conditions such as ADHD, OCD, anxiety, and major depressive disorder were identified using the DISC-IV-TR (Shaffer et al., 2000). Comorbid conditions were significantly more likely to occur in the tic disorder sample when compared to controls (Augustine et al., 2017).

Procedure and measures

Across both sites, families completed a single 3–5-hour study visit that included evaluation by board-certified experts, semi-structured interviews, and a battery of self- and parent-report rating scales.

YGTSS and tic disorder diagnosis—Trained doctoral-level clinicians administered the YGTSS (see Augustine et al., 2017 for full description of study instruments and in-depth information on YGTSS training). The YGTSS is a clinician-rated semi-structured interview and is considered the gold-standard measure of tic severity (Leckman et al., 1989; Scahill et al., 2014). Motor and phonic tics are rated separately according to five domains: number, frequency, intensity, complexity, and interference. The domain ratings are summed to create a severity score, with scores ranging from 0 to 50 if both motor and phonic tics are present (0 to 25 if only motor or phonic tics). An impairment score is also rated on a scale 0 to 50, indicating life impairment due to tics. Parents and children were interviewed together and asked about motor and phonic tics from the past week.

Tic disorder diagnosis was determined via a comprehensive process described in Lewin et al. (2014). Physicians and/or psychologists with expertise in tics reviewed each case and any disagreement was reviewed in a consensus panel discussion. This consensus diagnosis was used to determine if they met criteria for a tic disorder (i.e., the gold standard for whether a child had TS/tic disorder for purposes of evaluating screener performance).

MOVES and MOVES-6—Child participants aged 7 years and older completed the MOVES, a 20-item self-report measure rating the presence and frequency of tics, obsessions, and related concerns from the past week on a 4-point scale from 0 (never) to 3 (always; Gaffney et al., 1994). The total score is the sum of all items (Cronbach’s alpha = 0.92 for this sample). For this study, items 1, 2, 6, 10, 13 and 16 were selected from the MOVES as a shortened version referred to as the MOVES-6 (alpha = 0.85 for the current sample) for a secondary analysis. These items were chosen from the eight tic-focused items on the MOVES based on rates of endorsement among youth with tics and type of tic (see Table 1).

Item 13 was included so that there were at least two phonic-tic items. We selected item 13 instead of item 12 because the majority of individuals with tic disorders do not have coprolalia (involuntary use of obscene language), and several studies suggest coprolalia may not emerge until at least 5 years after first tic onset, is typically associated with more severe tics (Freeman et al., 2009; Goldenberg et al., 1994; Robertson et al., 1988), and is almost never the only tic symptom (Robertson, 2000). Item 13 was selected over item 5 because of slightly higher endorsement by youth with tics and the wording captured aspects of the premonitory tic urge.

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Analysis

Receiver operating characteristic (ROC) analysis was used to evaluate the optimal cut-point for the MOVES and the MOVES-6 and the area under the curve (AUC) was used to describe the success of the MOVES and MOVES-6 in predicting whether the child had a tic disorder or not. AUC greater than 0.9 are considered highly accurate (Swets, 1988). Two variants of clinical groups were considered: youth with clinically diagnosed TS, as well as youth with any persistent tic disorder (including TS). For analyses of TS, the 10 youth with persistent tic disorder were excluded. A sensitivity analysis was performed to determine whether results differed when the youth with persistent tic disorders were included. Consequently, we included youth with persistent tic disorders and TS in all subsequent analyses (see below). The Youden index (J), sensitivity, and specificity guided selection of the best cut point for correctly identifying tic cases (Fluss et al., 2005; Liu, 2012). The Youden Index is the product of false positive and false negatives subtracted from the product of the true positives and true negatives divided by the product of the total number identified as having a condition and the total number identified as not having the condition (Youden, 1950). While the Youden Index maximizes balance between sensitivity and specificity, the optimal cutoff might be determined by other factors (Fluss et al., 2005; Pickering, 1991). The cost of false negatives versus false positives might differ based on intended uses (Greiner et al., 2000). For example, in screening where the cost of missing cases is problematic, a higher sensitivity could be prioritized.

Finally, to evaluate whether the MOVES or MOVES-6 differentially predicted whether a child had a tic disorder as a function of age, sex, or race, we computed logistic regressions with tic disorder (presence or absence) as the outcome and an interaction between the MOVES score and the potential modifier, including lower order terms. A significant interaction would indicate that the MOVES varied as a function of these demographic characteristics. All analyses used an alpha of 0.05 as the criterion for statistical significance.

Results

We examined receiver operating characteristic (ROC) curves to assess classification ability of the full-scale MOVES and MOVES-6 for (a) TS only versus Controls and (b) All persistent tic disorders versus Controls. *TS-Only versus Controls*: For the full-scale MOVES index, the AUC was outstanding (0.92; 95% CI = 0.88 – 0.96) and the optimal cut-point (based on Youden's J) was a threshold score of 5, resulting in a sensitivity of 89% (95% CI = 79% - 91%), and a specificity of 77% (95% CI = 66% - 86%). Similarly, the MOVES-6 classification was outstanding (AUC = 0.95; 95% CI = 0.92 – 0.97) and the optimal cut-point (balancing sensitivity and specificity using Youden's J) was 3, resulting in a sensitivity of 88% (95% CI = 77% - 90%), and a specificity of 86% (95% CI = 77% - 93%).

All persistent tic disorders versus Controls:

The analyses were recomputed with any persistent tic disorder as the diagnostic outcome (including youth with other persistent tics disorders besides TS [n = 10]) versus Controls. Using the full-scale MOVES index, the classification accuracy was outstanding (AUC = 0.92; 95% CI = 0.88 – 0.95) and the optimal cut-point of 5 resulted in a sensitivity of 90%

(95% CI = 82% – 93%), and a specificity of 77% (95% CI = 65% – 86%). Similar results were seen for the MOVES-6 with outstanding classification accuracy (AUC = 0.95; 95% CI = 0.92 – 0.97) and an optimal cut-point of 3 corresponded to a sensitivity of 88% (95% CI = 81% – 92%), and a specificity of 86% (95% CI = 76% – 93%). Given the nearly identical performance, the remainder of the analyses are presented based on youth with any persistent tic disorder (including TS). The ROC curve for evaluating full-scale MOVES and MOVES-6 in separating youth with any tic disorder from Controls are presented in Figures 1 and 2 respectively. Tables 2 and 3 present several relevant metrics for full-scale MOVES and MOVES-6 (respectively), at various cutoffs including: sensitivity; specificity; Youden's J; totals of true positives, true negatives, false positives, and false negatives; and accuracy (% of cases correctly classified).

Additional analyses examined whether age (considered as a continuous variable), sex (male, female), and race (White, non-White) impacted the ability of the MOVES total score to predict whether the child had a tic disorder. None of the interactions for sex ($p = 0.797$), race ($p = 0.459$), or age ($p = 0.873$) were statistically significant, which indicated that none of the demographic characteristics impacted the predictive power of the MOVES total score in this sample. A similar pattern of results was observed when the MOVES-6 served as the predictor variable. The analyses indicate that the effectiveness of the full-scale MOVES Total score or MOVES-6 index did not vary as a function of the demographic factors examined here at alpha <0.05. Both the full-scale MOVES Total score ($r = 0.68$, $p < .001$) and MOVES-6 ($r = 0.73$, $p < .001$) were strongly correlated with YGTSS (total tic severity); the full-scale MOVES Total score and MOVES-6 were strongly correlated with each other ($r = 0.87$, $p < .001$).

Discussion

Results of the present study suggest the full-scale MOVES and the MOVES-6 performed well at predicting whether a child had a tic disorder in the present sample. For both, the AUC exceeded 0.9, suggesting highly accurate classification in this sample (Swets, 1988). The performance of the full-scale MOVES was similar to that reported in the original study by Gaffney (1994). It is not surprising that the MOVES-6 performed slightly better than the full-scale MOVES for identifying tic disorders because the full scale MOVES also includes indicators of obsessions and compulsions which were not included on the MOVES-6. The high correlation of the MOVES-6 with YGTSS total tic severity in our study was the same as the correlation Gaffney et al. (1994) reported for all eight MOVES tics-related items with the YGTSS ($r = 0.73$), providing additional evidence for the validity of the measure in identifying tics. Notably, the MOVES/MOVES-6 outperformed the DISC-IV diagnostic interview used in the same sample (see Lewin et al., 2014). This might suggest use of a symptom-based approach to screening wherein items describing specific behaviors/feelings ("parts of my body jerk") may better identify tics than items that name "tics" specifically.

One finding that differed substantially from the original paper by Gaffney et al. (1994) is the cutoff scores for maximizing sensitivity and specificity. The original paper using the full MOVES identified cutoff scores of 10 or 15 for maximizing sensitivity and specificity, respectively. In the current study, with a larger sample size, the cutoff for the

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full-scale MOVES to balance sensitivity and specificity (Youden's J) was 5 (J is equivalent for cutoffs of 5–7, but percent accuracy of classification decreases after 6). While both studies used expert assessment as the gold-standard for determining whether a child had a tic disorder, the current study used community controls whereas Gaffney et al. (1994) recruited psychiatric controls (patients recruited via outpatient psychiatry clinics). This might contribute to the lower cutoff in the current study because our controls were not from a psychiatric group. Notably, overall accuracy is nearly equivalent for cutoffs of 3–7 for the full-scale MOVES (80.0–82.7% classification accuracy). For the MOVES-6, the Youden J index suggests 3 to be the cutoff to best balance sensitivity and specificity. Notably, accuracy is roughly equivalent for cutoffs between 2 and 3 for the MOVES-6 suggesting similar overall performance (84.9–85.7% classification accuracy). The Youden index suggests optimal cutoffs balanced between sensitivity and specificity but does not consider the "costs" of either type of classification error, the comparison group, or the prevalence rate (Greiner et al., 2000). Thus, identifying the specific cutoff is dependent on the aim and tolerance of respective classification errors and the intended use.

Determining the best cutoff score can also be informed by the purpose of implementing the screener. For example, to maximize detection, a cutoff of 1 for the full-scale MOVES would result in an increase in sensitivity to 95% (versus 85% at cutoff of 6); false negatives would be reduced by 68% (n = 15) with only 6% decrease in overall accuracy of classification. However, there would be a 65% increase in false positives (n = 32). This tradeoff might be appropriate in situations such as risk screenings: for risk screening in clinical situations, a low cutoff may be optimal because a low cutoff maximizes sensitivity and limits the number of false negatives (limits missed cases of tic disorders). Since tic disorders may be under diagnosed and have a relatively low base-rate, a screener with high sensitivity may be needed to increase identification of tic disorders without missing true positives (Greiner et al., 2000). This may lead to some over-identification of children without tics or tic disorders. However, if specificity is good, cases can be reviewed and re-classified via higher-burden assessments such as a physician or psychologist assessment/interview, or possibly a self-reported diagnostic measure (Adams, et al., 2022). If the intended use is to screen for clinical trial inclusion, a higher cutoff may be desired to avoid moving forward with costly and time-intensive evaluation procedures to reduce human subject burden. In summary, the intended use of the MOVES or MOVES-6 can impact the ideal cutoff for differentiating between cases with tics and without.

For this study, the MOVES was only completed by participating children and teens. When examining the performance of the PRQ screener for an epidemiologic study in a general school population, its sensitivity for identifying children with tic disorders improved with two reporters (parent and teacher) and even more so with two reporters and a 2-hour classroom observation of the child by an individual trained to identify tics (Cubo et al., 2011). Thus, combining multiple reporters might improve the performance of the MOVES or MOVES-6 in general population settings. In addition, the use of two measures (e.g., screening and diagnostic assessments) might also improve performance depending on resources available for the latter.

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Limitations

The present study has several limitations. First, this study examines how well the MOVES/MOVES-6 distinguished between recruited controls and youth with known tic disorders and may not be generalizable to other populations. Further study to test how well these instruments can identify youth with tics who may not have a historical or current tic disorder diagnosis would inform how well this measure performs in a general population setting. The findings are promising but testing in a non-tic disorder population and examining, specifically, how well the scales identify any tic presentation (versus any persistent tic disorder) is a next logical step. Additionally, the MOVES-6 item selection was drawn from the same sample used to examine its performance to separate controls from tic disorder cases; however, it is encouraging that the findings reported here are similar to those reported from the original study on the MOVES (Gaffney et al., 1994). Next, youth with tic disorders were selected from tic-specialty clinics. It is unclear how well the MOVES-6 will perform in a non-specialty pediatric clinic, school, or other heterogeneous sample in identifying children with tics or tic disorders who are unaware of the symptoms as tics. In Gaffney's 1994 study, the MOVES could distinguish children with tic disorders from those in a control group recruited from a psychiatric clinic. Given the small sample size, we may not have been able to detect interaction by demographic characteristics. Additionally, sensitivity is influenced by participants' awareness of whether they had tics or tic-like movements or sounds at some point (for endorsement on the MOVES self-report). Given that children may lack this awareness may mean that the questionnaire overestimates sensitivity to detect tic disorder unknown to the children. Finally, the study design (with an over-representation of children with previously diagnosed tic disorders) prevented us from calculating positive predictive value and negative predictive value.

Next Steps

Overall, the performance of the MOVES and MOVES-6 is promising as a brief screener that could be used as a first step to identify children with tics or tic disorders. Both are brief and easy to score, which are benefits to screening instruments; additionally, these measures could be useful for screening for tics in large epidemiologic studies. Evaluation of the MOVES-6 in a general clinical or other community setting with a diverse sample could inform the utility of adopting the MOVES-6 screener. The MOVES and MOVES-6 only assess for the presence and frequency of tics, and although it performed well in predicting whether a child had a tic disorder in the current study, it does not include an assessment of other diagnostic criteria for tic disorders. Thus, additional follow-up assessment could be paired with the MOVES or MOVES-6 for determining whether individuals meet criteria for a tic disorder.

Summary

The MOVES and shortened MOVES-6 offer rapid screening for tic identification for a variety of uses. Choosing the best cutoff score depends on the purpose for screening. Low cutoffs allow for missing very few true cases of tic disorders. This study suggests that as few as 6 brief self-report screening questions can identify tic disorders versus controls

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without tics with high accuracy. The performance of reduced (6-item MOVES-6) format is significant for future use in non-specialty settings or for inclusion in larger batteries (e.g., with questions screening for a variety of concerns); efficiency is important in limited-resource settings. Given the high rates of psychiatric problems in youth with tics, simple and early identification is important. Incorporating a tic screener that has been validated in a general population setting into annual pediatrician visits may help identify cases before downstream impairment develops.

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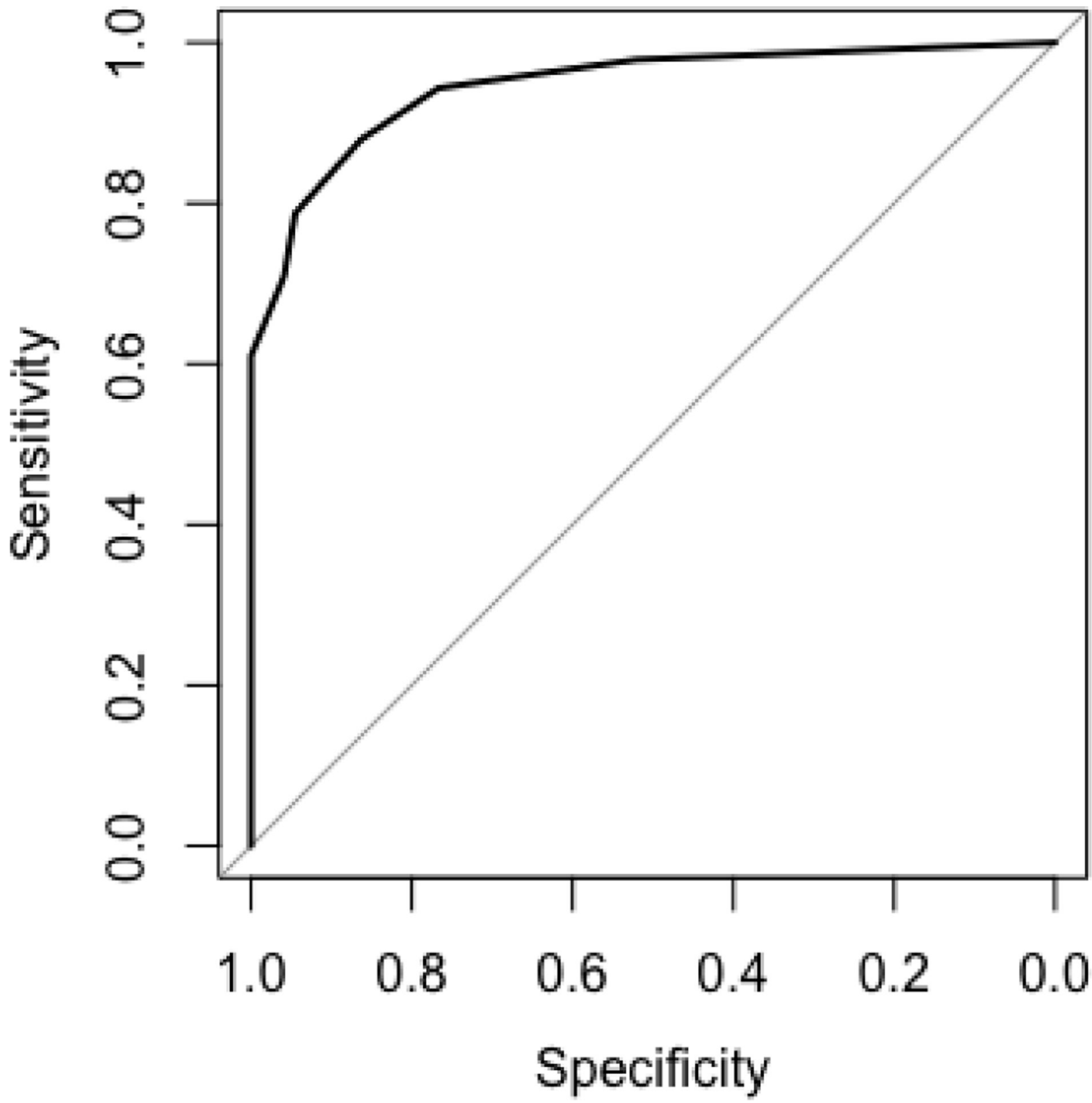

Figure 1.
Area under the curve for full-scale Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES) Total Score Predicting any Tic Disorder versus controls based on expert clinical assessment

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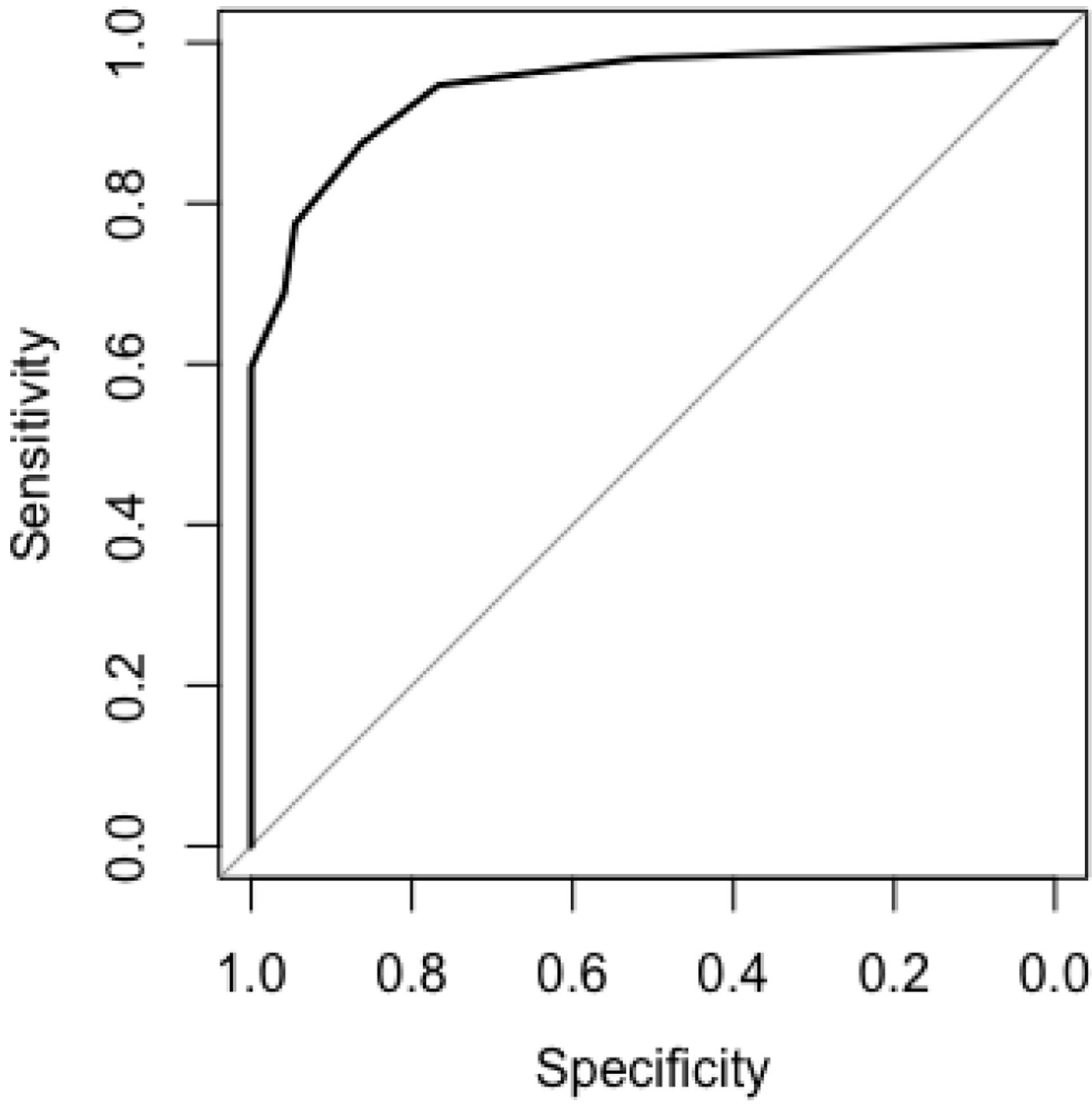

Figure 2.

Area under the curve for the 6-item Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES-6) Predicting any Tic Disorder versus controls based on expert clinical assessment

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Table 1.

Selection of tic items from the full Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES) *for MOVES-6.*

Item#	Content	Tic Type	% Endorsement by:	
			youth with tics	youth without tics (controls)
1*	I make noises (like grunts) that I can't stop	Phonic	70.1	10.6
2*	Parts of my body jerk again and again, that I can't control	Motor	65.5	6.8
5	Words come out that I cannot control	Phonic	34.5	2.8
6*	At times I have the same jerk or twitch over and over	Motor	75.3	6.8
10*	I can't control all my movements	Motor	74.4	8.2
12	Bad or swear words come out that I don't mean to say	Phonic	49.5	13.7
13*	I feel pressure to talk, shout or scream	Phonic	40.7	20.5
16*	I have habits or movements that come out more when I'm nervous	Motor	66.5	31.5

Note.

* Indicates items retained in the MOVES-6.

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Table 2.

Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and Accuracy for the Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES) compared with expert clinical assessment by cutoffs

Cutoff	Sensitivity	Specificity	Youden Index	TP	FP	FN	TN	Accuracy
0	100%	0%	0.00	144	73	0	0	66%
1	100%	33%	0.33	144	49	24	0	77%
2	99%	44%	0.42	142	41	32	2	80%
3	97%	63%	0.60	139	27	46	5	85%
4	93%	70%	0.63	134	22	51	10	85%
5*	90%	77%	0.66	129	17	56	15	85%
6	86%	79%	0.66	124	15	58	20	84%
7	82%	84%	0.66	118	12	61	26	82%
8	78%	84%	0.62	113	12	61	31	80%
9	76%	86%	0.62	109	10	63	35	79%
10	74%	90%	0.64	106	7	66	38	79%
11	69%	90%	0.60	100	7	66	44	76%
12	67%	93%	0.60	96	5	68	48	76%
13	59%	96%	0.55	85	3	70	59	71%
14	52%	97%	0.49	75	2	71	69	67%
15	47%	99%	0.45	67	1	72	77	64%
20	28%	100%	0.28	41	0	73	103	53%
25	18%	100%	0.18	26	0	73	118	46%
35	9%	100%	0.09	13	0	73	131	40%
45	1%	100%	0.01	1	0	73	143	34%

TP=true positives; FP=false positives; FN=false negatives; TN=true negative;

* We identified a cut-off of 5 as optimal for balancing sensitivity and specificity; Other cutoffs may be chosen based on the intended use of the screener.

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Table 3.

Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and Accuracy for the 6-item Motor tic, Obsession and compulsion, and Vocal tic Evaluation Survey (MOVES-6) compared with expert clinical assessment by cutoffs

Cutoff	Sensitivity	Specificity	Youden Index	TP	FP	FN	TN	Accuracy
0	100%	0%	0.00	144	73	0	0	66%
1	98%	52%	0.50	141	35	38	3	82%
2	94%	77%	0.71	136	17	56	8	88%
3*	88%	86%	0.74	127	10	63	17	88%
4	79%	95%	0.74	114	4	69	30	84%
5	71%	96%	0.67	102	3	70	42	79%
6	61%	100%	0.61	88	0	73	56	74%
7	51%	100%	0.51	74	0	73	70	68%
8	43%	100%	0.43	62	0	73	82	62%
9	39%	100%	0.39	56	0	73	88	59%
10	28%	100%	0.28	41	0	73	103	53%
15	3%	100%	0.03	4	0	73	140	35%
18	1%	100%	0.01	1	0	73	143	34%

TP=true positives; FP=false positives; FN=false negatives; TN=true negatives

* We identified a cutoff as 3 as optimal for balancing sensitivity and specificity; Other cutoffs may be chosen based on the intended use of the screener.