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Screening for motor coordination challenges in children using teacher ratings of physical ability and activity

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Abstract

We examined the effectiveness of a teacher-based rating scale called the teacher estimation of activity form (TEAF) to screen for developmental coordination disorder (DCD) in children. A random selection of 15 of 75 schools from the District School Board of Niagara in Ontario, Canada was chosen for this study. Every consented child in Grade 4 ($n = 502$) was evaluated for probable DCD (*p*DCD) in school using the short form Bruininks–Oseretsky test of motor proficiency (BOTMP–SF). Each student also completed the children's self perceptions of adequacy in and predilection toward physical activity (CSAPPA) scale, participation questionnaire, and Léger 20-meter shuttle run, and had their height and weight measured. The 27 children (5.1%) who scored below the 5th percentile on BOTMP–SF were designated as *p*DCD cases and the 475 children who scored above the 5th percentile served as controls. Results showed that mean TEAF scores were significantly lower for *p*DCD children than controls ($p < .001$). Total TEAF scores ranging from 28 to 32 were preferred in maintaining good sensitivity (.74, 95% CI = .55–.87 to .85, 95% CI = .68–.94). The area under the ROC curve was .77 (95% CI, .68–.86) for the TEAF total score, and some individual items performed approximately as well as the full scale. The TEAF was positively correlated with measures of physical activity and fitness. The TEAF appears to be an effective tool in screening for DCD,

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particularly in a population setting. Considering the brevity of the TEAF and the discriminative power of individual items, this instrument would be effective in an abbreviated version.
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1. Introduction

Developmental coordination disorder (DCD) is characterized by poor motor proficiency, resulting in a significant impairment in social and academic functioning, and is not the result of another psychiatric, neurological, or other medical condition (American Psychiatric Association, 2000). Developmental coordination disorder is common, affecting 5–6% of school-aged children (American Psychiatric Association, 2000; Kadesjo & Gillberg, 1998). If identified early, the physical health, academic, and emotional needs of affected children can be addressed and negative experiences prevented (Polatajko, Fox, & Missiuna, 1995; Schoemaker et al., 2006). The potential for improved quality of life justifies efforts to screen for and identify children with DCD in non-clinical settings (Hay, Hawes, & Faught, 2004). Screening for DCD in school-based settings, therefore, is of particular importance since most children, especially in Canada, are enrolled in the formal school system. Motor testing, however, is both time consuming and expensive, which has lead some to conclude that questionnaire-based assessments may be more practical for screening purposes (Cairney et al., 2007; Schoemaker, Smits-Engelsman, & Jongmans, 2003). To that end, several measures have been tested using child (Cairney et al., 2007; Hay et al., 2004), parent (e.g., DCDQ) (Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000) and teacher completed measures (Junaid, Harris, Fulmer, & Carswell, 2000; Schoemaker et al., 2003; Wright & Sugden, 1996). Teachers in particular may be especially important in screening for motor coordination problems in children. For one, teachers have a unique opportunity to observe children engaging in different play (e.g., recess) and scholastic (e.g., handwriting) activities, and therefore have an advantage not common to other professionals. In this paper, we explore the potential of teacher ratings in the identification of motor coordination problems in children aged 9–11 using a structured questionnaire that assesses physical activity and ability.

As Larkin and Rose (2005) note, studies using teachers' reports (observations and checklists) to screen for disorder have produced uneven results, with some studies showing promise (Henderson & Hall, 1982; Hoare & Larkin, 1991) and others not (Gubbay, 1975; Morris & Whiting, 1971; Revie & Larkin, 1993). The different methodologies used across these studies make it difficult to draw conclusions on effectiveness. However, more recent work has focused on the movement assessment battery for children (M-ABC) teacher's checklist, suggesting the field is moving away from unstructured teacher observations toward survey-based instruments. The focus on the M-ABC also likely reflects the widespread acceptance of this measure as a diagnostic tool for the condition.

Three studies focusing on teacher reports of coordination problems are particularly important. Wright and Sugden (1996) identified children with DCD using a teacher checklist in conjunction with the M-ABC to determine the prevalence in a Singaporean cohort. The teacher's checklist demonstrated moderate discriminant power in identifying movement problems in boys and girls. However, teachers tended to unjustifiably classify older children with more movement problems compared to younger children. Junaid et al. (2000) used the M-ABC checklist to screen for DCD. The checklist was moderately correlated with the M-ABC ($r = .51$), but the sensitivity was very low (14.3%). Schoemaker et al. (2003) reported an even lower correlation between these tests ($r = .44$), but found much higher rates of sensitivity (between 50% and 80% at the 15th percentile cutpoint across age groups). The modest correlations between the teacher's checklist and the M-ABC test, the generally poor specificity of the test, and mixed sensitivity compel us to search for alternative instruments. Moreover, the teacher checklist, while comprehensive in its assessment of motor coordination problems, is laborious for screening purposes (48 items). Teachers are busy professionals who may be less inclined to complete extensive surveys.

In our study, we examined the effectiveness of a teacher-based rating scale of physical ability and activity to screen for DCD. Although the TEAF was designed for population-based assessments of children, we aimed to determine the utility of the TEAF in screening for motor coordination challenges in children with probable DCD. In view of gender differences in physical activity (Caspperson, Christenson, & Pollard, 1986; Faught, Hay, Cairney, & Flouris, 2005; Hay, 1992), which may result from differences in socialization between boys and girls (Greendorfer, 1992), and the potential for a gender-bias in teacher reports of physical abilities (Hay & Donnelly, 1996), we also examined the screening utility of the TEAF for boys and girls separately.

2. Methods

2.1. Participants

Currently, the Physical Health Activity Study Team (PHAST) is conducting a prospective cohort study of 2360 students from 75 elementary schools in the District School Board of Niagara in Ontario, Canada. A random sample of 15 of the 75 schools was selected for this ancillary study. Children with known impediments to physical activity such as learning disorders and pre-existing physical limitations were excluded. A total of 502 students aged 9–11 years were assessed for coordination challenges using the short form of the Bruininks–Oseretsky test of motor proficiency (BOTMP–SF). The Human Research Ethics Boards of Brock University and the District School Board of Niagara reviewed and approved the research protocol.

2.2. Teacher estimation of activity form

Classroom teachers completed the teacher estimation of activity form (TEAF) on each student's general aptitude for and enjoyment of physical activity (Table 1). Teachers were blind to the results of the BOTMP–SF. The TEAF is a 10-item scale designed to obtain teachers' assessments of each of their students' motor ability, participation in physical activity, and generalized self-efficacy toward physical activity, based on observations made during school-based activities (Hay & Donnelly, 1996). The first six questions focus on personal observations of the student during physical education classes, intramural sports,

Table 1
Teacher estimation of activity form

Teacher instructions (Part A): This form asks a number of questions about the physical skills, abilities and participation levels of ____________ (student name) relative to other students of the same age and gender that you have taught. Your cooperation in carefully completing this form is much appreciated. Please base your answers on your personal observations of this student during physical education classes, intramural sports, interschool sports, and lunch periods and recess. Please check the most appropriate answer

1. In terms of physical ability (strength, agility, endurance), compared to other students of the same age and gender, this student is:

Well below average	Somewhat below average	Average	Somewhat above average	Well above average
❑	❑	❑	❑	❑

2. In terms of physical skill (how well they can play), compared to other students of the same age and gender, this student is:

Well below average	Somewhat below average	Average	Somewhat above average	Well above average
❑	❑	❑	❑	❑

3. Compared to other students of the same age and gender, to what extent does this student participate in physically active games during recess, lunch and after school?

Well below average	Somewhat below average	Average	Somewhat above average	Well above average
❑	❑	❑	❑	❑

4. Compared to other students of the same age and gender, to what extent does this student become involved in house league or intramural sports and inter-school sports?

Well below average	Somewhat below average	Average	Somewhat above average	Well above average
❑	❑	❑	❑	❑

5. Please rate this student's enjoyment at being involved in physically active games and sports.

Well below average	Somewhat below average	Average	Somewhat above average	Well above average
❑	❑	❑	❑	❑

6. Please rate this child's confidence in his or her ability to participate in physically active games and sports.

Well below average	Somewhat below average	Average	Somewhat above average	Well above average
❑	❑	❑	❑	❑

Teacher instructions (Part B): The following questions ask you to rate this student in a number of hypothetical situations dealing with physical activity. In all cases, please base your answer on your observations of this child during physical education classes, lunch periods and recess. Your careful consideration of these questions is much appreciated

7. If this student (along with his/her classmates of the same gender) had to complete an obstacle course that required substantial strength and endurance, would you expect this student to complete the course in a time that was:

Much better than average	Somewhat better than average	Average	Somewhat worse than average	Much worse than average
❑	❑	❑	❑	❑

8. If you were to teach this student a new sport skill that required a great deal of agility and coordination, compared to his/her peers, how quickly would you expect this child to learn and master that skill?

Much better than average	Somewhat better than average	Average	Somewhat worse than average	Much worse than average
❑	❑	❑	❑	❑

Table 1 (*continued*)

9. If you were placed in charge of developing your school's teams or a variety of inter-school sports competitions, over the course of the year, would you expect this child to try out for your school teams?				
Much better than average	Somewhat better than average	Average	Somewhat worse than average	Much worse than average
❑	❑	❑	❑	❑
10. During recess or lunch period if you saw a group of students this child's age and gender playing a very active game outside, how likely would it be that this child would be among those involved?				
Much better than average	Somewhat better than average	Average	Somewhat worse than average	Much worse than average
❑	❑	❑	❑	❑

interschool sports, lunch periods, and recess. The remaining four questions ask the "home room" teacher to rate the student in a number of hypothetical situations dealing with physical activity. Hay (1992) validated the TEAF, obtaining a correlation of $r = .89$ ($p < .01$) between hypothetical and concrete items. TEAF items are rated on a 5-point Likert-type scale, with responses including: (1) well below average, (2) somewhat below average, (3) average, (4) somewhat above average, and (5) well above average. Teachers are asked to rate children relative to others of the same age and gender. The TEAF requires approximately 10 minutes per child to complete. The TEAF response rate was 78% among the schools randomly selected to complete the questionnaire.

2.3. Participation questionnaire

The Participation Questionnaire (PQ) is a 61-item questionnaire that asks children to report their participation levels in free-time play, seasonal recreational pursuits, school sports, community team sport and clubs, and sports dances and lessons. Children completed the PQ in the classroom in approximately 20 minutes. Participation in organized activities encompasses a 1-year period, and free play is recalled from typical pastime choices. Subtotals are available for unorganized activity (free play), organized activity (sports teams, lessons), and seasonal activity. The scale is calculated using "activity units", with each unit corresponding to a physical activity choice, sports team, individual sport or dance lesson. Test–retest reliability of the PQ among elementary school children has been measured at .81 (Hay, 1992). The PQ has demonstrated good construct validity with significant gender differences and urban/rural differences, as predicted (Hay, 1992; Hay & Donnelly, 1996; Hay et al., 2004; Klentrou, Hay, & Plyley, 2003), as well as significant correlations with body fat, aerobic capacity, motoric competence, and other health outcomes (Klentrou et al., 2003). Criterion validity is very difficult to establish with any measure of physical activity; however, the PQ has demonstrated moderate (.62) correlations with teacher evaluations of activity (Hay, 1992; Hay & Donnelly, 1996). All of the aforementioned studies were conducted in Canada on children in the same age range as the present study.

2.4. CSAPPA scale

The children's self perceptions of adequacy in and predilection toward physical activity (CSAPPA) scale is designed to measure children's self-perceptions of their adequacy in performing, and their desire to participate in, physical activities (Hay, 1992). The CSAP-

PA was completed by children during normal class time and uses a structured alternative choice format. With regard to construct validity, the CSAPPA is moderately and significantly correlated with aerobic fitness (Léger shuttle run test), physical activity (energy expenditure) and self-reported participation in physical activities, body weight (percentage body fat and BMI) and motor proficiency (Cairney, Hay, Faught, Mandigo, & Flouris, 2005; Faught et al., 2005; Hay, 1992; Klentrou et al., 2003). Similar to the PQ, these studies were conducted in Canada with children in the same age range as the present study.

2.5. Body mass index and maximum aerobic capacity

A dual-purpose medical weight scale with height stadiometer was employed for the initial body composition measures. Height was measured and recorded to the nearest 0.2 cm. Body weight was measured and recorded to the nearest 0.1 kg. Again, the participants were without footwear and wearing only clothing required for regular physical education class. Body mass index (BMI) was calculated from the obtained weight and height measurements using the formula kg/m^2.

Predicted maximum aerobic capacity was evaluated using the 20-meter shuttle run test, which has been validated in a school setting for children 6–17 years of age (Léger & Gadoury, 1989). Testing was completed in the school gymnasium during regularly scheduled physical education classes. Students were tested in groups of around 10 students at a time (approximately 30 students per class). Each child was required to exercise at constantly increasing intensity until volitional fatigue. Specifically, Léger's test requires the participant to run at progressively increasing speeds on a 20-meter shuttle course. Children were required to run back and forth on a 20-meter course, touching the 20-meter line at approximately the same time that a sound signal is emitted from a pre-recorded compact disk. The starting speed is 8.5 km/hr and increases by 0.5 km/hr each minute. The test was complete when the child failed to maintain the required pace. The speed of the last completed stage (maximal aerobic speed {MAS}) was used to predict the child's maximal aerobic capacity. Maximum aerobic capacity expressed as the maximum volume of oxygen (VO_{2max}) utilized during physical activity was predicted using the regression equation: $VO_{2max} = 31.025 + 3.239\ (MAS)\ -3.248\ (\text{age in years}) + 0.1536\ (MAS \times \text{age})$ (Léger & Gadoury, 1989). The amount of motor skill is considered minimal and therefore was not considered a disadvantage towards children demonstrating clumsy characteristics of DCD (Cairney, Hay, Wade, Faught, & Flouris, 2006).

2.6. Developmental coordination disorder (DCD)

The Bruininks–Oseretsky test of motor proficiency (BOTMP) is the most commonly used standardized test in the diagnosis of DCD in North America (Crawford, Wilson, & Dewey, 2001). In this study, DCD was evaluated using its short form (BOTMP–SF). This test examines the full domain of motor proficiency (static and dynamic balance, reaction time, bilateral coordination, etc.) using selected items from the full scale. The short form has been validated against the full scale with inter-correlations between .90 and .91 for children between the ages of 8 and 14 (Bruininks, 1978). The BOTMP–SF was individually administered to each consenting child in the school gymnasium. A BOTMP–SF standard score below 38 was taken to indicate probable DCD (*p*DCD). We use the term probable DCD because our method of case-identification is a field test administered by trained researchers, not a diagnostic protocol administered by a pediatrician. Moreover, our case-identification method follows the majority, but not all of the criteria stipulated in the DSM-IV (American Psychiatric Association, 2000). The DSM-IV stipulates four criteria for the diagnosis: (A) significant motor impairment below the age-expected norms; (B) motor problems must result in significant impairment to activities of daily living and/or academic achievement/performance; (C) condition cannot be due to other known physical conditions (e.g., cerebral palsy, muscular dystrophy) or pervasive developmental delay; and finally (D) if mental retardation is present, motor impairments must be below the norm (age appropriate) expected for these children. In this study, the BOTMP–SF is used for criterion A, and, as mentioned in the discussion of the participants, all children with known learning disabilities and physical health problems were excluded from the analyses (Criterion C and D). Criterion B (limitations in activities of daily living) is the only aspect of diagnosis not measured. However, as Visser (2003) notes, most studies do not take into account the exclusion criteria in the DSM-IV. Although future research will need to address this problem, we elected to use the term probable DCD to more accurately describe our sample.

2.7. Statistical analyses

Each TEAF item was scored from 1 to 5, with higher scores indicating greater physical ability and activity (scores were reversed for the ROC curve analysis so that higher scores indicated a greater probability of DCD). Cronbach's alpha and factor analyses were performed on the TEAF in order to examine its structure and internal consistency, while Pearson correlation examined the association between the TEAF and independent markers of physical activity including CSAPPA score, Participation Questionnaire, VO_{2max} and BMI. Physical activity and fitness were measured by VO_{2max} (derived from performance on the Léger shuttle run), BMI, and the participation questionnaire. Self-efficacy with respect to physical activity was measured by the CSAPPA. Correlations between these measures and the TEAF were conducted to examine convergent validity. Agreement between the TEAF and the BOTMP–SF was then assessed using receiver operating characteristic (ROC) analysis. In ROC curve analysis, the sensitivity at each potential score on a test is plotted against the corresponding false positive rate (equal to 1-specificity). The resulting curve provides a graphical means of assessing the ability of the test to discriminate between those with and without a condition of interest. The screening test is considered better as the area under the curve (AUC) increases. A test with no better than chance agreement with the outcome would have a straight diagonal line from the bottom left corner to top right corner and an AUC of .5. In general, AUC between .5 and .7 are considered low; between .7 and .9 moderate; and above .9, high (Fischer, Bachmann, & Jaeschke, 2003). ROC curves for the full scale and for each individual item were fit using the binormal method in Stata 8/SE.

3. Results

A total of 502 children (266 males, 236 females) provided informed consent and participated. The BOTMP–SF identified 27 students as probable cases of DCD, a prevalence of 5.1% (95% CI, 3.5–7.4%). Table 2 outlines differences between children with and without *p*DCD across the main variables of interest in this analysis. Although not significant

Table 2
Comparison of probable DCD and non-DCD subjects[a]

	*p*DCD ($n = 27$)	non-DCD ($n = 475$)
Participation questionnaire	22.4 ± 6.1	24.3 ± 6.6
CSAPPA scale	56.9 ± 11.0	$63.8 \pm 10.1^{*}$
VO_2max (ml/kg/min)	43.9 ± 3.7	$48.4 \pm 4.3^{*}$
Body mass index (kg/m^2)	22.4 ± 5.6	$19.0 \pm 3.6^{*}$

[a] Mean scores with standard deviations are shown.
* $p < .001$.

($t = 1.5$, $p = .13$), children with *p*DCD reported lower levels of physical activity participation compared to children without the disorder on the participation questionnaire. However, children with *p*DCD did demonstrate lower self-efficacy, including enjoyment, adequacy, and predilection for physical activity compared to their counterparts ($t = 3.44$, $p = .001$). Children with *p*DCD also reported significantly lower VO_{2max} ($t = 5.16$, $p = .0001$) and higher BMI ($t = -4.68$, $p = .0001$) than other children.

Cronbach's alpha for the TEAF is .98. Exploratory factor analysis indicated that the instrument is unifactorial, with the first eigenvalue of 8.0 and the second 0.3. Pearson correlation analysis indicated a positive association between TEAF scores and CSAPPA ($r = 0.45$, $p = .001$), Participation Questionnaire ($r = 0.25$, $p = .001$) and VO_{2max} ($r = 0.56$, $p = .001$). An inverse correlation existed between TEAF and BMI ($r = -0.25$, $p = .001$). There was no evidence of differential associations when the analysis was performed by gender.

The ROC curve for the TEAF is presented in Fig. 1. Moreover, a complete range of TEAF cut-points and corresponding probabilities dictated by the trade-off between sensi-

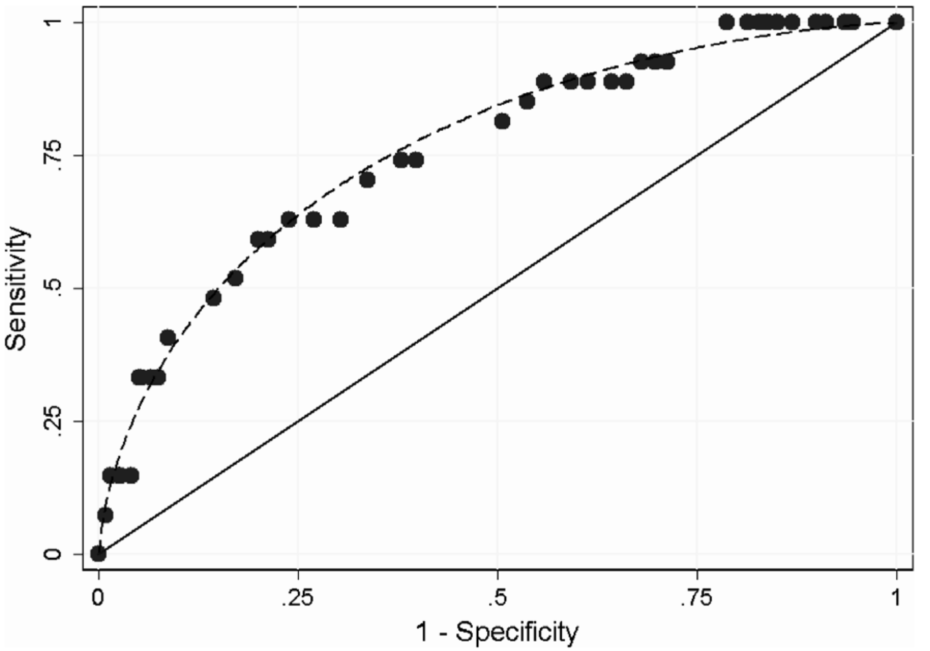

Fig. 1. ROC curve for TEAF and probable DCD.

tivity and specificity is outlined in Table 3. It was not our intent to suggest a specific TEAF cut-point, since the interpretation and utilization of TEAF scores will vary between population and clinical-based settings. However, we do discuss a range of cut-points that emphasize the importance of sensitivity and minimizing false-negative rate (Knapp & Miller, 1992). If we select a cut-point using the Youden index, which gives equal weight to sensitivity and specificity, a cumulative TEAF score <32 is preferred (sensitivity = .85, CI = .68–.94; specificity = .46, CI = .42–.51). A slightly lower cut-point <29 still provides an acceptable sensitivity of .74 (CI = .55–.87), while increasing specificity to .62 (CI = .58–.66). Within the range of cut-point values of 28–32, negative predictive value was .98

Table 3
Probability values (95% CIs) for all cut-points on the TEAF

Score	Sensitivity	Specificity	+Predictive value	−Predictive value
<50	1.00 (.88–1.00)	.05 (.04–.08)	.06 (.04–.08)	1.00 (.87–1.00)
<49	1.00 (.88–1.00)	.07 (.05–.09)	.06 (.04–.08)	1.00 (.89–1.00)
<48	1.00 (.88–1.00)	.09 (.07–.12)	.06 (.04–.08)	1.00 (.92–1.00)
<47	1.00 (.88–1.00)	.10 (.08–.13)	.06 (.04–.09)	1.00 (.93–1.00)
<46	1.00 (.88–1.00)	.13 (.10–.16)	.06 (.04–.09)	1.00 (.94–1.00)
<45	1.00 (.88–1.00)	.15 (.12–.18)	.06 (.04–.09)	1.00 (.95–1.00)
<44	1.00 (.88–1.00)	.16 (.13–.20)	.06 (.04–.09)	1.00 (.95–1.00)
<43	1.00 (.88–1.00)	.17 (.14–.21)	.06 (.04–.09)	1.00 (.96–1.00)
<42	1.00 (.88–1.00)	.19 (.15–.22)	.07 (.05–.09)	1.00 (.96–1.00)
<41	1.00 (.88–1.00)	.21 (.18–.25)	.07 (.05–.10)	1.00 (.96–1.00)
<40	.93 (.77–.98)	.29 (.25–.33)	.07 (.05–.10)	.99 (.95–1.00)
<39	.93 (.77–.98)	.30 (.26–.35)	.07 (.05–.10)	.99 (.95–1.00)
<38	.93 (.77–.98)	.32 (.28–.36)	.07 (.05–.10)	.99 (.95–1.00)
<37	.89 (.72–.96)	.34 (.30–.38)	.07 (.05–.10)	.98 (.95–.99)
<36	.89 (.72–.96)	.36 (.32–.40)	.07 (.05–.11)	.98 (.95–.99)
<35	.89 (.72–.96)	.39 (.34–.43)	.08 (.05–.11)	.98 (.95–.99)
<34	.89 (.72–.96)	.41 (.37–.45)	.08 (.05–.11)	.98 (.96–.99)
<33	.89 (.72–.96)	.44 (.40–.49)	.08 (.06–.12)	.99 (.96–1.00)
<32	.85 (.68–.94)	.46 (.42–.51)	.08 (.06–.12)	.98 (.95–.99)
<31	.81 (.63–.92)	.49 (.45–.54)	.08 (.06–.12)	.98 (.95–.99)
<30	.74 (.55–.87)	.60 (.56–.65)	.10 (.06–.14)	.98 (.95–.99)
<29	.74 (.55–.87)	.62 (.58–.66)	.10 (.07–.15)	.98 (.95–.99)
<28	.70 (.52–.84)	.66 (.62–.70)	.11 (.07–.16)	.98 (.95–.99)
<27	.63 (.44–.78)	.70 (.65–.74)	.11 (.07–.16)	.97 (.95–.98)
<26	.63 (.44–.78)	.73 (.69–.77)	.12 (.07–.18)	.97 (.95–.98)
<25	.63 (.44–.78)	.76 (.72–.80)	.13 (.08–.20)	.97 (.95–.99)
<24	.59 (.41–.75)	.79 (.75–.82)	.14 (.09–.21)	.97 (.95–.98)
<23	.59 (.41–.75)	.80 (.76–.83)	.14 (.09–.22)	.97 (.95–.98)
<22	.52 (.34–.69)	.83 (.79–.86)	.15 (.09–.23)	.97 (.95–.98)
<21	.48 (.31–.66)	.86 (.82–.89)	.16 (.10–.26)	.97 (.94–.98)
<20	.41 (.25–.59)	.91 (.88–.94)	.21 (.12–.34)	.96 (.94–.98)
<19	.33 (.19–.52)	.93 (.90–.95)	.20 (.11–.35)	.96 (.94–.97)
<18	.33 (.19–.52)	.93 (.91–.95)	.23 (.12–.38)	.96 (.94–.98)
<17	.33 (.19–.52)	.95 (.92–.96)	.26 (.15–.43)	.96 (.94–.98)
<16	.33 (.19–.52)	.95 (.93–.97)	.27 (.15–.44)	.96 (.94–.98)
<15	.15 (.06–.32)	.96 (.94–.97)	.17 (.07–.37)	.95 (.93–.97)
<14	.15 (.06–.32)	.97 (.95–.98)	.24 (.10–.47)	.95 (.93–.97)
<13	.15 (.06–.32)	.97 (.96–.99)	.25 (.10–.49)	.95 (.93–.97)
<12	.15 (.06–.32)	.99 (.97–.99)	.36 (.15–.65)	.95 (.93–.97)
<11	.07 (.02–.23)	.99 (.98–1.00)	.33 (.10–.70)	.95 (.93–.97)

Table 4
ROC curve analysis of individual TEAF items

Item	Mean	SD	AUC	AUC L95%	AUC U95%
Physical ability	2.8	1.1	.79	.71	.88
Physical skill	2.8	1.1	.79	.71	.87
Participation in active games	2.8	1.1	.76	.65	.86
Involvement in intramural sports	3.0	1.2	.79	.70	.88
Enjoyment of active games and sports	2.6	1.1	.73	.64	.83
Confidence in physical ability	2.8	1.1	.67	.57	.77
Strength and endurance	2.9	1.1	.75	.66	.84
Ability to acquire new physical skills	2.9	1.1	.78	.69	.86
Likelihood of trying out for sports teams	3.0	1.2	.71	.61	.81
Likelihood of participating in sports	2.8	1.1	.75	.65	.85

(CI = .95–1.0) mainly due to the low prevalence (5.1%). Positive predictive value at this same point of the TEAF scores ranged only from 0.08 to 0.10 (95% CI = .06–.07 to .12–.15). The ROC curve for the TEAF total score is characteristic of a moderately accurate screening tool, with an AUC of .77 (95% CI, .68–.86). With regard to gender differences, performance was nearly identical for male and female students (AUC for boys = .79, 95% CI = .69–.90; girls, AUC = .77, 95% CI = .67–.87; chi-square for difference = .08, $df = 1$, $p = .77$). Analysis of each of the 10 individual questions demonstrated that each performed approximately as well as the full scale, with the possible exception of question six, which addresses the student's "confidence in their physical ability" (AUC = .67, 95% CI = .57–.77) (Table 4).

4. Discussion

The aim of this study was to determine the utility of the TEAF in screening for motor coordination challenges in children. Several individual items dealing with general aptitude for physical ability had performance equivalent to the full scale. Each question addressed physical ability and activity in real and hypothetical situations. Teachers showed an accurate understanding of their students' physical ability potential and activity behavior. The TEAF scores were consistent with childrens' reported activity patterns as well as their level of self-efficacy during physical activity, suggesting reasonable convergent validity of teachers' reports with child self-reported physical activity. Habitual physical activity patterns are regularly diminished in children with motor coordination challenges (Hay et al., 2004), especially moderate to vigorous physical activity (Fisher et al., 2005). This is often exacerbated when the child suffers from poor self-efficacy, resulting in withdrawal from organized sports and free play activity such as school recess (Cairney et al., 2005). The avoidance of daily physical activity increases the risk of unhealthy body fat gain and decreases fitness conditioning (Dewey & Wilson, 2001; Faught et al., 2005). Our study did identify an inverse association with BMI and participation in physical activity, particularly in children with *p*DCD. The TEAF correlated well with the aerobic fitness level of children in our study, also suggesting good convergent validity. Habitual physical activity patterns do not always correlate with fitness level in children, largely due to the contribution of genetic predisposition and excess body fat. However, a child's self-efficacy has proven to be a significant predictor of aerobic endurance in children. Cairney, Hay, Faught, Léger, and Mathers (2008) found that it accounted for 30% of the variance in workload in children participating in the Léger 20-meter shuttle run. This relationship is equally pronounced among children with DCD, as they suffer from poor self-efficacy due to diminished motor proficiency (Cairney et al., 2006). Clearly, children with DCD face tremendous pressure from their school peers during curricular and co-curricular physical activity. The sense of inadequacy and fear of ridicule from classmates is a real obstacle in the school environment.

Considering the elementary school teacher is continually exposed to the behaviors of their students in situations involving physical activity, they are in a position to judge deficits. However, as noted earlier, the available data on the ability of teachers to screen for mild motor impairments has been mixed, with some studies showing positive results (Henderson & Hall, 1982; Hoare & Larkin, 1991) and others not (Gubbay, 1975; Morris & Whiting, 1971; Revie & Larkin, 1993). While differences across studies may be due to context (the setting of schools), differing methodologies across studies make comparisons difficult. It is interesting to note, however, that most studies were conducted in either Australia or England, and positive and negative findings were found in both settings.

Several individual TEAF items dealing with general aptitude for physical ability had psychometric performances equivalent to the full scale. The results of the factor analysis, along with the very high alpha values, are strong evidence that the TEAF could be shortened and still maintain a high degree of utility and discriminant function. With regard to screening, an abbreviated version of the TEAF would be considered optimum by the home room teacher in a busy classroom setting. Considering that heterogeneity of motor challenges that fall under the rubric of DCD is so great, some would argue that a measure that includes a broad range of motor skills, such as the M-ABC teacher checklist, is better for screening purposes (Schoemaker et al., 2003). However, our results suggest that a single or a few items might be as effective as the 10-item TEAF, and our results are comparable with those reported using the 48-item M-ABC teacher checklist (Schoemaker et al., 2003). This may be due to the fact that it is easier for teachers to report on "general perceptions" of the children's physical ability, than on specific motor domains (e.g., ball skills). The brevity of the 10-item TEAF makes this tool attractive because of its practicality and minimal expense for large-scale screening purposes.

A challenge that teachers may inadvertently experience in evaluating the physical ability and activity patterns in their students is the existence of a gender bias (Hay & Donnelly, 1996). Teachers have a tendency to consider girls' competence in physical activity to be below average compared to boys of the same age. The explanation for this phenomenon is attributed to socialization theory. Socialization research, in the context of gender differences, examines the social learning differences in nurturing boys compared to girls. Greendorfer (1992) explains that males are encouraged and predisposed to sport and physical activity, wherein they develop basic motor skills that support physical ability and foster confidence for future participation. Conversely, females do not receive the same level of encouragement for developing motor skills and, hence, may have less desire to attain comparable levels of motor development. This form of socialization could provoke a tendency for young girls to avoid both structured and unstructured physical activity. Epidemiologic research over the past 20 years has consistently shown that boys participate more in sports and free play activities than girls (Caspperson et al., 1986; Faught et al., 2005; Hay, 1992). We also found sound tendency (analysis not show) for boys to report greater participation in sport, recreation, and free-play physical activity compared to girls of the same age. This would suggest that this form of socialization still exists. However, the association between the TEAF and our measure of probable DCD did not vary significantly by gender, suggesting that the practical impact of any bias in reporting is minimal in this context.

As in all research, there are limitations that need to be considered when evaluating this work. First, in order to test the screening potential of the TEAF in relation to DCD, it would be preferable to use the full diagnostic criteria for the disorder (American Psychiatric Association, 2000), something that we could not do here. Closely related to this point, we have used the BOTMP–SF as our standard; it is possible that results would be different if diagnosis was done with the full-length BOTMP, the M-ABC (Henderson & Sugden, 1992), or a full clinical assessment. Addressing these limitations in the future would make possible a more robust evaluation of the TEAF's screening potential for DCD.

We concluded that the level of agreement between teacher ratings of childrens physical ability and activity with formal assessments for DCD using the BOTMP–SF is not adequate for identification of cases. However, the TEAF would be sufficient for preliminary screening in a population-based school environment. Further research could address the possibility of combining teacher ratings with self-report or parent-completed instruments to improve identification.

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