Development and Validation of a Pediatric Sports Activity Rating Scale

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Background: Having reliable, validated, and simple outcome measures is vital to conducting high quality outcomes research in the field of orthopaedic surgery. There is a paucity of such instruments in children and adolescents who are otherwise healthy and athletically active. In addition to frequency and intensity of athletic activity, level of play and coach/trainer supervision are important variables unique to children and adolescents that are not otherwise captured in adult scoring systems. The purpose of this study was to create and validate a concise and comprehensive activity rating scale for athletically active children and adolescents ages 10-18 years old.

Methods: Item generation was performed with a panel of orthopaedic surgeons and adolescent athletes. Item reduction and scale refinement resulted in a final 8-item outcome instrument. Validation (51 subjects) and test-retest reliability (41 subjects) were performed using existing methodology. The Flesch-Kincaid score was calculated at a 7.8 grade reading level (approximately 13 years old); therefore although all subjects provided their own answers, parents were allowed to assist children with the questionnaire who were younger than 13 years.

Results: Test-retest reliability was excellent (ICC=0.91), and there were no floor or ceiling effects. Construct validity testing revealed positive correlation noted between the new activity rating scale and level of competition in athletic activity and number of reported hours of athletic activity per week. There was also positive correlation between the pediatric rating scale and existing adult and pediatric scales. The 8-item questionnaire took one-and-a-half minutes for participants to complete on average.
Conclusions: This 8-item pediatric activity rating scale can be used to evaluate activity level as a prognostic variable for clinical research studies. It is a simple, reliable, and valid metric to assess activity in children and adolescents 10-18 years old. By using this instrument for child and adolescent athletes, outcomes after treatment can be better evaluated.
Background

Over 30 million children in the United States participate in organized sports programs, and over one-third of school-age children will sustain a sports injury requiring the attention of a healthcare professional. Treatment algorithms for these children are largely developed based on the results of clinical outcomes research that evaluates the effect of an intervention on recovery from injury. Having reliable, validated, and simple outcome measures is vital to conducting high quality outcomes research in the field of orthopaedic surgery.

To that end, multiple upper extremity, lower extremity, joint specific, and quality of life outcomes are currently utilized in adult outcomes research and patient assessment. However, many items in these adult-validated instruments do not pertain to children. Furthermore, within the realm of pediatric orthopaedic surgery, existing rating scales are largely geared toward children with marked disability (e.g. the Gross Motor Function Classification System for use in children with cerebral palsy). Those few that do measure activity through a broader range of functionality are large, time consuming, and activity-, sport- and/or joint-specific. Lengthy global activity measurements may lead to questionnaire fatigue, and activity-specific questionnaires incorporate cultural and regional biases, thus decreasing their global validity.

Activity level is a key prognostic variable for patients with sports injuries. Existing activity scales were developed for adults and lack specificity for children. A child- and adolescent-specific activity scale is critically needed for outcomes research within the field of pediatric...
sports medicine. The goal of this study is to develop and validate an activity rating scale for active children and adolescents for use in clinical assessment and outcomes research.

**Materials and Methods**

A formal search of PubMed and Ovid/Medline was performed in order to locate any existing pediatric or adolescent activity scales, as well as evaluation of recently-published reviews on existing outcome measures in orthopaedic surgery. A search strategy was employed on the following terms: activity, pediatric, adolescent, scale, and questionnaire. After eliminating joint- and sport-specific scales as well as scales targeted at children with disabilities, only the Physical Activity Questionnaire for Older Children (PAQ-C) and Physical Activity Questionnaire for Adolescents (PAQ-A) remained. Kocher et al. successfully validated a pedi-IKDC in children and adolescents, which is knee-specific. The Child Health Questionnaire (CHQ) is a family of generic quality of life instruments that are validated in children 5-18 years old. This scale, however, consists of parent-reporting and is designed to assess quality of life and not physical activity specifically.

This study was approved by the hospital Institutional Review Board (IRB) and consent or refusal did not affect patient care in any way.

**Item Generation**

To identify relevant items for inclusion in the scale, a panel of fellowship-trained orthopaedic surgeons (two pediatric, one sports medicine) were consulted to generate a list of items, and
the above-mentioned scales were reviewed for potentially relevant items. Twenty adolescent
athletes aged 10-18 were also separately surveyed until no new responses were generated to
determine what activity items were important to them. Items identified by the surgeons and
the subjects were compiled and duplicates eliminated.

Item Reduction

A separate cohort of twenty active adolescents was asked to score the importance and
frequency of each item on a 10-point scale, and these scores were summed, averaged, and
ranked. This method selects items that have the greatest clinical relevance to the population of
interest.(9) “Running”, “cutting”, “decelerating”, and “pivoting” (similar to a previously
published activity rating scale)(2) were each independently identified as high scoring items, as
well as items measuring “endurance” and “level of competition”. The original clinicians
involved in item generation determined clinical sensibility after item reduction to ensure that
the final item set was relevant to both practitioners and subjects.(10)

Various design and scoring schemata were considered. A multi-item scale was deemed to be
most appropriate to eliminate concerns surrounding validity of hierarchically-ranked scoring
systems.(11) A concise 8-item pediatric activity rating scale was created with a goal of
facilitating completion in less than 2 minutes to minimize patient burden. The instructions
specifically ask the subject about activity in a one month window in order to create an
instrument that would be stable to day-to-day variation in activity but sensitive enough to
monitor change over time.

Pilot Testing
The pediatric activity rating scale was pilot-tested in a cohort of interest soliciting feedback on language, wording, layout, and ease of completion. After performing modifications to language through pilot testing to ensure understanding and ease of use, and the activity scale was finalized (Figure 1). The Flesch-Kincaid score of the final instrument was calculated at a 7.8 grade reading level (approximately 13 years old); therefore although all subjects provided their own answers, parents were allowed to assist children who were younger than 13 years old with all questionnaires.

Validation

Fifty one English-speaking children age 10-18 who are otherwise healthy (no chronic disease or active health condition other than seasonal allergies) and who are involved in at least one organized athletic or physical activity (school and/or community based) were evaluated. Subjects were recruited from the pediatric orthopaedic clinic who presented for minor complaints as well as other healthy children who were identified in the waiting room. Subjects who were 18 years old gave their own consent. Parental consent was obtained in children under 18 years old in addition to subject assent.

Criterion validity could not be evaluated because there is currently no accepted “gold standard” for pediatric sport activity level quantification. Face validity of the final activity rating scale was ensured by clinicians prior to initiation of the validation phase. Divergent validity was assessed by comparing scores on the pediatric activity rating scale with subject-reported and parent-confirmed highest level of competition and hours of organized athletic activity per week currently and in peak athletic season. We expected positive correlations
between these variables and scores on the pediatric activity rating scale. Age and body mass
index (BMI) were also evaluated for potential associations, however in active children we did
not expect age or BMI to be significantly correlated with the new activity score. Linear
regression modeling was used for analysis.

Construct validity testing was also performed by comparing scores on the pediatric activity
crating scale to existing outcome measures in the orthopaedic sports literature (Tegner, Marx,
Daniel, Noyes)(2, 12-14) and the Pediatric Activity Questionnaire (PAQ-A or PAQ-C based
on child’s age).(8) We expected positive correlations with these scales that measure adult
activity levels.

Test-Retest Reliability

Sample size calculation indicated that at least forty subjects are required for reliability
testing.(15) All 51 subjects who participated in the validation phase were eligible for potential
inclusion in the test-retest reliability assessment. Subjects were contacted and asked to
complete the pediatric activity rating scale two days to two weeks after first completion.(16,
17) Additionally they were asked if their condition had changed in any way. Those who
replied “no change” (41 subjects) were included in the reliability calculation.

Simplicity

Readability of the pediatric activity rating scale was assessed using Flesch-Kincaid grade
level analysis. Additionally, a subset of ten subjects of varying ages from the validation cohort
was timed in the administration of the pediatric activity rating scale and the PAQ for comparison, with administration order randomly assigned.

Statistical Methods

Statistical analyses were performed by members of the research team with advanced training in epidemiology and biostatistics using SAS Software version 9.1 (SAS Institute, Inc., Cary, North Carolina, USA). Sample size was derived from previously validated methodology. Spearman correlation was used to test associations between the pediatric activity rating scale and the Tegner, Marx, Noyes, and PAQ. In analyzing the Daniel scale, which is a 3-point nominal categorization score, the Kruskall-Wallis test was used. Test-retest reliability was assessed using intraclass correlation coefficient. Timed questionnaire administrations were compared using independent sample t-tests. All comparisons were performed using two-tailed analyses and P=0.05 as threshold for statistical significance.

Results

Demographic characteristics (Table 1) and organized sports participation (Table 2) were recorded. Included patients consisted of 51 children age 10-18 who either presented to a pediatric orthopaedist with a minor complaint: Hip pain (two), scoliosis screening with curves <20 degrees (seven), back pain (five), healthy during follow-up visit (five), foot/ankle pain (three), knee pain (five), tendonitis (one), minor small bone fracture (eg. phalanges) (four).

Also, there were nineteen who were friends or relatives who accompanied the patients in the waiting room. Score distribution on the pediatric activity rating scale is displayed in (Figure
2). There were no floor or ceiling effects, with two patients (3.9%) scoring the maximum 30 out of 30 and no patients scoring zero out of thirty. This is contrasted to the Noyes and Marx adult scales in which ceiling effects were present in this pediatric cohort (Figure 3).

Validation Results

Fifty-one subjects completed the survey for validation. Divergent validity was confirmed with significantly positive correlations between the pediatric activity rating scale and level of competition ($r=.56$, $P<0.0001$), hours per week of current athletic activity ($r=.62$, $P<0.0001$), and hours per week of athletic activity during peak season ($r=.62$, $P<0.001$). Age and BMI were not significantly correlated with the pediatric activity rating scale, and BMI was not significantly correlated with hours of activity or level of competition. Age was correlated with level of competition ($r=.33$, $P=0.018$).

There was construct validity with existing adult scales. Tegner ($r=.44$, $P=0.001$), Marx ($r=0.51$, $P=0.0001$), Noyes-Sports ($r=.30$, $P=0.03$), and Noyes-Functional ($r=.44$, $P=0.001$) all showed statistically significant correlation to the new activity scale. There was no significant association between the pediatric activity rating scale and the Daniel scale; mean scores for each of the three Daniel scale categories were nearly identical (21.1, 21.7, and 20.2 for categories I, II, and III, respectively). There was a significant correlation between the pediatric activity rating scale and the PAQ ($r=.60$, $p<0.001$).

Test-Retest Reliability Results
Forty-one patients of the original validation cohort answered “no change” when asked if there were any changes in their condition and were therefore eligible for inclusion in test-retest reliability calculation. Test-retest reliability of the new activity scale was excellent (ICC=0.91).

In addition to grade reading level (grade 7.8), comparison of the two pediatric scales was performed with timed administration (in random order) of the new activity scale and the PAQ in a subset of 10 subjects of varying ages. The activity scale was performed under two minutes consistently, and significantly faster on average than the PAQ (1:31 vs. 3:51) (paired sample t-test, P<0.001).

Discussion

As anticipated, divergent validity testing showed positive correlations with hours of reported athletic activity and level of competition. Age and BMI were not significantly correlated with score on the pediatric activity rating scale, which was expected. Unlike the supposition in adults that activity level decreases with age,(2) children are likely more able to maintain their activity as they progress through adolescence. Furthermore, in this cohort of active children, differences in BMI may be due to differences in muscle mass, adiposity, or both. While decreased activity may lead to larger increases in BMI over time during adolescence,(18) cross-sectional associations between BMI and activity in active children are not known. Our data suggest that BMI is not a surrogate measure for activity level, as there was no significant
correlation between BMI and hours of athletic activity or level of competition. The positive
correlation noted between age and level of competition was expected, as children tend to
engage in more competitive sports as they get older and progress from primary school youth
athletics to high school and national competition. Although level of competition increased
with increasing age, overall activity as measured by the pediatric activity rating scale did not
significantly change.

Construct validity testing showed moderate positive correlations between the pediatric activity
rating scale and existing adult and child scales. Importantly, these moderate correlations
indicate that while there is a statistically significant correlation, the activity measured by our
rating scale differs from that of existing scales. The only existing scale that did not show any
association was the Daniel scale. The Daniel scale is a nominal 3-point scale, in which
analyzes only type of sport played (I, jumping and pivoting sports; II, lateral motion sports; III,
other sports such as running and swimming). In addition to a majority of subjects (64.7%)
responding with category I, this scale is intuitively less pertinent to quantification of activity
levels in children. In examining only type of sport played, it does not account for level of
participation, frequency, or multiple sports.

In contrast to some of the existing adult studies, a ceiling effect was not noted with our
pediatric activity rating scale. Whereas the adult activity metrics evaluate frequency and
various sport maneuvers to quantify activity, this is not always appropriate in children. For
instance, a 35 year old athlete who runs 5 times per week is likely to have higher activity than
one who runs once per week. However, children tend to be more active than adults. An
adolescent athlete who runs 5 times per week at varsity track practice is very different than an
otherwise sedentary adolescent who may report running 5 times per week while playing
outside with friends. The pediatric activity rating scale accounts for these differences with items that factor level of competition, endurance, and level of supervision of sport activity by coaches and trainers. By appraising these unique items, the ceiling effect otherwise noted in testing children with existing adult scales is avoided.

Finally, while other lengthy pediatric scales exist, the simplicity of our 8-item pediatric activity rating scale is a great advantage. In addition to decreasing burden on patients and parents, it minimizes the potential for questionnaire fatigue, and will likely increase completion compliance for clinical outcomes studies. This subsequently maximizes patient/subject retention and minimizes loss of clinical research data points.

While this novel activity scale has many advantages for clinical research, there are some limitations to its use. In subjects who are predominantly active in sports that do not require running, cutting, decelerating, and pivoting (eg. swimming, diving), these four items may give an overall score that underestimates activity level. However, for the vast majority of sports and activities, this score is applicable. Even for those sports in which these maneuvers may be less applicable, endurance and level of competition and supervision may be quantified, extending its use when comparing cohorts of athletes within these unique sports.

In conclusion, this 8-item pediatric activity rating scale is a simple, reliable, and valid metric to assess activity in children and adolescents 10-18 years old. It is a valuable tool for clinical research in active children and for evaluating activity level as a prognostic variable for clinical research studies in pediatric orthopaedic sports medicine. By using this instrument for child and adolescent athletes, outcomes after treatment can be better evaluated.
Table 1. Demographic and activity responses of 51 subjects.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>14.4 +/- 2.0 years</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>21</td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
</tr>
<tr>
<td><strong>Body Mass Index (BMI)</strong></td>
<td>21.8 +/- 3.7</td>
</tr>
<tr>
<td><strong>Athletic Level of Competition</strong></td>
<td></td>
</tr>
<tr>
<td>Recreational</td>
<td>13</td>
</tr>
<tr>
<td>Travel</td>
<td>11</td>
</tr>
<tr>
<td>Junior Varsity</td>
<td>7</td>
</tr>
<tr>
<td>Varsity</td>
<td>14</td>
</tr>
<tr>
<td>National/Elite</td>
<td>6</td>
</tr>
<tr>
<td><strong>Activity per Week</strong></td>
<td></td>
</tr>
<tr>
<td>Currently</td>
<td>10.8 +/- 7.2 hours</td>
</tr>
<tr>
<td>In Peak Season</td>
<td>16.7 +/- 10.0 hours</td>
</tr>
</tbody>
</table>
Table 2. One hundred and thirty three sports played by 51 subjects.

<table>
<thead>
<tr>
<th>Sport</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basketball</td>
<td>27</td>
</tr>
<tr>
<td>Soccer</td>
<td>16</td>
</tr>
<tr>
<td>Baseball</td>
<td>15</td>
</tr>
<tr>
<td>Tennis</td>
<td>10</td>
</tr>
<tr>
<td>Distance Running</td>
<td>9</td>
</tr>
<tr>
<td>Recreational Activities</td>
<td>7</td>
</tr>
<tr>
<td>Dance</td>
<td>6</td>
</tr>
<tr>
<td>Football</td>
<td>7</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>5</td>
</tr>
<tr>
<td>Volleyball</td>
<td>6</td>
</tr>
<tr>
<td>Softball</td>
<td>4</td>
</tr>
<tr>
<td>Swimming</td>
<td>4</td>
</tr>
<tr>
<td>Squash</td>
<td>3</td>
</tr>
<tr>
<td>Gymnastics</td>
<td>2</td>
</tr>
<tr>
<td>Ice Hockey</td>
<td>2</td>
</tr>
<tr>
<td>Martial Arts</td>
<td>2</td>
</tr>
<tr>
<td>Cycling</td>
<td>2</td>
</tr>
<tr>
<td>Diving</td>
<td>1</td>
</tr>
<tr>
<td>Track and Field</td>
<td>1</td>
</tr>
<tr>
<td>Golf</td>
<td>1</td>
</tr>
<tr>
<td>Cheerleading</td>
<td>1</td>
</tr>
<tr>
<td>Weight Lifting</td>
<td>1</td>
</tr>
<tr>
<td>Field Hockey</td>
<td>1</td>
</tr>
</tbody>
</table>

Total 133
**Pediatric Activity Rating Scale**

In the previous Month:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Less than one time per month</th>
<th>One time per month</th>
<th>One time per week</th>
<th>2-3 times per week</th>
<th>More than 4 times per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running: running while playing a sport or jogging</td>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Cutting: quickly changing directions while running</td>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Decelerating: coming to a quick stop while running</td>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Pivoting: turning your body with your foot planted (for example: skiing, skating, kicking, throwing, hitting a ball)</td>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Duration: perform athletic activity for as long as you would like to without stopping</td>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Endurance: perform athletic activity for one whole hour without stopping</td>
<td>(0)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
</tbody>
</table>

**Competition:** Do you participate in organized competitive sports or physical activities?
- No (or gym class only) (0)
- Yes but WITHOUT an official or judge (such as club or pickup games) (1)
- Yes, WITH an official or judge (2)
- Yes, at a national or professional level (3)

**Supervision:** Do you participate in supervised (coach, trainer, instructor) sports practice or activities (other than gym class)?
- No (0)
- Yes, 1-2 times per week (1)
- Yes, 3-4 times per week (2)
- Yes, 5 or more times per week (3)

Figure 1.

The pediatric activity rating scale. Scoring is performed by adding points from each question for total possible score range from 1 to 30 points. For "Running", "Cutting", "Decelerating", "Pivoting", "Duration", and "Endurance", each question is worth 0, 1, 2, 3, or 4 points. For the "Competition" and "Supervision" questions, each question is worth 0, 1, 2, or 3 points. Scoring for each item is listed in parentheses; in the clinical version these scores are omitted and not to be seen by the patient.
Figure 2.

Distribution of scores of 51 subjects who completed the child and adolescent activity scale. While there is a slight negative skew, the subject cohort was comprised of active children. No ceiling effect is noted.
Figure 3.
Figure 3. Distribution of scores of 51 children who completed the adult activity scales resulted in
ceiling effects for Noyes – Functional (A), Noyes – Sports (B), and Marx (C). Use of these adult scales in children is limited by a large proportion of subjects receiving maximum scores.


