Developing and assessing the measurement properties of an instrument to assess the impact of musculoskeletal pain in children aged 9 to 12—the pediatric musculoskeletal pain impact summary score

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Abstract

Background: Despite the high prevalence of musculoskeletal (MSK) pain in children, there is a lack of instruments to measure the impact of MSK pain on children’s activity and participation.

Objective: To assess the reliability and construct validity of the Pediatric MSK Pain Impact summary score in school children (aged 9 to 12) with MSK pain.

Methods: We used a pragmatic approach in a reflective framework to assess internal consistency, structural validity, convergent validity, and discriminative validity in a sample of 615 children with MSK pain.

Results: The confirmatory factor analysis results indicate that the summary score has limited internal consistency and construct validity. The estimated Cronbach’s alpha was 0.63, and most goodness of fit indices met the recommended thresholds (SRMR = 0.030; GFI = 0.993, CFI = 0.955, RMSEA 0.073), although they were close to the lower bounds of the thresholds. The convergent validity showed appropriate correlation of the summary score with quality of life (r = -0.33), care-seeking (r = 0.45), and medication intake (r = 0.37). Discriminative validity showed that the...
Introduction

Musculoskeletal (MSK) pain in children is highly prevalent and disabling worldwide.\(^1\) Up to 40% of children and adolescents experience persistent MSK pain,\(^2\) which can substantially impact children’s life.\(^3\) The burden of MSK pain in children results from reduced social interaction with family and friends, increased health care costs, and escalation of anxiety and depression symptoms.\(^4\)\(^,\)\(^5\) Furthermore, evidence shows that persistent MSK pain in children and adolescents predisposes to MSK pain in adulthood.\(^3\) While the experience of pain can be broad and cause diverse impacts, children who develop MSK pain often have limited participation in everyday activities.\(^4\)\(^,\)\(^6\) According to the International Classification of Functioning (ICF), activity and participation are “constituents of health”, and encompass individual and societal aspects of functioning.\(^3\) The impact of pain is defined as the effect of the pain experience on the different aspects of an individual’s life and participation.\(^4\)\(^,\)\(^6\) School and sporting activities are examples of significant components of a child’s life that are impacted by the experience of MSK pain.\(^10\)

Despite the potential impact of pain and its high prevalence in children, valid and reliable patient-reported outcome measures (PROMs) that quantify MSK pain impact in children and adolescents are scarce.\(^11\) Michaleff et al.\(^11\) compiled a list of the instruments most commonly used to measure pediatric pain. The study found that existing instruments primarily focus on measuring pain intensity, frequency, and location, such as the Faces Pain Scale-Revised (FPS-R) and the Verbal Numerical Rating Scale for pain.\(^11\) While a few instruments, such as the Young Spine Questionnaire (focused on spinal pain rather than general MSK pain) and The Functional Disability Inventory, measure the impact of pain, they were initially developed and validated for purposes other than MSK pain.\(^12\)\(^,\)\(^13\)

Consequently, instruments validated in adults have been used in children and adolescents to measure MSK pain outcomes, such as the impact of low back pain.\(^7\)\(^,\)\(^14\) However, using an instrument developed for adults on children without proper validation is not recommended. Children and adults differ significantly in their physical, mental, and social characteristics.\(^15\) Therefore, it is important to ensure that the instruments used to assess PROMs are valid in this population.\(^16\) We aimed to develop an instrument using a set of items currently used in research and clinical practice aiming to measure the impact of pain on activity and participation of primary school children (aged 9 to 12) using a reflective framework and assess its reliability (internal consistency) and construct validity.

Methods

Design

This study was designed to develop and assess the measurement properties of a tool to measure pain impact in children in grades 4 to 6 (aged 9 to 12) — the Pediatric MSK Pain Impact summary score. The methods of this study were based on the Consensus-based Standards for the selection of health status Measurement INstruments (COSMIN).\(^17\) We opted to include the set of items as part of the data collection of an ongoing cluster randomized controlled trial (ACTRN12616001228471), which we considered as a pragmatic approach. The randomized cluster trial was conducted following the Declaration of Helsinki and approved by the Hunter New England Human Research Ethics Committee (Ref. No. 06/07/26/4.04), University of Newcastle (Ref. No. H-2008–0343), and the Maitland-Newcastle Catholic Schools Office. Informed consent was obtained from all parents from all children involved in the study. According to the Committee on Health and Research Ethics, written informed consent has been obtained.

Development phase

Definition of the construct

The definition of MSK pain impact for this study was “pain associated with a significant disability”\(^9\) from the MSK system (including bones, muscles, and joints)\(^9\) resulting in impairment of the functional status (activity and participation) as per the ICF in primary school-aged children aged 9 to 12.\(^3\) We proposed a summary score to measure how well the indicators of pain severity; impact on day-to-day activities, on sporting activities, and school absence reflect the construct of MSK pain impact.

Item selection process

We collated pre-existing questions typically used to assess the presence of pain, pain severity, and the impact of pain.
on physical activity, day-to-day activities, and school absence. We included the questions in the baseline survey of a cluster randomized trial that aimed to assess the effectiveness of a school-based physical activity and nutrition intervention (Supplementary material A).

We used the FPS-R to measure pain severity. The FPS-R is a valid instrument to measure pain severity in children aged 5 to 12. The FPS-R item responses are presented on a six-point scale ranging from 1 (no pain) to 6 (a lot of pain). We obtained permission from the developers to use the FPS-R as part of this summary score.

To measure activity limitations and participation restrictions following the ICF framework, we used three pain impact items capturing different aspects of the impact of MSK pain — restrictions in everyday activity, school, and sports. We adapted the wording of items from previous studies on adolescents with LBP to reflect the widespread MSK pain impact on primary school-aged children. The items asked children to indicate whether their pain caused them to; miss school, stop sports or physical activities, or interfered with everyday activity. Each item was rated on a Likert-type scale with the options; “often”, “once in a while”, “once or twice”, and “never”.

Scoring instructions

The scoring of the Pediatric MSK Pain Impact summary score is a sum of each response option from the four included items: the 6-point Likert pain severity scale (FPS-R) and the three items of pain impact (on 4-point Likert scales). The FPS-R scale score ranges from 1 (no pain) to 6 (a lot of pain). The three pain impact items 4-point Likert scale ranging from 1 (never) to 4 (often). A higher overall Pediatric MSK Pain Score summary score indicates greater functional impact due to MSK pain.

Validation phase

Classical test theory approach was applied to assess the measurement properties of the Pediatric MSK Pain Impact summary score (Appendix - www.spoergeskemaer.dk/pediatric-msk-impact). We used confirmatory factor analysis (CFA), proposing a one-factor structure, to examine the validity of the four-items-of-pain impact related to functional status.

Setting

We used baseline data from children enrolled in a cluster randomized trial conducted in 12 Catholic primary (elementary) schools in the Hunter New England Region, New South Wales, Australia. All schools were stratified by size (small, < 300 students; or large, > 300 students) and placed in random order. To be eligible, the schools had to have an enrolment of greater than 120 students, be current users of the school mobile communication app (Skoolbag), and not participate in other nutrition or physical activity-based research studies. We aimed to assess the measurement properties of the pain impact questions in children in grades 4 to 6 (aged 9 to 12).

Participants

All students (aged 9 to 12) attending the 12 schools were invited to participate in the data collection component of the cluster randomized trial via a package sent to their parents, who were asked to provide written consent. Students with parental consent to participate were invited to complete a baseline survey (Supplementary material A). We included students in grades 4 to 6 (aged 9 to 12) who indicated in the baseline survey: 1) the presence of pain or aches in their body, selecting from response options “often,” “once in a while,” or “once or twice”, 2) answered questions relating to the area of their body where they typically experienced pain, and 3) the items about the impact of their pain on their school activities.

Statistical analysis

a. Item characteristics: We assessed descriptive properties (frequency, means, standard deviations, range, skewness, and kurtosis), the percentage of missing responses for each item, and the use of the distribution of responses for each item. We analyzed each item to assess their feasibility and acceptability to the construct of MSK pain impact. We assessed the correlation between each pair of items to identify possible redundancy. Polychoric correlations were used due to the ordinal nature of the items. Items with a polychoric correlation > 0.8 were examined for possible exclusion due to high correlation. Polychoric correlations can be weak (0.2–0.39), moderate (0.4–0.59), strong (0.6–0.79), or very strong (0.8–1).

b. Reliability: We assessed internal consistency as an indicator of the reliability of the questionnaire. Internal consistency is “the degree of the interrelatedness among the items” or the full scale. A Cronbach’s alpha coefficient (adequate score: ≥ 0.70) and item correlations, were used to assess the overall adequacy of the model. We estimated the following CFA model indices and recommended criteria were estimated: Standardized Root Mean Square Residual (SRMR) < 0.08; Comparative Fit Index (CFI) > 0.95; Root Mean Square Error of Approximation (RMSEA) < 0.06; Bentler-Bonett Normed Fit Index (NFI) > 0.95; Model Chi-squared p-value > 0.05; Goodness of Fit Index (GFI) > 0.90; Adjusted GFI >
We formulated a priori hypotheses about the strength and direction of correlations to examine relationships between the pain impact measurement score and the comparative measures. Only students who answered all four items were used to calculate the overall score. We used Spearman rank correlation coefficients to assess the relationship between the overall summary score and the comparative measures. The comparative measures, collected at baseline in the trial, were: Pediatric quality of life Inventory (PedsQL) 4.0 total score and physical functioning scale; care-seeking; medication use; and physical activity and sedentary behavior, both measured by accelerometers. The description of each comparative measure and each hypothesis is presented in Supplementary material B.

Results

Overall, 815 children aged 9 to 12 from 12 schools returned the baseline survey of the cluster randomized trial. Seven hundred forty-eight children reported whether they had pain or not. Of this, 648 children said they had pain at least “once or twice”. Finally, 615 children met our inclusion criteria. A description of the included participants’ characteristics is provided in Table 1. Most of the polychoric correlations were weak (< 0.40) for the items “pain intensity”, “stayed at home from school”, and “stopped doing

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years), mean (SD)</strong></td>
<td>10 (1)</td>
</tr>
<tr>
<td><strong>Sex (female), n (%)</strong></td>
<td>327 (53%)</td>
</tr>
<tr>
<td><strong>School year, n (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Year 4</td>
<td>223 (36%)</td>
</tr>
<tr>
<td>Year 5</td>
<td>211 (34%)</td>
</tr>
<tr>
<td>Year 6</td>
<td>181 (29%)</td>
</tr>
<tr>
<td><strong>Remote classification, n (%)</strong>*</td>
<td></td>
</tr>
<tr>
<td>Major city</td>
<td>488 (79%)</td>
</tr>
<tr>
<td>Inner/Outer Regional/Remote Australia</td>
<td>127 (21%)</td>
</tr>
<tr>
<td><strong>SEIFA disadvantage classification, n (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Most Disadvantaged*</td>
<td>414 (67%)</td>
</tr>
<tr>
<td>Least Disadvantaged</td>
<td>201 (33%)</td>
</tr>
<tr>
<td><strong>Location of pain, n (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Legs</td>
<td>302 (49%)</td>
</tr>
<tr>
<td>Feet</td>
<td>261 (42%)</td>
</tr>
<tr>
<td>Head</td>
<td>237 (39%)</td>
</tr>
<tr>
<td>Arm</td>
<td>170 (28%)</td>
</tr>
<tr>
<td>Spine</td>
<td>128 (21%)</td>
</tr>
<tr>
<td>Hips</td>
<td>53 (9%)</td>
</tr>
</tbody>
</table>

* calculated using Social Disadvantage and Accessibility/Remoteness using the Australian Bureau of Statistics 2016 Socio-Economic Index for Australia (SEIFA).

| Proportions may not add up to 100 due to students selecting more than one location. |

Sports or physical activity” (Table 2). The item “pain interfered with normal activity” had a weak to moderate polychoric correlation. No items illustrated potential redundancy with correlation estimates > 0.80.

All four items were slightly skewed towards the response item “never” response (positive skewness values, right-hand skew) (Fig. 1). Missing data were minimal (5%) for all items.

Reliability

The internal consistency estimate measured by the standardized Cronbach’s alpha coefficient was 0.63, below the threshold value of 0.70.

Construct validity

- **Structural validity**: all but two indices met the recommended criteria for a good fit, with the Chi-squared statistic and Bentler-Bonett NFI below the recommended threshold (Table 3).
- **Convergent validity (hypothesis testing)**: The total Pediatric MSK Pain Impact summary score was calculated from complete cases (n = 599). There were 16 students with at least one missing response on the pain impact items. The correlations with PedsQL 4.0 physical functioning scale (H2), physical activity (H4), and sedentary behavior (H5) did not meet the a priori hypotheses (Table 4). Three out of the six (50%) hypotheses were not confirmed.
- **Discriminative validity**: 322 students were included in the analysis (122 with frequent pain and 200 with infrequent pain). The discriminative validity showed a mean
difference of 2.93 (95% CI: 2.36, 3.50) in the Pediatric MSK Pain Impact summary score between children with frequent and infrequent MSK pain. The percentage of total variance in the Pediatric MSK Pain Impact summary score that could be attributed to the between-school variation was 0.9% (ICC: 0.009 [95% CI: 0.001, 0.127]; p<.0001) Students with frequent pain episodes scored 11 (95% CI: 10.5, 11.5), and students with infrequent pain scored 8 (95% CI: 7.7, 8.5) in the Pediatric MSK Pain Impact summary score.

<table>
<thead>
<tr>
<th>Items</th>
<th>Pain intensity</th>
<th>Stayed at home</th>
<th>Stopped sports/PA</th>
<th>Pain interfered normal activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain intensity</td>
<td>1</td>
<td>0.37</td>
<td>0.25</td>
<td>0.40</td>
</tr>
<tr>
<td>Stayed at home</td>
<td>0.37</td>
<td>1</td>
<td>0.35</td>
<td>0.44</td>
</tr>
<tr>
<td>Stopped sports/PA</td>
<td>0.25</td>
<td>0.35</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pain interfered normal activity</td>
<td>0.40</td>
<td>0.35</td>
<td>0.44</td>
<td>1</td>
</tr>
</tbody>
</table>

PA, physical activity; Polychoric correlations can be weak (0.2–0.39), moderate (0.4–0.59), strong (0.6–0.79), or very strong (0.8–1).29.

![Fig. 1](image_url) Histogram of each item.

Table 2  Polychoric correlation matrix.

<table>
<thead>
<tr>
<th>Items</th>
<th>Pain intensity</th>
<th>Stayed at home</th>
<th>Stopped sports/PA</th>
<th>Pain interfered normal activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain intensity</td>
<td>1</td>
<td>0.37</td>
<td>0.25</td>
<td>0.40</td>
</tr>
<tr>
<td>Stayed at home</td>
<td>0.37</td>
<td>1</td>
<td>0.35</td>
<td>0.44</td>
</tr>
<tr>
<td>Stopped sports/PA</td>
<td>0.25</td>
<td>0.35</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pain interfered normal activity</td>
<td>0.40</td>
<td>0.35</td>
<td>0.44</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3  Structural validity indices — confirmatory factor analysis.

<table>
<thead>
<tr>
<th>Type of Index</th>
<th>Fit index</th>
<th>Fit value</th>
<th>Recommended criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute</td>
<td>Pr &gt; Chi-Square†</td>
<td>0.015</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td></td>
<td>Standardized RMR (SRMR)</td>
<td>0.030</td>
<td>&lt; 0.08 acceptable</td>
</tr>
<tr>
<td></td>
<td>Goodness of Fit Index (GFI)</td>
<td>0.993</td>
<td>&gt; 0.90</td>
</tr>
<tr>
<td></td>
<td>Bentler Comparative Fit Index‡</td>
<td>0.955</td>
<td>&gt; 0.95 ideal</td>
</tr>
<tr>
<td></td>
<td>Bentler-Bonett NFI</td>
<td>0.943</td>
<td>&gt; 0.95</td>
</tr>
<tr>
<td>Parsimony</td>
<td>Adjusted GFI (AGFI)†</td>
<td>0.964</td>
<td>&gt; 0.90</td>
</tr>
<tr>
<td></td>
<td>Parsimonious GFI (PGFI)‡</td>
<td>0.331</td>
<td>No criteria*</td>
</tr>
<tr>
<td></td>
<td>RMSEA Estimate</td>
<td>0.073</td>
<td>&lt; 0.06</td>
</tr>
</tbody>
</table>

† Indices below the recommended thresholds.;
‡ Indicative of fair fit.;
* No accepted threshold; however, the penalties applied to this index often result in considerably lower values compared to other goodness of fit indices; PGFI values around 0.5 have been found when other indices are above 0.9031; GFI: Goodness of Fit Index; NFI: Normed Fit Index; RMSEA: Root Mean Square Error of Approximation; SRMR: Standardized Root Mean Square Residual.
The polychoric item correlations were In our study, could have provided Also, greater and embedded the Nevertheless, future investigation into the internal items can have lower Cronbach plausible that Cronbach meaning low interrelatedness of the items.

Discussion

We found that the Pediatric MSK Pain Impact summary score had insufficient reliability (internal consistency) and marginal construct validity to assess the impact of MSK pain in children aged 9 to 12. The internal consistency was minimal, with a Cronbach’s alpha (0.63) below the recommended criteria (> 0.70). The polychoric item correlations were adequate. The construct validity may be considered minimal even though estimates met agreed thresholds for most structural validity indices, convergent validity (50% of hypotheses confirmed) and discriminative validity (2.93; 95% CI: 2.36, 3.50). Despite the shortcomings, the instrument showed a reasonable discriminative validity as it could discriminate pain impact levels between children with frequent and infrequent pain.

Reliability (internal consistency) findings

The Cronbach’s alpha (0.63) was below the recommended threshold of 0.70, suggesting limited internal consistency. Therefore, internal consistency for this measure should be interpreted as minimal/emerging. This is because it is possible that Cronbach’s alpha results may be due to the few items of the instrument. Instruments with less than eight items can have lower Cronbach’s alpha without necessarily meaning low interrelatedness of the items. Also, greater Cronbach’s alpha estimates are expected in larger samples, meaning that small changes are less likely to affect the overall score, and because our sample is large (n = 815), our confidence in the internal consistency result remains fairly strong. Nevertheless, future investigation into the internal consistency of the measure should be considered.

Construct validity findings

The analysis of structural validity suggests that the summary score reflects the unidimensionality of the construct of pain impact in school-aged children (aged 9 to 12). It is considered best practice to report at least three goodness-of-fit indices, such as SRMR, RMSEA, and CFI. In our study, the goodness-of-fit indices met the recommended criteria. However, we acknowledge that most indices were very close to the recommended threshold, which may still be insufficient compared to other measures.

The Pediatric MSK Pain Impact summary score showed moderate convergent validity but poor divergence with other constructs. Two of the three expected positive correlations (care seeking and medication intake) met our specified correlation threshold. Whereas one of three expected negative correlations (quality of life) met the specified threshold. However, physical function showed only a weak negative correlation. The remaining two hypotheses were rejected due to a weak unexpected positive correlation (physical activity) and an unexpected negative correlation (sedentary behavior). While this unexpected cross-over (or lack of) with other constructs may undermine the Pediatric MSK Pain Impact summary independence as a construct, we found the score to have good discrimination of “known group” who would be expected to have a higher burden of pain.

Limitations

We acknowledge the limitations of our study. First, we opted for a pragmatic approach to develop and assess the measurement properties of the instrument. Following the recommended development steps could have provided valuable insights for item reformulation or additions to the instrument items. We selected and adapted pre-existing items used in low back pain studies and embedded the items into an existing trial without conducting pilot and field-testing steps. Additionally, the skewness observed in the response items may suggest the presence of a potential floor effect at the item level, which possibly reflects limited.

Sensitivity analysis

The results of both sensitivity analyses (Supplementary material C) did not modify the main findings substantially.

Table 4 Construct validity hypothesis.

<table>
<thead>
<tr>
<th>Hypothesis (h)</th>
<th>Correlation</th>
<th>p-value</th>
<th>Confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 PedsQL 4.0 total score</td>
<td>Moderate negative</td>
<td>&lt;0.0001</td>
<td>Yes</td>
</tr>
<tr>
<td>H2 PedsQL 4.0 Physical Funct</td>
<td>Moderate negative</td>
<td>&lt;0.0001</td>
<td>No</td>
</tr>
<tr>
<td>H3 Care seeking</td>
<td>Moderate positive</td>
<td>&lt;0.0001</td>
<td>Yes</td>
</tr>
<tr>
<td>H4 Medication intake</td>
<td>Moderate positive</td>
<td>0.5410</td>
<td>No</td>
</tr>
<tr>
<td>H5 School Day MVPA</td>
<td>Moderate negative</td>
<td>0.1139</td>
<td>No</td>
</tr>
</tbody>
</table>

95% CI, 95% confidence interval; H, hypothesis; Physical Funct, physical functioning; r, spearman correlation coefficient. Spearman correlation indices: weak: 0.3, moderate: 0.3 to 0.5, strong: 0.6.
content validity and is likely to limit the potential responsiveness of the measure. Due to feasibility and capacity constraints, we were unable to evaluate additional measurement properties such as Standard Error of Measurement (SEM), Minimal Detectable Change (MDC), responsiveness, and Minimal Clinically Important Difference (MCID). Future research should consider these aspects to provide a more comprehensive evaluation of the instrument’s performance.

Future perspectives for research

Further research should be conducted to expand the applicability of the instrument. First, future studies could improve the content validity of the instrument by asking the perspectives of children, parents, and teachers about the relevance, comprehensiveness, and comprehensibility of the items, response options, and instructions. Furthermore, future research should investigate how emotional, cognitive, and social aspects of pain can be integrated into this short instrument, as these aspects can potentially affect children’s activity and participation. However, it is important to emphasize that while considering adding new items to the instrument in the future, maintaining its brevity is important for reducing respondent burden while ensuring reliable and valid estimates. Longitudinal outcome measures can be particularly hard for children to complete. Finally, it is recommended to assess the measurement properties of this instrument in other age ranges. As children’s cognitive development evolves with age, their perceptions of subjective pain constructs may differ. Exploring this across various age groups will yield valuable insights into the measure’s validity and applicability across the developmental spectrum.

Conclusions

The Pediatric MSK Pain Impact summary score is a short instrument designed to assess the impact of MSK pain on the physical functioning of school-aged children aged 9 to 12. The instrument could distinguish between children with infrequent and frequent pain who are likely to be impacted by MSK pain. However, the results showed limited internal consistency and moderate convergent validity, as only three hypotheses were met. It is possible that the short length of the instrument might have negatively impacted the measurement properties. Further research should investigate additional measurement properties and whether adding extra items or reformulating current ones improves the instrument’s performance. We also note that the measure focuses on the physical impact domain and does not address other domains, such as psychological well-being and social participation.

Data Availability Statement

The data supporting this study’s findings are not publicly available and will be available upon reasonable request and with the permission of all involved authors.

Author contributions


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Conflicts of interest

The authors declare no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.bjpt.2024.101052.

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