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# Discriminatory Capacity of the Physical Domain versus the Full-Scale Pediatric Quality of Life Inventory with Traumatic Brain Injury Severity in Children

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## Abstract

A previous study demonstrated that the Pediatric Quality of Life Inventory (PedsQL), a health-related quality-of-life instrument consisting of physical and psychosocial domain scores, reliably differentiates between children with varying severities of traumatic brain injuries (TBI) (N=729) 3, 12, and 24 months after injury. However, the PedsQL physical domain score alone may simplify evaluation outcomes in physical rehabilitation and clinical research when comparing different trauma interventions. Therefore, we performed a secondary analysis to evaluate and compare the discriminative capacity of TBI injury severity for changes in the overall PedsQL or the PedsQL physical domain score alone. We used linear mixed models to assess the change of outcome scores from baseline compared to arm-injury controls. Somers' D was calculated to compare discriminatory capacity with injury severity as a predictor of change in PedsQL outcome scores. We found that TBI severity in children can be differentiated by the PedsQL physical domain score alone. However, at all follow-up timepoints, TBI severity had higher discriminatory capacity for changes in the overall PedsQL. Our results suggest that the overall PedsQL should be used preferentially in children with TBIs, though further investigation of the physical domain is warranted in conditions where physical injuries may predominate.

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**Keywords**

Brain Injuries; Traumatic; Pediatrics; Quality of Life; Rehabilitation

## INTRODUCTION

Traumatic brain injury (TBI) is a leading cause of death and disability in children.[1] In the United States, 145,000 children and adolescents are living with lasting TBI sequelae affecting their physical, psychosocial, and cognitive health.[2] Health-related quality-of-life instruments can quantify the subjective burden of disability after illness or injury, including TBI. Importantly, these measures act as an outcome by which TBI interventions can be evaluated for both short-term and long-term quality-of-life.

The Pediatric Quality of Life Inventory (PedsQL) is valid and reliable in assessing health-related quality-of-life in children, and has been recommended as a core quality-of-life measure after TBI and a primary measure of global outcome.[3,4] Using physical, emotional, social, and school functioning domains, the PedsQL has been shown to be reliable in differentiating between children with different severities of TBI after injury.[5] How a child is doing emotionally, interacting socially with others, and performing in school, however, may be sensitive to premorbid conditions unrelated to TBI such as depression, developmental delay, and learning difficulties.[6] Furthermore, the physical domain may also reflect these factors, but we did not test this independently.

The PedsQL physical domain score alone (excluding the psychosocial domain scores [emotional, social, and school functioning domains]) may be a more valid measure of recovery after TBI compared to the overall PedsQL, as suggested previously.[6] Two of the PedsQL physical domain survey items, however, were determined to more reflect emotional quality-of-life items than physical (i.e., “having hurts or aches” and “low energy level”).[6] Despite this, using the PedsQL physical domain score alone may simplify evaluation outcomes in physical rehabilitation and clinical research when comparing different trauma populations.

As such, our objective was to evaluate and compare the discriminative capacity of TBI injury severity for changes in the overall PedsQL or the PedsQL physical domain score alone. We hypothesized that children with TBI would report greater reductions in physical health-related quality of life with increasing injury severity. More specifically, we hypothesized that the PedsQL physical domain alone can differentiate between children with different severities of TBI after head trauma, similar to the overall PedsQL score.

## METHODS

We conducted a secondary analysis of a prior study of children with TBI.[5] All study procedures were approved by the institutional review boards of participating institutions. Written informed consent was obtained from all parents, and written assent was obtained from children 14 years or older when appropriate.

### Inclusion Criteria

The overall study design of the primary study has been previously reported.[5] In brief, the primary study was conducted from March 1, 2007 to September 30, 2008, and enrolled all children younger than 18 years-old treated for TBIs in the emergency departments (ED) or as inpatients at any of nine hospitals from King County, Washington, and the Children's Hospital of Philadelphia. Children with isolated arm injuries were also included as a control group. Different proportions of children were sampled to ensure representation across age, gender, and injury severity.[5] A total of 729 children with TBI and 197 children with arm injury were included.

### Study Procedures

A parent of the eligible child was contacted as soon as possible after injury to describe pre-injury functioning. If cognitively able, adolescents aged 14 years or older were also contacted by the investigators of the parent study and completed separate surveys. For our analysis, a composite score was used if both the parent and adolescent aged 14 years or older submitted the PedsQL survey.

The PedsQL survey includes physical (8 survey items), emotional (5 items), social (5 items), and school (5 items) domains. Each item is scored on a 5-point Likert scale ("Never any symptoms" = 100 to "Almost always has symptoms" = 0) and are averaged across the total number of items. Follow-up surveys were conducted 3, 12, and 24 months after the date of injury. Self-reported data on potential confounders of race/ethnicity, insurance, household income, and respondent education were also collected. Patient demographic data and additional injury characteristics are available in Table 1.

### Patient Cohorts

As defined by the Centers for Disease Control and Prevention and World Health Organization during the conduct of the parent study,[5] children with TBI were stratified by injury severity based on Glasgow Coma Scale (GCS) scores. Mild TBI was defined as a GCS score of 13 to 15 at the time of medical evaluation. Mild TBI was further subdivided into three subcategories of increasing injury severity: Mild I, no abnormalities on computed tomography (CT) or no CT performed; Mild II, skull fracture without intracranial hemorrhage; and Mild III, intracranial hemorrhage. Moderate TBI was defined as a GCS motor score of 4 to 5 (out of scale of 1 to 6) and severe TBI was defined as a GCS motor score of 1 to 3.

### Secondary Analysis

The scores of the PedsQL physical domain alone and the overall PedsQL range from 0 to 100 with higher PedsQL scores indicating better health-related quality-of-life. Mean PedsQL scores for each cohort are based on all children with data at each respective time point. In the current analysis, we used linear mixed models to assess the changes of PedsQL scores from baseline to 3, 12, and 24 months after TBI compared with controls, adjusting for patient age (as a continuous variable), sex, race, insurance status, parent income, and parent education. A 4.5-point change in PedsQL score has been found to represent a clinically meaningful difference.[3] The PedsQL physical domain scores are reported numerically

including unadjusted and adjusted values with 95% confidence intervals (Table 2), and graphically as changes over time (Figure).

Discriminatory capacity was quantified using Somers' D. To compare the two discriminatory capacity measures at a given timepoint, we compared the two Somers' D measures, stratified by hospital.[7] The asymmetric version of Somers' D was computed using the ordinal injury severity (ranging from arm injury to severe TBI) as a predictor of change in outcome score from baseline to each timepoint (3, 12, and 24 months). Similar to other correlation measures, Somers' D ranges from −1 to 1, with 0 representing no association. Values closer to −1 demonstrate better discriminatory capacities between injury severities (i.e., greater reduction in PedsQL with greater injury severity).

For each timepoint, Somers' D was estimated and compared between when change in the PedsQL physical score alone was the outcome versus when change in the total PedsQL score was, using Fisher's Z transformation to improve the validity of the asymptotic normal distribution assumptions for statistical inferences. For the within-timepoint pairwise comparisons of Somers' D values, p-values less than 0.05 were considered statistically significant differences.

## RESULTS

The PedsQL physical domain alone showed greater reductions in health-related quality-of-life with increasing TBI severity (Table 2 and Figure). After adjusting for age, sex, race, insurance status, parental income, and parental education, children with moderate and severe TBI had significantly lower PedsQL physical domain score changes at 3, 12, and 24 months from baseline compared to arm injury controls (Table 2). These results were similar to the overall PedsQL scores using all domains.[5]

For each timepoint (3, 12, and 24 months), injury severity discriminated more strongly with respect to changes in overall PedsQL than for PedsQL physical domain scores alone ($p<0.01$). Somers' D values for the PedsQL physical domain scores alone at 3, 12, and 24 months from baseline were 0.02 (95% CI −0.06 to 0.11), 0.02 (95% CI −0.06 to 0.10), and −0.02 (95% CI −0.11 to 0.06), respectively. Somers' D values for PedsQL using all domains at 3, 12, and 24 months from baseline were −0.08 (95% CI −0.16 to 0.00), −0.11 (95% CI −0.20 to −0.03), and −0.13 (95% CI −0.21 to −0.04), respectively.

## DISCUSSION

TBI can lead to serious neurocognitive disorders with varied effects in survivors that can be broadly classified into physical, psychosocial, and cognitive.[1,8] The PedsQL provides clinicians and researchers a well-validated measure of health-related quality-of-life to assess interventions and recovery after TBI. It also provides affected children and their families an opportunity to address specific aspects of the child's injury and the quality of care he/she is receiving.[3]

Our results show that mean reductions from baseline on the PedsQL physical domain scores alone and the overall PedsQL score were similar within categories of TBI severity and

that these reductions were worse with more severe injury. However, analysis of Somers' D values demonstrated that injury severity has stronger discriminative capacity for changes in overall PedsQL than for changes in the PedsQL physical domain scores alone. Given that the PedsQL using all domains takes less than 5 minutes to complete, there appears to be no apparent benefit with measuring the PedsQL physical domain scores alone.[4,9] Additionally, there is a general consensus of the importance of evaluating short-term and long-term cognitive sequelae in children with TBI, as physical functioning tends to improve with time.[6,8]

Children with TBI often experience extracranial injuries, as a result of falls, motor vehicle accidents, and assault.[1,10] These injuries range in distribution and can have significant impact on functional outcomes, as demonstrated even in our mild TBI cohort (Table 1 and 2).[10] Of note, these injuries with or without significant TBI may not demonstrate an independent effect on psychosocial and cognitive outcomes.[8] Although the physical functioning domain scores of the PedsQL was not as responsive as overall PedsQL in children with TBI in our study, the physical component may prove useful in other trauma populations or in the study of other disease states.

Simplifying evaluation tools has proven useful in select circumstances. For example, in children with TBI, the motor component of the GCS score has been shown to better predict long-term outcomes when compared to the full GCS score.[11] As such, the physical domain scores of the PedsQL may be useful in patients with predominantly physical injuries, for instance, where psychosocial and cognitive domains are not likely to play a major role in recovery. Measuring the PedsQL physical domain scores alone may also be useful in children where psychosocial and cognitive domain scores are difficult to determine. However, further research is needed in these populations.

## LIMITATIONS

Our results should be considered in the context of some limitations. First, recall bias was not accounted for at each timepoint. This may be especially relevant at baseline given that the median time between injury and baseline interview was 37 days. Second, nearly one-half of the children in the mild I TBI cohort did not have CT scans (Table 1), leaving the possibility that some of these children could have been misclassified within the mild TBI categories. However, prior work has demonstrated that clinicians can accurately identify the presence of clinically important TBI, and that children who do not receive a cranial CT scan likely do not have a clinically important TBI.[12] Third, we did not collect information on specific TBI treatments which may potentially influence outcome measurements. Lastly, our analysis does not account for the amount and type of rehabilitation between timepoints. This may be relevant as some patients may be under medical orders to restrict physical activity in the early months of recovery.

## CONCLUSION

The PedsQL physical domain scores are significantly different between children with moderate and severe TBI at 3, 12, and 24 months after injury. However, at all follow-up

timepoints, TBI severity had higher discriminatory capacity for changes in the overall PedsQL than the PedsQL physical domain score alone. Our results suggest that the overall PedsQL should be used preferentially over the PedsQL physical domain score alone in children with TBIs. Further investigation of the physical domain score is warranted in disease states where other physical injuries may predominate.

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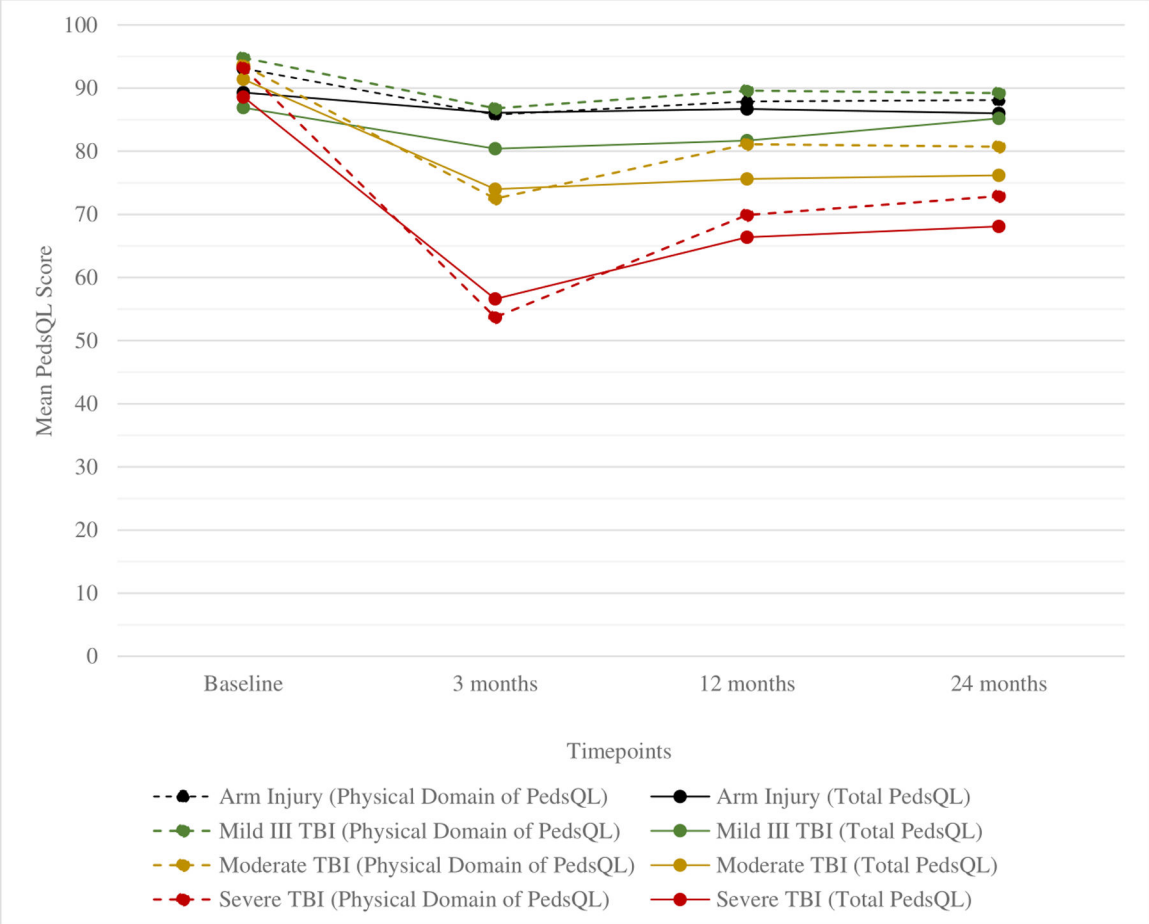


**Figure.**

Health-Related Quality of Life 3, 12, and 24 Months after Injury [a]

[a] - Both the total PedsQL and the Physical Domain of the PedsQL scores range from 0–100

**Table 1.**

Patient Demographics and Injury Characteristics

| | Patient Cohorts | | | | | |
|---|---|---|---|---|---|---|
| | **Arm Injury n=197** | **Mild I TBI n=479** | **Mild II TBI n=31** | **Mild III TBI n=106** | **Moderate TBI n=96** | **Severe TBI n=17** |
| **Patient Demographics, %** | | | | | | |
| Age (years) at injury | | | | | | |
| 0–4 | 32.0 | 28.7 | 12.9 | 28.3 | 38.5 | 29.4 |
| 5–9 | 21.3 | 23.5 | 38.7 | 20.8 | 11.5 | 17.7 |
| 10–14 | 27.9 | 28.5 | 22.6 | 23.6 | 24.0 | 23.5 |
| 15–17 | 18.8 | 19.3 | 25.8 | 27.4 | 26.0 | 29.4 |
| Sex | | | | | | |
| Male | 61.9 | 61.8 | 77.4 | 74.5 | 68.8 | 70.6 |
| Female | 38.1 | 38.2 | 22.6 | 25.5 | 31.2 | 29.4 |
| Race/Ethnicity | | | | | | |
| White, non-Hispanic | 65.5 | 66.7 | 80.7 | 65.1 | 49.0 | 23.5 |
| Black, non-Hispanic | 2.5 | 2.2 | 0.0 | 7.6 | 11.5 | 23.5 |
| Hispanic | 12.2 | 8.1 | 6.5 | 10.4 | 15.6 | 17.7 |
| Asian | 3.1 | 1.8 | 0.0 | 4.7 | 2.1 | 5.9 |
| Other or multiple | 16.8 | 21.1 | 9.7 | 12.3 | 21.9 | 29.4 |
| Unknown | 0.0 | 0.2 | 3.2 | 0.0 | 0.0 | 0.0 |
| Health Insurance | | | | | | |
| None | 2.0 | 1.8 | 6.5 | 6.6 | 11.5 | 5.9 |
| Medicaid | 25.9 | 25.2 | 25.8 | 18.9 | 36.5 | 64.7 |
| Private | 71.1 | 70.8 | 67.7 | 68.9 | 50.0 | 11.8 |
| Tricare/CHAMPUS | 0.0 | 0.2 | 0.0 | 5.7 | 2.1 | 11.8 |
| Basic health | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 | 5.9 |
| Unknown | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Household Income | | | | | | |
| Less than $30,000 | 16.8 | 20.4 | 25.8 | 21.7 | 30.2 | 41.2 |
| $30,000 – $60,000 | 15.7 | 17.1 | 16.1 | 19.8 | 27.1 | 35.3 |
| $60,000 – $100,000 | 25.4 | 19.1 | 29.0 | 28.3 | 21.9 | 5.9 |
| More than $100,000 | 37.6 | 39.3 | 22.6 | 24.5 | 14.6 | 0.0 |
| Unknown | 4.6 | 4.2 | 6.5 | 5.7 | 6.3 | 17.7 |
| Respondent parent’s education | | | | | | |
| Less than high school | 9.1 | 7.0 | 6.5 | 11.3 | 18.8 | 23.5 |
| High school/GED | 11.2 | 12.1 | 16.1 | 17.9 | 29.2 | 29.4 |
| Some college | 25.4 | 27.6 | 35.5 | 34.0 | 29.2 | 35.3 |
| College graduate | 33.0 | 30.0 | 32.3 | 19.8 | 15.6 | 0.0 |
| Graduate school | 20.8 | 23.3 | 9.7 | 16.0 | 7.3 | 5.9 |
| Unknown | 0.5 | 0.0 | 0.0 | 0.9 | 0.0 | 5.9 |
| **Injury Characteristics,[a] %** | | | | | | |

| | Patient Cohorts | | | | | |
|---|---|---|---|---|---|---|
| | **Arm Injury n=197** | **Mild I TBI n=479** | **Mild II TBI n=31** | **Mild III TBI n=106** | **Moderate TBI n=96** | **Severe TBI n=17** |
| Mechanism of injury | | | | | | |
| Motor vehicle crash | 3.2 | 6.8 | 16.1 | 16.4 | 35.1 | 38.4 |
| Pedestrian/bicyclist struck | 2.7 | 6.2 | 12.9 | 11.5 | 17.6 | 7.7 |
| Fall | 83.1 | 57.4 | 54.8 | 53.9 | 34.1 | 23.1 |
| Assault | 10.5 | 29.6 | 16.2 | 17.2 | 8.8 | 15.4 |
| Other | 0.5 | 0.0 | 0.0 | 1.0 | 4.4 | 15.4 |
| Isolated TBI[b] | 0.0 | 62.5 | 48.4 | 50.0 | 21.9 | 23.5 |
| Head CT | 1.6 | 50.2 | 100.0 | 100.0 | 100.0 | 100.0 |
| Injury severity score, mean (SD) | 4.5 (3.0) | 2.9 (4.1) | 7.3 (2.9) | 12.3 (8.0) | 23.8 (11.4) | 33.0 (9.1) |
| Preinjury comorbidities[c] | | | | | | |
| None | 35.0 | 36.5 | 38.7 | 40.6 | 45.8 | 58.8 |
| 1 | 31.5 | 24.1 | 9.7 | 28.3 | 18.7 | 23.5 |
| 2 | 15.7 | 14.8 | 29.0 | 10.4 | 11.5 | 0.0 |
| 3+ | 17.8 | 24.6 | 22.6 | 20.7 | 24.0 | 17.7 |

Abbreviations: CHAMPUS, Civilian Health and Medical Program of the Uniformed Services; GED, general equivalency diploma; SD, standard deviation

[a] Medical records were not available for 26 patients, 3 in arm injury cohort and 23 in Mild I TBI cohort

[b] Isolated TBI refers to head trauma with no other injury, including but not limited to chest, abdominal, spinal, or extremity injury

[c] Preinjury comorbidities assessed included developmental delay, seizures, previous TBI with loss of consciousness, hemiplegia or paraplegia, lung disease, diabetes, attention-deficit/hyperactivity disorder, depression, other mental health or behavioral problems, learning problems, previous fractures, and previous surgery.

**Table 2.**

Health-Related Quality of Life 3, 12, and 24 Months after Injury[a, b]

| | Patient Cohorts | | | | | |
|---|---|---|---|---|---|---|
| | **Arm Injury n=197** | **Mild I TBI n=479** | **Mild II TBI n=31** | **Mild III TBI n=106** | **Moderate TBI n=96** | **Severe TBI n=17** |
| **PedsQL Physical Domain Alone** | | | | | | |
| Baseline | 93.1 | 91.1 | 95.2 | 94.8 | 93.6 | 93.2 |
| 3 Months | 85.8 | 83.9 | 87.7 | 86.8 | 72.5 | 53.7 |
| Adjusted | Reference | 0.0 (−2.9,3.0) | −0.2 (−6.6,6.2) | −0.8 (−5.0,3.6) | ***−13.8 (−18.4,−9.3)*** [c] | ***−32.2 (−42.1,−22.3)*** [c] |
| 12 Months | 87.9 | 86.3 | 90.6 | 89.6 | 81.1 | 69.9 |
| Adjusted | Reference | 0.3 (−2.6,3.3) | 0.6 (−5.9,7.1) | 0.0 (−4.5,4.5) | ***−7.3 (−11.8,−2.8)*** [c] | ***−18.0 (−27.7,−8.4)*** [c] |
| 24 Months | 88.1 | 85.3 | 93.1 | 89.2 | 80.7 | 72.9 |
| Adjusted | Reference | −1.4 (−4.3,1.6) | 2.3 (−4.4,9.0) | −1.1 (−5.5,3.3) | ***−8.5 (−13.2,−3.9)*** [c] | ***−15.9 (−25.4,−6.3)*** [c] |
| **PedsQL All Domains** | | | | | | |
| Baseline | 89.3 | 85.6 | 87.6 | 86.9 | 91.4 | 88.6 |
| 3 Months | 86.1 | 81.1 | 83.1 | 80.4 | 74 | 56.6 |
| Adjusted | Reference | −1.4 (−3.7,0.8) | −1.3 (−6.2,3.7) | −3.3 (−6.6,0.0) | ***−14.0 (−17.5,−10.5)*** [c] | ***−27.8 (−35.4,−20.2)*** [c] |
| 12 Months | 86.7 | 82.1 | 82.7 | 81.7 | 75.6 | 66.4 |
| Adjusted | Reference | −1.4 (−3.7,0.9) | −1.7 (−6.9,3.4) | −2.4 (−5.9,1.2) | ***−12.5 (−16.1,−8.8)*** [c] | ***−19.4 (−27.0,−11.7)*** [c] |
| 24 Months | 86 | 82 | 83.9 | 85.2 | 76.2 | 68.1 |
| Adjusted | Reference | −0.7 (−3.0,1.6) | 0.7 (−4.4,5.9) | 0.9 (−2.5,4.3) | ***−10.7 (−14.4,−7.1)*** [c] | ***−16.0 (−23.6,−8.3)*** [c] |

[a] 5 patients in the Arm Injury cohort, 6 in the Mild TBI cohorts (4 in the mild I and 2 in mild III), 3 in the Moderate TBI cohort, and 1 in the Severe TBI cohort were lost to follow-up after initial baseline survey

[b] Adjusted mean “difference-in-differences” estimate comparing mean within-person over-time changes from baseline between patients in the given injury severity group (column) and arm-injury controls, adjusted for age, sex, race, insurance status, parent income, and parent education, on the basis of all children

[c] Significant result