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Development and Validation of Equations to Link Pediatric Evaluation of Disability Inventory (PEDI) Functional Skills Scores to PEDI-Computer Adaptive Test Scores for Youth with Cerebral Palsy

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ABSTRACT

Aim: The Pediatric Evaluation of Disability Inventory (PEDI) was revised to the PEDI-Computer Adaptive Test (PEDI-CAT). The PEDI has been used for over two decades to track function in youth, so it is important that follow-up data are not lost with this transition. The purpose of this study was to develop and validate equations for linking PEDI scores to PEDI-CAT scores.

Methods: Caregivers of 101 youth 6.1 to 19.8 years of age with cerebral palsy (CP) and classified at Gross Motor Classification System (GMFCS) Levels I–V completed the PEDI and PEDI-CAT. Scaled score data from this sample were used to develop and validate linking equations using least squares regression and bootstrap cross-validation techniques. Next, equations were tested in an independent sample of 35 children with developmental disabilities.

Results: The equations to predict PEDI-CAT scores exhibited excellent model fit. PEDI *Self-care*, *Mobility*, and *Social Function* explained 92%, 84%, and 85% of the variation in PEDI-CAT *Daily Activities*, *Mobility*, and *Social/Cognitive* domains, respectively. No differences were detected between actual and predicted PEDI-CAT scores across all domains and by GMFCS level for the equation development sample and for an equation validation independent sample.

Conclusions: The model fit was excellent; however, equations should be used cautiously when evaluating changes in function for individual children with ceiling level PEDI scores. Valid score prediction equations for youth with CP will assist with transitioning from the PEDI to the PEDI-CAT.

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Cerebral palsy; linking equations; PEDI; PEDI-CAT; score prediction linkage

Cerebral palsy (CP) is a chronic childhood disability with prevalence in the United States ranging from 3.1 to 3.6 per 1000 (Christensen et al., 2014). Utilization of rehabilitation services for children and adolescents with CP is high and includes providers from multiple disciplines and settings (e.g. hospital, outpatient, and school). Using valid and reliable outcome measures to track functional abilities for youth with CP is critical for optimal medical, rehabilitation, and surgical care. Functional outcomes are used to

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assist with planning and evaluating interventions and in research to determine intervention effectiveness. The measurement of functional outcomes is further complicated by the varying abilities, ages, and settings of youth with CP.

Three outcome measures which have been used to report functional skills in youth with CP are the Pediatric Evaluation of Disability Inventory (PEDI) (Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992; Ostensjo, Carlberg, & Vollestad, 2003), Gross Motor Function Measure (GMFM) (Hanna, Bartlett, Rivard, & Russell, 2008; Russell, Rosenbaum, Avery, & Lane, 2002), and Pediatric Outcomes Data Collection Instrument (PODCI) (Allen et al., 2008; Barnes et al., 2008). The GMFM is widely used in clinic and research settings but it is limited to mobility outcomes. The PODCI has been used to capture functional outcomes following orthopedic surgeries in youth with CP and although it is responsive to changes after orthopedic surgeries and provides information on self-care as well as mobility function, it has limited information on cognition and some floor and ceiling effects for mobility outcomes (McCarthy et al., 2002; Wren et al., 2007). The PEDI is one of the most commonly used functional outcome measures to document mobility, self-care, and social function skills in youth with CP. The PEDI has advantages when compared to other commonly used measures in research examining function of youth with CP; however, it has limitations including a ceiling effect for youth with high levels of function, no normative score option for youth over 7½ years, and over 200 items making it time consuming to administer (Haley et al., 2010). To address these shortcomings, the PEDI-Computer Adaptive Test (PEDI-CAT) was developed and released in October 2012 (Haley, Coster, Dumas, Fragala-Pinkham, & Moed, 2012; Haley et al., 2011).

Hospitals, schools, and outpatient clinics across the US as well as numerous other countries use the PEDI to record functional abilities of youth with CP longitudinally. PEDI data is used to track functional changes and to assist with determining what additional interventions may be needed for youth with disabilities. More recently in the Netherlands, functional trajectories were developed using the PEDI (Ketelaar, Gorter, Westers, Hanna, & Verhoef, 2014). It is critical that long-term follow-up data is not lost with the transition from the PEDI to PEDI-CAT. Fortunately, the transition of scaled scores from the PEDI to the PEDI-CAT can potentially be accomplished using score prediction linkage. Transforming scaled scores will assist with ongoing monitoring of individuals' function over time and for program evaluation purposes.

As youth with CP comprise one of the largest diagnostic groups who receive rehabilitation services across multiple settings throughout their lifespan, valid linking equations are needed so that PEDI Functional Skills scaled scores can be transformed to the newer PEDI-CAT scoring metric. The purpose of this study was to develop and validate linking equations of the original PEDI *Mobility*, *Self-care*, and *Social Function* scaled scores to the new PEDI-CAT scaled scores for the *Mobility*, *Daily Activities*, and *Social/Cognitive* domains for youth with CP.

Methods

Research design

This study utilized data collected in two studies and it consisted of two parts: 1) Equation development and 2) Equation validation. The equation development segment

of this study was part of a larger PEDI-CAT validation study focusing on use of the measure for children with CP. It was conducted at Boston Children's Hospital, the results of which are published elsewhere (Shore et al., 2017; Shore et al., 2019). The equation validation segment for this study was part of a PEDI to PEDI-CAT concurrent validity study focusing on children with developmental disabilities. It was conducted at Franciscan Children's Hospital and those results are also published previously (Dumas & Fragala-Pinkham, 2012).

Participants of the equation development sample

This equation development study was approved by the Institutional Review Board at Boston Children's Hospital. Potential study participants for the equation development part of the study were identified prior to their clinic appointment by a research assistant and informed consent was provided prior to participation. Primary caregivers of youth with a confirmed diagnosis of CP, between 6 and 21 years of age, were recruited for this study through the multi-disciplinary CP Clinic at Boston Children's Hospital. Primary caregivers were included if they were parents or child's legal guardian, able to read English or Spanish and were familiar with the child's typical functional performance. Caregivers of youth who had recent orthopedic surgery (less than 6 months) or recent botulinum toxin A administration (less than 2 months) were excluded from the study. One hundred and one caregivers of youth with CP provided informed consent and participated in this study.

One hundred and one children (54 males, 47 females) were included in the equation development sample with an average age of 11.9 years (range 6.1 to 19.8 years). The sample was comprised of 23% GMFCS Level I, 19% Level II, 17% Level III, 21% Level IV, and 21% Level V. The majority of the sample were White (76%) and also included 15% Black, 4% Asian, 1% American Indian or Alaskan Native, and 4% Other.

Most caregivers were biological parents (87%) with 8% non-biological parents and 4% legal guardians. For caregiver educational background, 56% reported having graduated from college, 37% reported having a high school diploma or GED, 7% reported having some high school education or less. The majority (57%) reported a household income of greater than \$70,000, 22% reported a household income of \$40,000–\$69,000, 18% reported a household income of \$10,000–\$39,000 and 4% reported a household income of less than \$10,000.

Participants of the equation validation independent sample

For the equation validation part of this study, approval was obtained from Franciscan Children's Institutional Review Board prior to data collection. Caregivers of youth ages birth through 20 years of age with disabilities were recruited through outpatient clinics and a school for children with disabilities at Franciscan Children's Hospital. Two physical therapists obtained informed consent from caregivers prior to study participation and data collection. Primary caregivers who were familiar with their child's typical functional performance were included in the study. Those who could not read and answer questions in English or Spanish were excluded from study participation.

For the equation validation component of this study, 35 children with disabilities (23 boys, 12 girls) with an average age of 11.5 (SD 4.9) years (range 3.9 to 19.9 years) comprised the independent sample for the *Mobility* domain data. The majority of children in this sample had a diagnosis of CP ($n=22$), followed by autism ($n=5$), genetic conditions ($n=4$) and hypotonia/developmental delay ($n=4$). The majority were White (66%; $n=23$), followed by 14% Black ($n=5$), 11% Asian ($n=4$), and 9% Hispanic ($n=3$). A subset of the equation validation sample had data available for *Self-care/Daily Activities* and *Social Function/Social/Cognitive* domains which were included in the analysis. This subset included 16 children with CP ($n=11$), genetic conditions ($n=3$), or developmental delay ($n=2$) and had a mean age of 9.2 years (SD 5.6).

The caregiver respondents were all parents with 89% ($n=31$) being mothers. The majority identified their Race/Ethnicity as White (83%; $n=29$), followed by 9% Hispanic ($n=3$), 6% Black ($n=2$), and 3% Asian ($n=1$). For educational background, 57% ($n=20$) of caregivers reported having graduated from college, 23% ($n=8$) reported graduating from high school, 9% ($n=3$) reported having less than a 9th grade education, and 11% (4) did not report educational background.

Measures

The PEDI was developed in 1992 and was one of the first pediatric functional outcome measures. It utilizes a paper and pencil format and is generally conducted by a therapist or other trained individual using an interview format with parents or caregivers to gather information about their child's functional abilities. It has two scales including a Functional Skills Scale and Caregiver Assistance Scale. Each scale has three domains of *Mobility*, *Self-care*, and *Social Function*. The PEDI takes up to 40–60 minutes to complete and consists of 197 Functional Skills items with a dichotomous rating scale of Capable or Unable and 20 Caregiver Assistance items with a 6 point assistance rating scale ranging from Independent to Total Dependence (Haley et al., 1992). The PEDI has been validated for children with disabilities and specifically for children for CP (Ketelaar, Vermeer, & Helders, 1998; Vos-Vromans, Ketelaar, & Gorter, 2005) and has been translated into multiple languages (Haley et al., 2010). Normative scores are available for children 6 months to 7 1/2 years whereas scaled scores can be used for recording functional abilities of children with disabilities who are over 7 1/2 years and have decreased functional skills (Haley et al., 1992).

The PEDI-CAT was designed to be completed by parent or caregiver report and it utilizes a computer adaptive platform in which items are presented according to level of difficulty. The computer algorithm selects the items that are presented based on responses to previous items. Essentially the PEDI-CAT software mirrors what an experienced clinician would do by selecting items that are directed at the child's approximate level of functional ability and minimizing the number of items that have to be completed. The PEDI-CAT has an item bank of 276 items in the domains of (1) *Daily Activities*; (2) *Mobility*; (3) *Social/Cognitive*, and (4) *Responsibility* (Haley et al., 2012). The Responsibility domain was developed to replace the Caregiver Assistance scale of the PEDI and reports parent and child responsibility for carrying out functional tasks. The PEDI-CAT content was expanded by adding harder tasks in all of the content areas

to decrease the ceiling effects noted on the PEDI (Dumas et al., 2010; Haley et al., 2010). The four PEDI-CAT domains are self-contained and can be used separately or in combination with the other domains. This study focuses on the first three domains listed because comparable PEDI Functional Skills domains are available. These three PEDI-CAT domains use the same 4-point response scale of easy, a little hard, hard, or unable. The PEDI-CAT is completed by caregivers or clinicians who are familiar with the child's typical performance. The score report includes normative scores and a scaled score on a 20–80 metric. Normative scores are available as a percentile score and as a T-score (mean 50 and standard deviation [SD] of 10) for children birth to 21 years of age.

Strong psychometric properties of the PEDI-CAT have been reported for children with a wide range of disabilities (Dumas, Fragala-Pinkham, Feng, & Haley, 2012; Dumas, Fragala-Pinkham, Haley, et al., 2012; Fragala-Pinkham, Dumas, Lombard, & O'Brien, 2016; Haley et al., 2011) and more recently for children and adolescents with CP (Shore et al., 2017; Shore et al., 2019). Specifically, convergent validity between the Mobility domain of the PEDI-CAT and the Functional Mobility Scale has been reported for children and youth with CP classified at GMFCS Levels I–III. Convergent validity between the PEDI-CAT Daily Activities and Social/Cognitive domains and corresponding domains of the Pediatric Quality of Life has been reported for youth with CP. Convergent validity between the PEDI-CAT Daily Activities and the Social/Cognitive domains and the corresponding domains of the Caregiver Priorities and Child Health Index of Life with Disabilities has also been established for nonambulatory children with CP. Divergent validity was demonstrated by a lack of correlation between the PEDI-CAT Daily Activities, Social/Cognitive, and Responsibility domains and the Functional Mobility Scale and between the PEDI-CAT Mobility domain and the PedsQL Communication domain (Shore et al., 2019). Excellent discriminant validity was reported for all PEDI-CAT domains as scores for each domain were able to discriminate between ambulatory (GMFCS levels I–III) or nonambulatory (GMFCS levels IV–V) as well as manually independent (Manual Ability Classification System [MACS] levels I–II) or manually dependent functional levels (MACS levels III–V) (Shore et al., 2017). Excellent test-retest reliability has been reported for all domains of the PEDI-CAT ($ICC = 0.96\text{--}0.99$) (Dumas, Fragala-Pinkham, Haley, et al., 2012; Shore et al., 2019).

Procedures

For the equation development part of the study, demographic information was recorded for each caregiver/youth pair, including race, gender, and type of caregiver. After completing the demographic form, the caregiver completed the PEDI-CAT on an iPad using touch screen technology and the fixed PEDI using the typical paper and pencil format and through interview conducted by a research assistant trained by a pediatric physical therapist with expertise in administering and interpreting the measures. The order of test administration was counter-balanced to avoid an order effect. The measures were completed while the family waited for their clinic appointment. Gross Motor Function Classification System (GMFCS) (Palisano, Rosenbaum, Bartlett, & Livingston, 2008)

levels were documented during the clinic visit by the orthopedist or physiatrist using information gathered from the parents about the youth's typical level of function. If there was additional time, caregivers also completed additional measures. Only PEDI and PEDI-CAT data and GMFCS Levels will be reported and discussed in this article.

For the equation validation part of this study, caregivers completed the PEDI-CAT *Mobility* domain on a laptop computer as well as the original paper PEDI Functional Skills *Mobility* domain via interview by a pediatric physical therapist. Additionally, a subset of the equation validation independent sample also completed the PEDI Functional Skills *Self-care* and *Social Function* domains and the corresponding PEDI-CAT *Daily Activities* and *Social/Cognitive* domains. Both tests were completed on the same day and the order of completion varied to avoid a test order effect related to fatigue or practice. Demographic data of the youth's age, gender, and diagnosis were recorded.

Data analysis

Equation development

Least squares regression model-fitting techniques were used to find the best models to predict PEDI-CAT *Daily Activities*, *Mobility*, and *Social/Cognitive* scaled scores based on the PEDI *Self-care*, *Mobility*, and *Social Function* domains scaled scores, respectively. Residual plots from regression analyses were assessed for model fit and all assumptions of regression were met. Model fit was evaluated by adjusted R^2 (R^2_{adj}) and root-mean-square error (RMSE). Bland-Altman analysis of agreement was performed between actual and predicted PEDI-CAT domain scores (Bland & Altman, 1986). Limits of agreement were defined as ± 2 SD units and bias was determined if the mean difference exceeded zero based on a paired t-test between the actual and predicted scores. Intraclass correlation coefficients (ICCs) along with 95% confidence intervals were calculated to additionally quantify the agreement between actual and predicted PEDI-CAT domain scaled scores (Cicchetti & Sparrow, 1981; Fleiss, 1981).

Bootstrap model validation

Bootstrap cross-validation was performed for each of the three developed linking equations using the 0.632+ correction method (Efron & Tibshirani, 1997). In this study, bootstrapping was used to take modified random samples with replacement from our sampled data to estimate prediction error in the equations using the resampled data. An estimate of the prediction error with an optimism correction over all resampled data was calculated and compared to the residual mean-square-error (MSE) of each linking equation from the original data. Over-fitting was assessed by comparing the average adjusted R^2 values from the resampled data to the original data.

Equation validation in an independent sample

The developed linking equations were used to calculate PEDI-CAT *Daily Activities*, *Mobility*, and *Social/Cognitive* domain scaled scores in an independent validation sample

of 35 participants who had complete pairs of PEDI and PEDI-CAT *Mobility* domain scaled scores and a subset of 16 participants who had complete pairs of PEDI *Self-care* and PEDI-CAT *Daily Activities* domain scaled scores and PEDI *Social Function* and PEDI-CAT *Social/Cognitive* domain scaled scores. The predicted values were compared to the actual PEDI-CAT domain scaled scores using paired Student’s t-tests. The RMSEs were calculated for predicted versus actual domain scaled scores. To develop a good predictive model, we required the R^2_{adj} to be at least 80% and the RMSE from the independent samples to be less than 6 for each domain (Alexander, Tropsha, & Winkler, 2015). All tests were two-sided and p-values less than 0.05 were considered significant.

Actual versus predicted PEDI-CAT scores were compared and graphed according to GMFCS Levels for all three domains since PEDI and PEDI-CAT scores differ across the levels (Shore et al., 2017). The *Mobility* domain content is closely aligned with gross motor function and GMFCS levels are also moderately to strongly correlated with other functional abilities (e.g. fine motor, self-care, and communication) and classification systems (Hidecker et al., 2012).

Results

Equation development

For all three domains, the relationship between instruments was slightly curvilinear and was best fit with a unique function that included a radical term (Table 1). The linking equations exhibited excellent model fit such that PEDI *Self-care*, *Mobility*, and *Social Function* scaled scores explained 92%, 84%, and 85% of the variation in PEDI-CAT *Daily Activities*, *Mobility*, and *Social/Cognitive* domains scaled scores, respectively (Table 1).

Responses to both the PEDI and PEDI-CAT instruments varied by GMFCS level, as expected, and the developed models fit all the data with precision (Figures 1–3). The average MSE for the bootstrapped samples was nearly identical to the MSE for the linking equation estimated by the full data for all domains (Figures 1–3). Similarly, there was little variation in the adjusted R^2 values across the 100 bootstrapped samples validating the use of the equations in future data from this same population for all three domains.

Comparison of actual versus predicted PEDI-CAT scores for the equation development sample

There were no differences detected between actual and predicted PEDI-CAT scaled scores across all three domains and by GMFCS level for the equation development

Table 1. Linking equations between PEDI and PEDI-CAT domain scaled scores.

PEDI-CAT (PC) domain	PEDI functional skills (P) domain	Equation	R^2_{adj}	RMSE
Daily activities (da)	Self-care (sc)	$PC_{da} = 6.84 - 0.05*P_{sc} + 6.09*\sqrt{P_{sc}}$	92%	2.80
Mobility (mb)	Mobility (mb)	$PC_{mb} = 18.14 - 0.04*P_{mb} + 4.66*\sqrt{P_{mb}}$	84%	4.53
Social/cognitive (sc)	Social function (sf)	$PC_{sc} = -97.57 - 1.81*P_{sf} + 34.96*\sqrt{P_{sf}}$	85%	4.63

R^2_{adj} , adjusted R^2 value from the fitted regression model; RMSE, root-mean-square error.

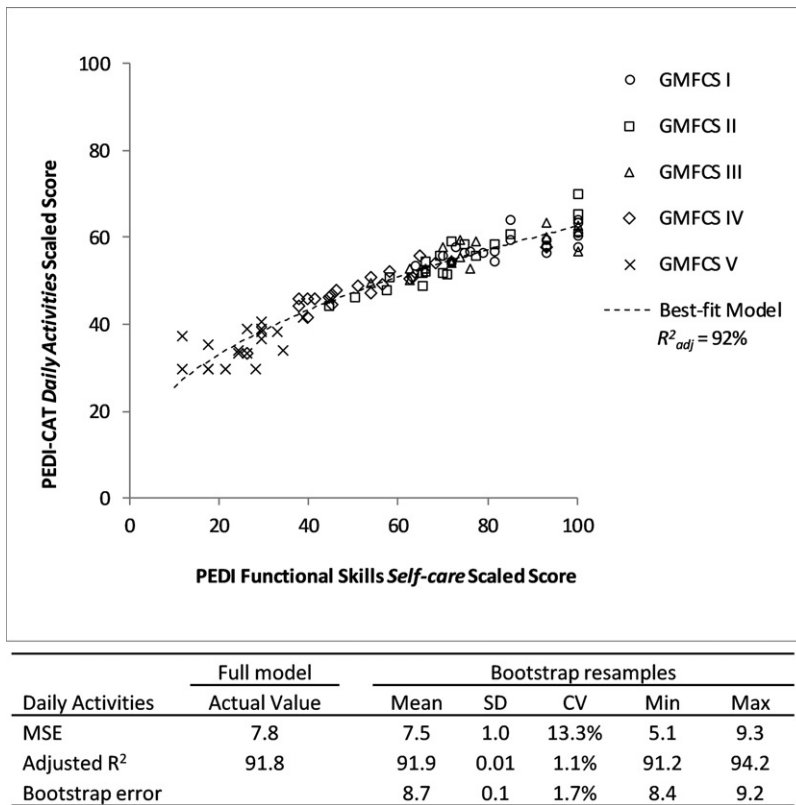


Figure 1. PEDI-CAT Self-care and PEDI-CAT Daily Activities scaled scores with regression model and validation statistic.

sample using the linking equations (Figures 1–3). Intraclass correlation coefficients indicated excellent agreement between actual and predicted values (all ICC > 0.90, Table 2). Bland–Altman analyses indicated that the 95% limits of agreement between the actual and predicted PEDI-CAT scaled scores ranged from -5.7 to 5.7 for *Daily Activities*, from -8.9 to 8.9 for *Mobility*, and from -7.2 to 7.2 for *Social/Cognitive* (Figure 4).

Comparison of actual versus predicted PEDI-CAT scaled scores for the equation validation independent sample

There were no differences detected between the mean actual and predicted scaled scores for *Daily Activities* ($p=0.45$), *Mobility* ($p=0.56$), or *Social/Cognitive* ($p=0.95$) (Table 3). The RMSE for each set of predicted data was less than 6 for each domain indicating a useful model for linking purposes (Table 3).

Discussion

The purpose of this study was to develop and validate equations to allow rehabilitation professionals to compare PEDI Functional Skills scaled scores to PEDI-CAT scaled

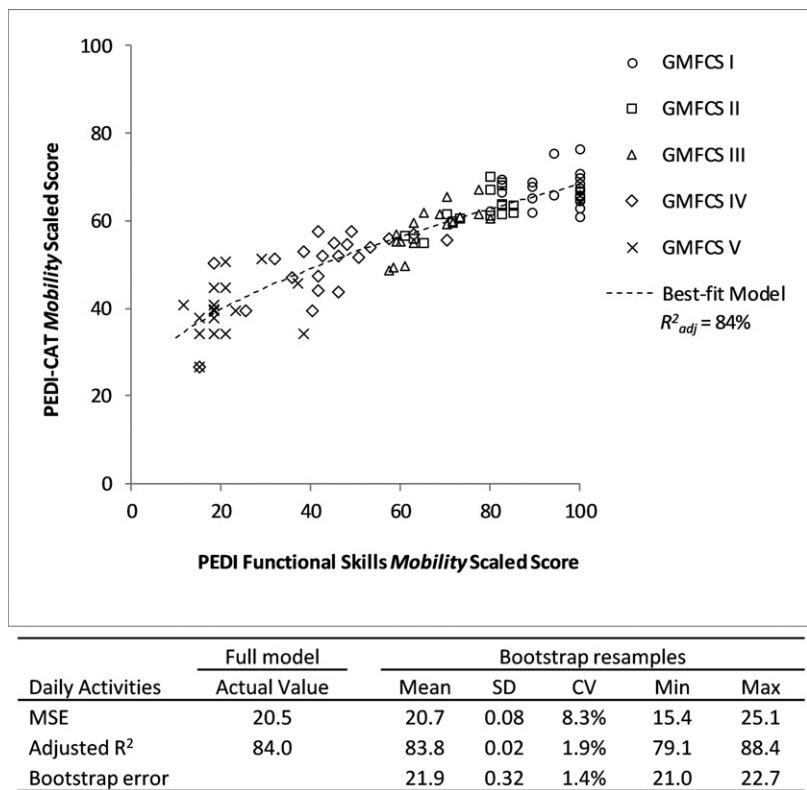


Figure 2. PEDI Mobility and PEDI-CAT Mobility scaled scores with regression model and validation statistics.

scores. The validation of linking equations for youth with CP would allow users to convert to the PEDI-CAT without losing longitudinal data on youth followed in clinic, hospital, and community settings. It was possible to create equations that link the older PEDI scaled scores to the newer version of the outcome measure, the PEDI-CAT, for the three domains of *Mobility*, *Daily Activities* and *Social/Cognitive*. For all three models developed, model fit was excellent with R^2_{adj} values above 80% for all models. In addition, RMSE was below the a priori threshold of six for all models based on predicted values in the independent samples. This indicates that the models provide accurate scaled score prediction linkage between PEDI scaled scores and the PEDI-CAT scaled scores for *Daily Activities*, *Mobility* and *Social/Cognitive* domains.

In a clinical setting, these newly developed equations can be used to compare PEDI Functional Skills scaled scores to PEDI-CAT scaled scores in clinical cohorts over time to answer research or program evaluation questions. For example, PEDI *Mobility* scaled scores were recorded for a group of children with CP who had lower extremity orthopedic surgery. After that data collection period, the clinic switched to the PEDI-CAT to report mobility outcomes. When the group of children returned to the follow-up orthopedic clinic one year later, the PEDI-CAT *Mobility* domain was administered and scaled scores were recorded. In order to compare scores from year 1 to year 2, we used the equations to convert PEDI *Mobility* domain scaled scores from year 1 to PEDI-CAT *Mobility* domain scaled scores. The mean PEDI-CAT predicted scaled scores for year 1

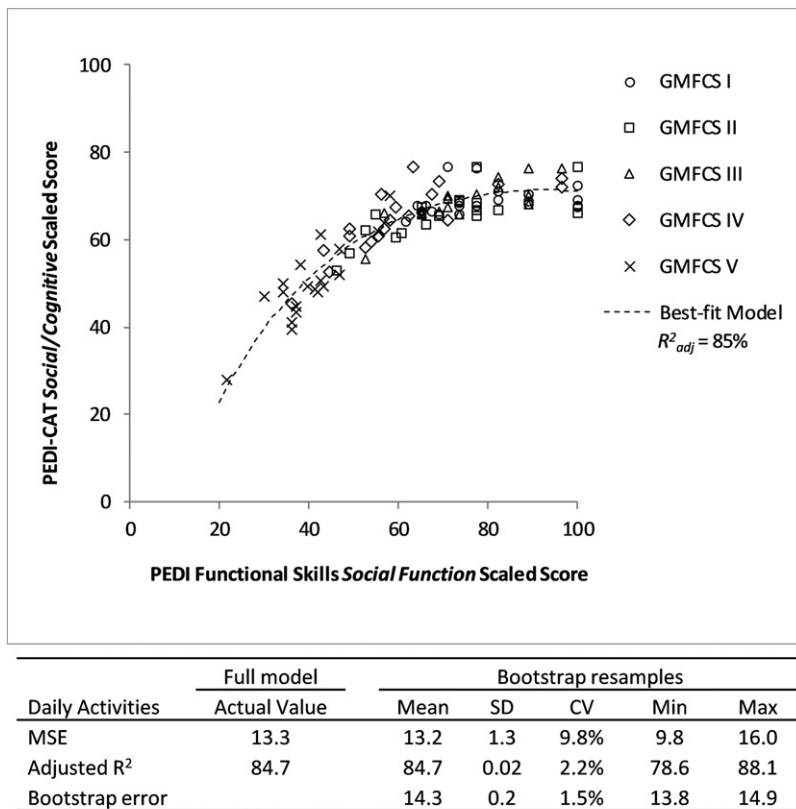


Figure 3. PEDI Social Function and PEDI-CAT Social/Cognitive scaled scores with regression model and validation statistics.

were 56.0 (SE 1.1; CI_{95} : 53.8–58.2) and the mean PEDI-CAT scaled scores for year 2 were 65.7 (SE 1.1 CI_{95} : 62.8–67.9). We would then compare means to determine if the year 2 *Mobility* scaled scores are significantly higher than the year 1 scores. We would also check the confidence intervals to make sure that they do not overlap.

Although model fit was excellent, there were some minor differences in scaled scores. Therefore we suggest that when evaluating changes in function for individual children, 95% confidence intervals should be used to interpret changes across scores. When comparing data for individual children, therapists can provide an interval for the predicted PEDI-CAT scaled scores calculated using the equations to within ± 5.7 points for *Daily Activities*, ± 8.9 points for *Mobility*, and ± 7.2 points for *Social/Cognitive*. For example, a 12-year-old boy with CP classified at GMFCS level III, was seen in follow-up clinic and his mother completed the PEDI-CAT during the clinic visit. The boy received a PEDI-CAT *Mobility* scaled score of 57.85 and a year prior he had a PEDI *Mobility* scaled score of 60.9. Using the *Mobility* equation and his previous PEDI *Mobility* scaled scores, the predicted PEDI-CAT *Mobility* score is 52.07. We can say that his typical mobility performance has been maintained over the past year because there is a difference of 5.78 scaled score points from clinic visit 1 to clinic visit 2, which is within the ± 8.9 point range.

Table 2. Actual versus predicted PEDI-CAT domain scaled scores for the Equation Development Sample and by GMFCS level.

Domain/Group	N	Actual		Predicted	
		Mean	(SE)	Mean	(SE)
Daily activities					
All participants	99	50.1	(1.0)	50.1	(1.0)
GMFCS level					
I	22	58.1	(0.7)	58.5	(0.7)
II	18	54.7	(1.6)	54.1	(1.1)
III	17	56.2	(1.1)	56.1	(1.0)
IV	21	47.9	(1.1)	47.2	(1.1)
V	21	35.0	(1.0)	35.8	(1.0)
Mobility					
All participants	101	55.4	(1.1)	55.4	(1.0)
GMFCS level					
I	23	67.0	(0.8)	67.0	(0.4)
II	19	62.6	(1.0)	62.0	(0.6)
III	17	58.1	(1.3)	58.5	(0.6)
IV	21	49.9	(1.7)	49.8	(1.2)
V	21	39.4	(1.3)	39.6	(0.8)
Social/Cognitive					
All participants	98	63.6	(1.0)	63.6	(0.9)
GMFCS level					
I	22	69.0	(0.7)	69.5	(0.4)
II	18	65.7	(1.4)	66.7	(1.1)
III	17	68.8	(1.2)	68.5	(0.7)
IV	21	64.6	(1.7)	63.1	(1.3)
V	20	50.5	(2.1)	50.8	(1.9)

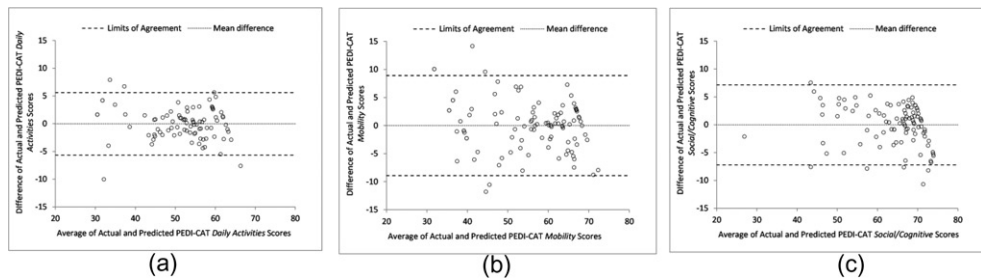


Figure 4. Bland-Altman plots for actual versus predicted PEDI-CAT scaled scores using linking equations.

Table 3. Actual versus predicted PEDI-CAT domain scaled scores based on the linking equations for equation validation independent sample.

Domain	N	Actual		Predicted		RMSE	P*
		Mean	(SE)	Mean	(SE)		
Daily activities	16	53.5	(1.8)	53.1	(1.8)	1.89	0.45
Mobility	35	59.2	(1.3)	58.8	(1.4)	4.41	0.56
Social/Cognitive	16	64.1	(2.1)	64.1	(1.8)	2.49	0.95

SE, standard error; RMSE, root-mean-square error.

*P-values are based on a paired t-test for the difference between actual and predicted mean score.

One reason for potential differences in the predicted and actual scores may be due to wording differences in the two tests. When the PEDI was released in 1992, the instructions were to use the child’s typical performance to score items on the test (Haley et al., 1992); however, as terminology has changed over the years, the use of the PEDI has

shifted to scoring the Functional Skills as what the child is capable of doing and scoring the Caregiver Assistance Section of the PEDI as typical performance (Holsbeeke, Ketelaar, Schoemaker, & Gorter, 2009; Smits et al., 2014). The PEDI-CAT manual instructs the responder to use the child's typical performance as a basis to score items. Functional abilities in terms of capability versus performance (Smits et al., 2014) can differ in some children so this may increase score variability if the PEDI is scored based on a child's current capability and PEDI-CAT is scored as typical performance.

A limitation of this study is that the independent sample included some participants with diagnoses other than CP, which may have influenced the scores; however, inclusion of other diagnoses assists with generalizability of the equations to other disabilities. Predicted scores in the sample were excellent, however, suggesting that the linking equations may be extended to other disabilities than CP. Further study is needed to validate these equations for other common childhood disabilities.

The equation development sample did not include children younger than age 6; however, the functional ability of the children in the sample who were classified at GMFCS Levels IV & V was significantly decreased (>3 SDs below same-aged peers with typical development) and in the range of developmental skills typical for infants and young children. The equation validation independent sample age did extend down to 3.9 years and overall the model fit was excellent. Another limitation of this study is that the equation validation independent sample size was 35 for the Mobility domain and 16 for *Self-care/Daily Activities* and *Social Function/Social/Cognitive* domains. Although the results are promising, further study with larger sample sizes that are inclusive of infants and young children is needed to confirm that the equations are valid for this group.

It has been recommended that items be added to the PEDI-CAT to improve floor and ceiling effects. Further score equating will be necessary to link the PEDI to the PEDI-CAT since the PEDI is still currently being used and the transition has been gradual depending on the setting. Additionally, future work linking the PEDI-CAT to commonly used functional measures for adults would assist clinically when transitioning youth to adult services or when developing research spanning the ages of adolescents, young adults and older adults with CP.

Conclusions

Equations that link the PEDI scores to the newer PEDI-CAT were created. Overall, the model fit was excellent, indicating that the models provide accurate linkage between PEDI scores and the PEDI-CAT for *Daily Activities*, *Mobility* and *Social/Cognitive* domains. Valid linking equations will assist the clinician with transitioning from the PEDI to the PEDI-CAT without losing the opportunity to compare scores over time especially when comparing groups of children. Equations should be used cautiously when evaluating changes in function for individual children with ceiling level PEDI scores.

Disclosure statement

Patricia Miller and Benjamin Shore do not have interests to declare. Maria Fragala-Pinkham and Helene Dumas are senior authors of the PEDI-CAT and have a

professional relationship with CRECare, owner of the PEDI-CAT. In accordance with Taylor & Francis policy and our ethical obligation as researchers, Maria Fragala-Pinkham and Helene Dumas are reporting that we have a professional relationship and consult with a company that may be affected by the research reported in the enclosed paper. We have disclosed those interests fully to Taylor & Francis, and we have in place an approved plan for managing any potential conflicts arising from that involvement.

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