Effects of Age, Sex, and Comorbidities on the Pediatric Outcomes Data Collection Instrument (PODCI) in the General Population

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Background: The Pediatric Outcomes Data Collection Instrument (PODCI) is an outcomes assessment tool developed to allow measurement of health-related quality of life in children with disorders having musculoskeletal impact. The instrument was tested by Hunsaker and colleagues on a large population-based sample of children ($n = 5300$), and partial results of that survey were published in 2002. Further publication of the findings did not occur. The PODCI was designed to collect data on age, sex, comorbidities, race and ethnicity, makeup of the household, and other demographic data that could have an impact on function and psychosocial issues. This retrospective study evaluated the impact of age, sex, and health/comorbid conditions on the subscales of the PODCI.

Methods: Using the database that was developed by Hunsaker and colleagues for the American Academy of Orthopaedic Surgeons, a 1-way multivariate analysis of variance was conducted to determine effects of prior comorbid condition versus no prior comorbid condition on the dependent variables of the PODCI Upper Extremity Function, Transfers and Basic Mobility, Sports and Physical Function, Comfort, and Happiness scales by parent respondent. A follow-up analysis of the health/comorbid condition, age, and sex of the child on the PODCI subscales using independent samples t tests was performed.

Results: Significant differences in the PODCI subscales of Transfers and Basic Mobility, Sports and Physical Function, Comfort, and Happiness occurred between children with a prior comorbid condition versus no prior reported comorbid condition. The sex of the child with a comorbid condition versus without a comorbidity appears to affect the PODCI subscale scores except for the Upper Extremity Function subscale. PODCI scales show an initial increase with age. Age at plateau varies, as do patterns of scores after plateau, with gradual decreases in quality-of-life scales.

Conclusions: With further exploration of the population-based database, it was possible to confirm that age, sex, and comorbidities do have an impact on the levels of functional and psychosocial assessments done with the PODCI. Assessments done with the PODCI should include the assessment of, and potential correction for, these variables.

Level of Evidence: Prognostic studies level II retrospective.

Key Words: Pediatric Outcomes Data Collection Instrument, PODCI, comorbidity, population-based norms

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The American Academy of Orthopaedic Surgeons (AAOS) Outcomes Studies Committee, collaborating with the Council of Musculoskeletal Specialty Societies and the Pediatric Orthopaedic Society of North America, developed a pediatric functional outcomes assessment instrument aimed at assessing individuals with a musculoskeletal disorder.¹ The Pediatric Outcomes Data Collection Instrument (PODCI) was designed as a questionnaire for children aged 2 to 18 years to collect patient-based data for both clinical assessment of treatment effectiveness and musculoskeletal research by evaluating function and quality of life (QOL). In 2002, Hunsaker et al,² described the normative values from the general population for the PODCI subscales, Upper Extremity Function (UE), Transfers and Basic Mobility (TBM), Sports and Physical Function (SPF), Comfort, Happiness, and Global. Hunsaker reported that standardized scaled scores for specified age, sex, ethnicity, and comorbidity were available through AAOS. Unfortunately, these scores are not available (personal written communication, K. Hitchcock, 2009). There are few published values for PODCI scoring for assessing outcomes in pathologic processes for age or consideration of health/comorbidity.^{3–6} With restricted ability to match PODCI scores by PODCI norms for age and sex,^{7–10} comparative values for comorbidities, age, and sex are needed to evaluate treatment outcomes. Further evaluation is needed to determine whether sex, age, and comorbid conditions influence PODCI outcome scores.

Comparison of pretreatment and posttreatment clinical data, with normative data from the general population, is important to assess whether findings in individuals before treatment are different from population

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norms or come closer to normative ranges of functioning after treatment. In considering the clinical importance of treatment-outcome studies, Kendall et al¹¹ raised 2 basic questions. First, is the pretreatment to posttreatment change large enough to be considered relevant? Second, can treated individuals be distinguished from “normal individuals” serving as a reference group? Clinical measures address the first question, whereas normative comparisons address issues of severity compared with data from a normal, age-adjusted, and sex-adjusted population. Hunsaker’s group noted a need for scores in different ages and sex to assess for normal values.²

Comorbid or health conditions may also affect changes in PODCI scores or be associated with lower outcomes scores.^{1,12} The PODCI has been reported in the literature assessing children and adolescents with a wide variety of disorders from scoliosis^{7,10} to cerebral palsy (CP).^{13–18} When assessing functional outcomes in children, functional levels may not only be affected by growth and maturity factors, but also by other illnesses or conditions that may impact daily life. The increased focus of the International Classification of Function, Disability, and Health to consider a more holistic picture of the impact of medical conditions on an affected individual has made clear the need to consider other factors. Assessing functional outcomes of participation in the community, as opposed to assessing body structure and function measures in the health care setting, necessitates including other factors influencing function. Without a database of PODCI norms to compare with the PODCI outcomes for children with comorbidities, reported PODCI outcomes are incomplete.

Assessments of QOL using various outcomes instruments have demonstrated patterns of responses that vary with age,^{1,3,19} sex,^{3,20} type of scales (physical observation, functional scales, or psychosocial scales),²¹ a particular condition being assessed,^{1,22} health of respondent,²³ and severity of involvement with the particular condition or conditions.^{23,24} The purpose of this study was to establish the mean and SD for PODCI subscales on the basis of sex, age, and scores reflecting health conditions in a generalized population. To further explore the PODCI, we hypothesized that sex, age, and health/comorbid conditions would affect PODCI outcome scores.

METHODS

PODCI Instrument

The PODCI was designed to assess the degree to which a patient’s condition or conditions affect his or her physical and emotional functioning, self-image, and symptom status. Three versions of the PODCI include: a questionnaire for children (completed by parents of children under the age of 11) and 2 surveys for adolescents (1 completed by adolescents aged 11 and older and 1 by a parent of that adolescent). Adolescent responses can be matched and compared with parent proxy surveys. The PODCI subscales comprise the following fields: UE,

TBM, SPF, Comfort, Happiness, and Global. The PODCI also includes a comorbidity scale with the following health conditions: arthritis, anorexia or bulimia, asthma, attention or behavioral problems, chronic allergies or sinus trouble, developmental delay, mental retardation, diabetes, epilepsy, hearing impairment, learning problems, vision problems, speech problems, sleep problems, and/or heart problems. The respondent answers 3 health condition questions: (1) “Have you (or your child) ever had the problem?” (CM1); (2) “Do you (or your child) receive treatment for it now?” (CM2); and (3) “Does it limit your (your child’s) activity now?” (CM3). Comorbidity subscales and a comorbidity index (CMIndex) that computes an average of the responses are calculated.¹

PODCI Database From AAOS

The PODCI AAOS database reported by Hunsaker² was obtained (with assistance of James Dewey, Mark Kosinski, John Ware, and Michael Goldberg) to evaluate PODCI outcomes in a generalized population sample, which includes subgroups with and without reported health conditions. The PODCI instrument was 1 of 11 musculoskeletal outcome measures evaluated for reliability and reporting normative data. A panel methodology matched US respondents recruited by the National Family Opinion to the 1998 US Census data on geographical region, age, income, household size, and reported comorbidities.² The Internal Review Board for this institution reported that this secondary data analysis did not meet the criteria for human subjects’ research.

Data Analysis

The AAOS database with complete data on the PODCI parent version was used in this study ($n = 5300$). Children identified as having no current or past history of health conditions were compared with children with a health condition in order to verify that the groups have the same stratification as the 1998 census. The data were taken from the CM1 question asking whether the child had ever had a health condition. A χ^2 analysis showed no difference in the stratification of the children with or without health conditions with respect to race, sex, and parent version of the PODCI. The sample does not appear to be further stratified by the subgroup of current limiting comorbidities (CM3).

PODCI subscale scores reflected a typical healthy population with higher scores characteristic of better health. Subscale scores demonstrated significant skewness and kurtosis and were transformed to meet the assumptions for analyses. A 1-way multivariate analysis of variance (MANOVA) was conducted to determine whether there was a significant group difference in the prior health condition versus no prior health condition with respect to the dependent variables of the following parent-reported PODCI subscales: UE, TBM, SPF, Comfort, and Happiness scales. Using the Bonferroni method (with a test at $P < 0.01$) to control for Type I error, an analysis of variance (ANOVA) was conducted on each dependent

variable as a follow-up to the MANOVA. The eta squared, η^2 , in the ANOVA reported the proportion of the variance in the PODCI subscale score explained by the comorbid group. Further analysis of health conditions used an independent samples *t* test to evaluate whether the means of the PODCI subscales for the 2 independent groups, children with a currently limiting health condition (CM3) versus those children who had an identified health condition in the past (CM1), are significantly different from each other. We also used independent samples *t* tests to investigate whether PODCI scores differed between the sex of children and whether the sex of children within the subgroups of children with and without a health condition had mean group differences. A multiple line graph of PODCI subscale means by age for children with and without health conditions was constructed to further review the effects of age on the PODCI. As a retrospective database analysis, power was not calculated a priori, and a postevaluation power analysis is not recommended.²⁵ The sample size is considered large compared with other studies of the PODCI. Statistical analysis was performed using SPSS (version 21.0; IBM Corp., Armonk, NY). Significance was set at $P < 0.05$.

RESULTS

The most common health conditions reported by parents were allergy and sinus, asthma, attention/behavioral problems, sleep disturbances, and learning problems (Table 1). With respect to the evaluation of group differences in health conditions, the MANOVA revealed that the combined PODCI subscales were significantly related to whether children ever had a health condition ($F_{5,5043} = 59.89$, $P < 0.001$, multivariate $\eta^2 = 0.056$) (descriptive statistics of the PODCI by age, sex, and comorbidities are reported in Appendices 1–3, Supplemental Digital Contents 1–3, <http://links.lww.com/BPO/A18>, <http://links.lww.com/BPO/A19>, <http://links.lww.com/BPO/A20>). For the MANOVA, the η^2 suggests that 5.6% of the variance in the PODCI subscale scores was explained by the independent variable, prior health condition or no prior health condition. Subsequent analyses revealed that children with a current or prior health condition experienced lower scores than children without a health condition on the following subscales: TBM ($F_{1,5047} = 1.82$, $P < 0.001$, partial $\eta^2 = 0.005$), SPF ($F_{1,5047} = 16.69$, $P < 0.001$, partial $\eta^2 = 0.018$), Comfort ($F_{1,5047} = 29.749$, $P < 0.001$, partial $\eta^2 = 0.027$), and Happiness ($F_{1,5047} = 33.85$, $P < 0.001$, partial $\eta^2 = 0.035$). Significant differences did not emerge for the UE subscale ($F_{1,5047} = 0.003$, $P < 0.896$, partial $\eta^2 = 0.000$). Further examination of the group that ever had a health condition (CM1) compared with the group with a currently limiting health condition (CM3) found that children with a current health condition had significantly lower scores on all PODCI subscales (Table 2). With the evaluation of sex and child health conditions, both boys and girls with health conditions had significantly lower subscale scores except for the PODCI UE subscale

TABLE 1. Comorbidities in AAOS Database as Reported by Parent

Comorbidity	N
Asthma	841
Chronic allergies or sinus trouble	1211
Attention or behavioral problems	790
Learning problem	534
Developmental delay	280
Vision problems	1011
Sleep disturbance	243
Speech problems	440
Juvenile arthritis (1 or 2 joints)	66
Intellectual disability (mental retardation)	56
Hearing impairment or deafness	146
Heart problem	132
Epilepsy (seizure disorder)	73
Juvenile arthritis (many joints)	22
Diabetes	33
Anorexia or bulimia (eating disorders)	34
Total limiting comorbidities	5201

(Table 3). In terms of child sex differences, boys had significantly higher scores on the PODCI subscale scores of Comfort and Happiness, and no sex differences in scores were found for the other subscales (Table 4). Through the evaluation of age and health conditions, age effects showed an initial increase in the subscales for groups both with and without health conditions and a varied plateau of scores, with decreases in the pain and happiness scales as age increased (Figs. 1, 2).

DISCUSSION

Although the PODCI has been reported to be a valid and reliable instrument,^{1,2} PODCI scores should still be considered within the context of sex, age, and reported comorbid conditions. Further evaluation is needed to determine whether the increase in PODCI scores with age could be based on a natural history of improvement in function over time and how children with comorbidities fit into this growth pattern. The typical rate of increase with age in function in certain diagnoses might be shown to be different from the rate in the general population, implying delays in development.^{26,27} Gait analysis of children with CP has shown improvement up to a point with a plateau effect and even decline in adolescence.^{28,29} The QOL indices, comfort and happiness, were significantly affected by the sex of the child and showed a decrease in scores in adolescence. Knowing progression of rates in normative group functions allows comparison of functional progression in groups with musculoskeletal disorders.

Incomplete PODCI responses have been reported in the youngest children (ages 2 to 5), which may be due to the response structure. Daltroy et al¹ reported that responses were scored as incomplete, especially on the UE or SPF, because the child had not met a milestone (even if “normal” for that age). When adjusting for other health factors, only the UE scale showed age bias. Controlling

TABLE 2. Independent Samples *t* Test to Compare “Ever Had Comorbidity” with “Currently Limiting Comorbidity” in the AAOS Database PODCI Subscales by Parent Response

PODCI	Comorbidity	N	M (SD)	<i>t</i> (df)
Upper Extremity	Ever had comorbidity	2339	97.5 (6.8)	6.8** (603.2)
	Currently limiting	549	93.1 (14.8)	
Transfers/Basic Mobility	Ever had comorbidity	2319	99.3 (3.6)	6.1** (571.4)
	Currently limiting	548	96.2 (11.8)	
Sports and Physical Function	Ever had comorbidity	2347	93.7 (9.7)	15.9** (615.8)
	Currently limiting	548	80.5 (18.8)	
Comfort/Pain	Ever had comorbidity	2339	90.2 (14.9)	13.0** (662.1)
	Currently limiting	548	77.0 (22.6)	
Happiness	Ever had comorbidity	2285	83.4 (16.9)	13.3** (716.7)
	Currently limiting	542	70.6 (20.9)	
Global Function	Ever had comorbidity	2303	95.2 (6.3)	15.2** (607.8)
	Currently limiting	544	86.8 (12.6)	

***P* < 0.001 with equal variances not assumed.

for age and comorbid conditions in comparing PODCI scores was strongly recommended.

The level of function on PODCI subscales changes with age, as well as with health conditions versus without health conditions. The finding that the parent's report of the child ever having had a comorbid condition may affect function suggests that the assessment method is valid. When a parent reports that a child is currently limited by a health/comorbid condition, the child demonstrates more limitation than those ever having had a health condition. This finding indicates that there is discriminative ability inherent in the scales. Although the health

conditions may vary in severity and are not necessarily medically diagnosed, there is clearly statistical evidence that the ratings are meaningful.

Consideration of comorbidity scores has been suggested when assessing a patient group using the PODCI.¹ Nevertheless, only a few articles have reported on comorbidities.^{12,14,30} A comparison group will be helpful in assessing children with musculoskeletal conditions, if the comorbidities of those groups are measured and compared with the data reported here. As early as 1970, Feinstein³¹ noted the importance of considering comorbid conditions when comparing groups of patients or

TABLE 3. Independent Samples *t* Test to Compare Sex in the AAOS Database PODCI Subscales by Comorbidity, Ever Had Versus No Comorbidity

PODCI	Sex	Comorbidity	N	M (SD)	<i>t</i> (df)
Upper Extremity	Male	Comorbidity	1589	96.6 (9.3)	-0.611 (2716)
		No comorbidity	1129	96.3 (8.2)	
	Female	Comorbidity	1299	96.7 (8.6)	-0.49 (2563)
		No comorbidity	1266	96.6 (7.1)	
Transfers/Basic Mobility	Male	Comorbidity	1574	98.6 (6.3)	3.24* (2358.7)
		No comorbidity	1122	99.2 (2.9)	
	Female	Comorbidity	1293	98.7 (6.2)	2.91* (1796.0)
		No comorbidity	1258	99.3 (2.7)	
Sports and Physical Function	Male	Comorbidity	1592	91.3 (13.2)	7.26*** (2721.9)
		No comorbidity	1133	94.4 (9.2)	
	Female	Comorbidity	1303	91.1 (12.8)	6.39*** (2388.1)
		No comorbidity	1271	93.9 (9.4)	
Comfort/Pain	Male	Comorbidity	1586	88.8 (17.0)	7.72*** (2697.4)
		No comorbidity	1132	93.3 (13.2)	
	Female	Comorbidity	1301	86.4 (17.9)	10.27*** (2385.1)
		No comorbidity	1267	92.8 (13.1)	
Happiness	Male	Comorbidity	1554	81.9 (17.9)	10.61*** (2569.2)
		No comorbidity	1074	88.5 (14.3)	
	Female	Comorbidity	1273	79.8 (19.0)	11.11*** (2435.5)
		No comorbidity	1234	87.5 (15.5)	
Global Function	Male	Comorbidity	1563	93.8 (8.6)	7.13*** (2664.6)
		No comorbidity	1107	95.8 (5.8)	
	Female	Comorbidity	1284	93.2 (8.6)	8.50*** (2199.6)
		No comorbidity	1244	95.7 (5.5)	

**P* < 0.05.

****P* < 0.001.

TABLE 4. Independent Samples *t* Test to Compare Sex in the AAOS Database PODCI Subscales

PODCI	Sex	N	M (SD)	<i>t</i> (df)
Upper Extremity	Male	2718	96.5 (8.9)	−0.9 (5281)
	Female	2565	96.7 (7.9)	
Transfers/Basic Mobility	Male	2696	98.9 (5.1)	−1.2 (5243.7)
	Female	2551	99.0 (4.8)	
Sports and Physical Function	Male	2725	92.6 (11.8)	0.3 (5297)
	Female	2574	92.5 (11.3)	
Comfort/Pain	Male	2718	90.7 (15.6)	2.6** (5248.1)
	Female	2568	89.5 (16.0)	
Happiness	Male	2628	84.6 (16.9)	2.1* (5133)
	Female	2507	83.6 (17.8)	
Global Function	Male	2670	94.7 (7.6)	1.1 (5196)
	Female	2528	94.4 (7.3)	

P* < 0.05.*P* < 0.01.

interventions. Further evaluation of the limitations of function in patient groups should include the relationship of the limitation with their musculoskeletal condition or associated medical factors.

The child's sex may also influence the PODCI score as seen in Sheffler et al's⁹ study of prosthetic use and parent-child-reported PODCI scores.⁹ Sex of the child had an impact on parent and self-scores, with the parents of sons scoring greater on comfort and pain than did the boys themselves. Parents rated their daughters lower on UE function than did the girls themselves. Differences in sex and parent responses based on the PODCI and patient Gross Motor Function Classification System levels have also been shown.²⁰ However, Barnes et al³ reported that

sex of a patient was not a significant predictor of the parent PODCI for children with CP.

If PODCI scores are collected on all children with a selected condition having musculoskeletal impact, regardless of treatment, meaningful comparisons between treatment and no-treatment groups can be made. A comparison group helps sort out the impact of coexisting factors, enabling a clear focus on the target condition. For example, in an article on children with CP,³² pre-operative and postoperative PODCI scale scores were compared, showing increases in some scale scores. Without knowing what would be expected for changes with age, sex, or comorbidity, it is not possible to report that the multilevel surgery made the difference or whether the changes were due to maturation or changes in the comorbidity level. Using not only a population-based comparative database but also collecting data on age, sex, and comorbidity factors on children without surgical treatment as a comparative group would then allow more appropriate assessment of the impact of treatment.

AAOS and Pediatric Orthopaedic Society of North America recognized the value in developing an instrument that can be used to compare effects across different health conditions or diseases.³³ It is beneficial to have not only disease-specific outcomes instruments, but also more generic instruments to allow comparisons across disorders and interventions.³⁴ Either functional decline in certain diagnostic groups or a lack of typical development can be assessed by having population-based data available on a large group of children. Having specific details of age, sex, and comorbidities to compare across conditions is a critical piece of outcomes assessment in the era of the

FIGURE 1. Parent response to PODCI subscales by age for children with no comorbidities.

FIGURE 2. Parent response to PODCI subscales by age for children with comorbidities.

International Classification of Function, Disability, and Health and the holistic evaluation of the child.

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