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Association of physical function, anxiety, and pain interference in non-shoulder upper extremity patients using the PROMIS platform

Nikolas H. Kazmers, MD MSE[1,*], **Man Hung, Ph.D.**[1,2], **Ajinkya A. Rane, MD**[1], **Jerry Bounsanga, BS**[1], **Cindy Weng, MS**[3], and **Andrew R. Tyser, MD**[1]

[1]University of Utah, Department of Orthopaedics, 590 Wakara Way, Salt Lake City, UT 84108

[2]University of Utah, Division of Public Health, 375 Chipeta Way, Salt Lake City, UT 84108

[3]University of Utah, Department of Pediatric Research Enterprise, 295 Chipeta Way, Salt Lake City, UT 84108

Abstract

Purpose—The relationship between psychosocial factors and self-reported physical function among hand and upper extremity patients is complex. The Patient-Reported Outcomes Measurement Information System (PROMIS) platform has attempted to create a variety of specifically-targeted metrics which can be administered using computer adaptive testing (CAT). Three metrics measuring self-reported physical function (herein referred to in combination as "functional" metrics) include the PROMIS Physical Function (PF) CAT, PROMIS Upper Extremity (UE) CAT, and the quick-Dash (qDASH). Two metrics assessing psychosocial factors include the PROMIS Anxiety and Pain Interference (PI) CATs ("non-functional" metrics). This study evaluates whether the functional metrics were correlated with non-functional metrics.

Methods—The five questionnaires were administered prospectively on a tablet computer to all consecutive adult patients presenting to outpatient hand and upper extremity (non-shoulder) clinic at a tertiary academic medical center from 1/1/2014 – 11/1/2014. For patients with multiple visits during the study period, only the first was included. Data were evaluated retrospectively to assess the relationship between functional and non-functional measures, with Pearson correlation coefficients to understand the relationship between continuous variables, and one-way ANOVAs to examine for differences in outcome measures across demographic groups. Multivariable linear regression analyses were performed to determine factors predicting functional disability.

Results—We included 1299 patients: mean age was 46.8 years, 53% were female, and 23% were unemployed or on disability. The PROMIS PF CAT, PROMIS UE CAT, and qDASH scores were all significantly correlated with PROMIS Anxiety CAT (Pearson correlation coefficients −0.46, −0.48, and 0.53, respectively) and PROMIS PI CAT (−0.60, −0.65, and 0.76, respectively) scores.

[*]Corresponding author nikolas.kazmers@utah.edu, Phone: 248-895-0568.

Multivariable regression analyses demonstrated that increased PROMIS Anxiety and Pain Interference CAT scores each independently and adversely influenced PROMIS PF CAT, PROMIS UE CAT, and qDASH scores.

Conclusions—Increasing levels of patient anxiety and pain interference are independently associated with decreased patient-reported upper extremity function.

Clinical Relevance Statement—This study provides further support of the biopsychosocial model by highlighting that increased anxiety is associated with decreased self-reported function using the PROMIS platform.

Keywords

Anxiety; Biopsychosocial; Pain interference; Physical function; PROMIS

Introduction

Patient-reported outcomes (PROs) are increasingly used to measure the efficacy of medical care, and are fundamental in determining the value of care provided.[1] It is likely that outcomes data will increasingly influence reimbursement of healthcare services under proposed pay-per-performance payment models.[2] With respect to provision of optimal patient care and equitable administration of health care resources, it is important to understand the strengths and limitations of current PRO measurement instruments.

A breadth of PRO metrics has been described and validated for hand and upper extremity applications. For example, the Disabilities of the Arm, Shoulder, and Hand (DASH) and abbreviated quick DASH (qDASH) have both been shown to be valid, responsive, and to reliably measure upper extremity disability.[3] These metrics are valuable, but have demonstrated occasional high ceiling effects in some populations and have a relatively large responder burden.[4,5]

The Patient-Reported Outcomes Measurement Information System (PROMIS) is a recently developed PRO evaluation platform developed by the National Institutes of Health with the goal of accurately and efficiently reporting patient symptoms, function, and quality of life.[6,7] In contrast to fixed-length scale metrics, PROMIS computer adaptive testing (CAT) is based upon probability-based computer algorithms utilizing item response theory to minimize question burden while maintaining high levels of measurement precision.[7,8] Psychometric characteristics of the PROMIS Physical Function (PF) and Physical Function Upper Extremity (UE) CATs have been described specifically in the context of hand and upper extremity patients, and both correlate strongly with the DASH and quickDASH.[5,8,9] While some studies did not observe floor or ceiling effects for the PF CAT[5] and UE CAT[9], others have demonstrated ceiling effects of 1.3% and 10.8%, respectively.[8]

In addition to measures of physical function, the PROMIS system contains metrics that address various aspects of mental health. The PROMIS Anxiety CAT was developed and validated to measure anxiety symptoms,[10] however it remains unclear whether these scores influence functional status for hand and upper extremity patients as measured by the PROMIS PF CAT, PROMIS UE CAT, or qDASH. Pain interference (PI), or the extent to

which pain interferes with accomplishing goals, has a strong influence on perceived disability among hand and wrist patients[11] and can be efficiently quantified using the PROMIS PI CAT.[12] PROMIS PI scores independently predicted inferior PROMIS PF and UE CAT scores amongst outpatients seeking hand surgical care, albeit in limited populations of 84 and 93 patients at a single center, respectively.[9,13]

The PROMIS system has attempted to maximize unidimensionality—specificity for a specific domain being measured—with minimal influence by comorbidities in other health domains. However, in the setting of hand and upper extremity surgery, biopsychosocial factors may ubiquitously influence outcomes following surgical and nonsurgical treatments.[14,15] Therefore, elucidating whether these factors influence outcomes as measured with the PROMIS PF and UE CATs is clinically important.

Our primary null hypothesis was that PROMIS Anxiety scores do not correlate with non-shoulder upper extremity function as measured by the qDASH and PROMIS PF and UE CATs. Our secondary null hypothesis was that these outcome measures are not associated with PROMIS PI scores.

Methods

We conducted an IRB-approved retrospective review of all new, returning, and postoperative adult patients presenting to an outpatient hand and upper extremity (non-shoulder) clinic at a tertiary academic medical center between 1/1/2014 and 11/1/2014 and who completed five questionnaires on a tablet computer. These included three functional outcome questionnaires: 1) PROMIS PF CAT v1.2, 2) PROMIS UE CAT v1.2, and 3) qDASH, and two non-functional outcome questionnaires: 1) PROMIS Anxiety CAT v1.0, and 2) PROMIS PI CAT v1.1. These data were automatically integrated into our institution's medical record via a secure wireless interface. Only patients evaluated by one of the four fellowship-trained orthopaedic hand surgeons at our institution were included. Patients < 18 years of age, and those evaluated outside of the listed date range, were excluded. Data from only the first visit was included for patients with multiple visits over the study period.

Basic descriptive statistics were calculated to illustrate the mean, median, standard deviation, and range of scores for the five questionnaires. Potential association between each combination of functional (PROMIS PF CAT, PROMIS UE CAT, qDASH) and non-functional (PROMIS Anxiety CAT, PROMIS PI CAT) outcome measures was examined by calculating Pearson correlation coefficients. One-way analysis of variance (ANOVA) was used to test for differences in means of each of the functional measures by sex, employment status, and smoking status. Pearson correlation coefficients were calculated to determine whether the functional scores were related to patient age. The magnitude of resulting r-values were interpreted as follows in terms of strength of the association: no association ($r < 0.2$), weak ($0.2 \leq r < 0.4$), moderate ($0.4 \leq r < 0.6$), strong ($0.6 \leq r < 0.8$), and very strong (≥ 0.8). Multivariable linear regression analyses were then performed, controlling for demographic variables that were found significant in either the Pearson correlation analyses or the one-way ANOVAs, to evaluate whether the non-functional outcomes were associated

with the three functional outcome scores. All tests were set at a significance level of 0.05 and were two-sided.

A *post-hoc* power analysis revealed that a sample size of 1299 yields >99% power to detect a squared multiple correlation of 0.4 at $\alpha = 0.05$ between the PROMIS UE CAT and the PROMIS Anxiety CAT after controlling for age, sex, employment status, and smoking status.

Results

A total of 1299 patients were included. The mean age was 46.8 ± 16.8 years, 53% were female, 23% were either unemployed or on disability, and 18% patients were active smokers (Table 1). The mean functional and non-functional outcome scores are summarized in Table 2. The PROMIS PF CAT, UE CAT and qDASH scores were all moderately correlated with the PROMIS Anxiety CAT (Pearson correlation coefficients −0.46, −0.48, and 0.53, respectively; $p<0.05$) and strongly correlated with PROMIS PI CAT scores (−0.60, −0.65, and 0.76, respectively; $p<0.05$). The PROMIS PF CAT, PROMIS UE CAT, and qDASH scores were significantly correlated with one another, and the PROMIS Anxiety and PI CATs were also significantly correlated (Table 3).

Age, sex, employment status, and smoking status were observed to be potential confounders of the three functional outcome scores (Table 4), and were controlled for in the multivariable linear regression model. PROMIS Anxiety and PI CAT scores both remained independently associated with all three functional outcomes (PROMIS PF and UE CATs, qDASH) in the multivariable regression model (Table 5). In the multivariable model, retired work status was significantly associated with decreased function as measured by all three studied functional metrics (unstandardized regression coefficients of −4.78, −2.55, and 4.40 for PROMIS PF CAT, PROMIS UE CAT, and qDASH, respectively). Disabled work status was significantly associated with decreased self-reported function for the PROMIS PF CAT (unstandardized regression coefficient −6.24) and qDASH (coefficient 5.17), whereas unemployed work status was significantly associated with the PF CAT (unstandardized regression coefficient −2.42), PROMIS UE CAT (unstandardized regression coefficient −1.56), and qDASH (unstandardized regression coefficient 3.29).

The PROMIS Anxiety CAT was most strongly associated with the qDASH, with unstandardized regression coefficients of −1.73 (standardized = −0.73) and 0.31 (standardized = 0.12) determined by univariate and multivariable linear regression analyses, respectively. The PROMIS PI CAT had the greatest magnitude of effect on the qDASH as well, with unstandardized regression coefficients of 2.32 (standardized = 0.76) and 2.06 (standardized = 0.67) determined by univariate and multivariable linear regression analyses, respectively.

Discussion

The main finding of this study is that patients exhibiting high levels of self-reported anxiety are also more likely to report higher levels of upper extremity disability, utilizing the PROMIS platform. We rejected our primary null hypothesis because we observed a

moderate negative correlation between the PROMIS Anxiety CAT and the PROMIS PF and UE CAT, and a moderate positive correlation between the Anxiety CAT and qDASH scores. Therefore, in our patient population which mirrors the expected mean and standard deviation for PROMIS Anxiety CAT scores (50 and 10, respectively), we conclude that anxiety is associated with decreased self-reported upper extremity function among patients presenting to an academic hand surgical practice with both traumatic and non-traumatic pathology.

Our findings related to anxiety are congruent with previously published literature.[16,17] Ring and colleagues observed a significant correlation between DASH score and pain-related anxiety for patients presenting with carpal tunnel syndrome, de Quervain tendinitis, lateral elbow pain, and trigger finger, but not for patients evaluated six weeks after initiation of non-operative distal radius fracture care.[17] Furthermore, pain-related anxiety was not an independent predictor of DASH score in their study.[17] More recently, Roh observed a correlation between pain-related anxiety and decreased grip strength, decreased total active range of motion, and increased disability three months following surgically-treated hand fractures.[18] In both studies, the authors utilized the revised Pain Anxiety Symptom Scale (PASS), which evaluates pain-related anxiety by measuring cognitive anxiety, fear of pain, escape and avoidance, and physiologic anxiety. In contrast, the PROMIS Anxiety CAT focuses upon fear, anxious misery, hyperarousal, and somatic symptoms pertaining to arousal – it only contains one behavioral avoidance question and therefore may not thoroughly evaluate behavioral fear avoidance.[10]

Oflazoglu recently observed that health anxiety, as measured with the five-item Short Health Anxiety Inventory (SHAI-5), was correlated with an estimated diagnosis of depression (as defined as a score of ≥10 on the Patient Health Questionnaire, which has been associated with a diagnosis of major depression).[16] However, correlation between anxiety and patient disability or function was not evaluated. Vranceanu observed a significant correlation between pain-related anxiety (PASS) and pain levels at time of suture removal following minor hand surgery, but did not observe a correlation with disability (DASH) following univariate or multivariable analysis.[14] These results are not necessarily contradictory to those in the current study, as we included nonsurgical and pre-surgical patients in addition to postoperative visits.

We also rejected our secondary null hypothesis because we observed a strong negative correlation between PROMIS PI CAT and the PROMIS PF and UE CAT, and a strong positive correlation between the PI CAT and qDASH scores. Therefore, we conclude that patients with high levels of pain interference are more likely to report perceived disability and impaired function when presenting to an academic hand and upper extremity (non-shoulder) surgical practice with both traumatic and non-traumatic pathology.

Our findings related to pain interference and perceived hand function are consistent with previous reports.[9,11,13,18,19] Menendez observed that 51% of variability in the qDASH was explained by differences in PROMIS PI CAT scores among new or follow-up hand surgery patients at an urban academic medical center, and furthermore reported a large correlation between PROMIS PI and qDASH scores and medium correlation between PROMIS depression CAT and qDASH scores.[19] Nota observed that pain interference had a strong

influence on qDASH variability in a similar patient cohort.[11] Three months following hand fracture surgical treatment, Roh observed that Pain Catastrophizing Scale (PCS) scores correlated with increased disability on the qDASH.[18] Interestingly and without a clear explanation, these correlations were absent at the six month postoperative visit.[18]

Recent studies utilizing PROMIS PF and UE CATs to measure disability and function among hand surgery patients provide insight into the relationship between upper extremity function and pain interference.[9,13] In a retrospective study of 93 consecutive new and follow-up outpatients, Overbeek observed that increasing PROMIS PI CAT scores were associated with greater disability on the PROMIS PF CAT and qDASH.[13] Similarly, Doring published data suggesting an association between the PROMIS UE and PI CATs.[9] Correlation coefficients between the PROMIS UE and PI CATs determined through univariate analysis in the current and Doring studies differed slightly (−0.82 versus −0.60, respectively), however mean and standard deviations for both metrics were similar. An additional point of agreement between the current study and prior publications is the significant correlation between measures of physical function (qDASH, PROMIS PF CAT, and PROMIS UE CAT) among patients presenting to a hand surgery clinic.[5,8,9,13]

However, our study has limitations. We have only demonstrated an association between functional and non-functional metrics and cannot claim that pain interference or anxiety causes decreased upper extremity function: our study does not address whether anxiety or pain interference causes, or results from (or a combination of both), upper extremity disability. We did not differentiate between patients undergoing treatment for anxiety or depression and those without psychiatric care, which may influence the results. We did not perform sub-analysis by visit type (new patient, postoperative patient, return patient), diagnosis, location of pathology (finger, hand, wrist, forearm, or elbow), or visit type (nonoperative, pre-operative, post-operative) – we acknowledge that our reported findings may differ for specific patient subsets. However, as a result of our minimal exclusion criteria, the ability to generalize our results may be substantial.

In addition to the above correlative findings, we also feel it important to note that this study very clearly illustrates the complex nature of the biopsychosocial model, in part due to the strength of the PROMIS metrics. The PROMIS metrics were planned and developed in a very rigorous manner, in part to be as unidimensional as possible (i.e. measure one aspect of health, or a single domain, at a time). As we have identified correlations between both functional and non-functional PROMIS metrics pertinent to upper extremity care, this information should serve to further demonstrate the substantial interplay between physical function and psychological factors in the care of hand patients, and to illustrate the difficulty in developing purely unidimensional metrics in this patient population. It remains unclear whether levels of anxiety or pain interference are intrinsic to each patient, whether pathophysiology of the upper extremity is the cause of increased anxiety or pain interference, or both. Future studies that expand upon our observed associations in attempt to investigate causation may further advance our understanding of the interplay between psychological and biological factors in hand surgery. Additionally, further investigation is warranted to evaluate the impact of baseline anxiety and pain interference on self-reported functional improvement following treatment.

In conclusion, this study demonstrates that higher levels of self-reported pain and anxiety are associated with lower levels of patient-reported upper extremity function in a large cohort of hand patients, as measured utilizing the Patient Reported Outcome Measurement System (PROMIS).

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Table 1

Baseline Patient Characteristics

Age (years)[a]		46.8(mean)	16.8 (S.D.)
Employment[b]	Full Time	630	58.50%
	Part Time	77	5.90%
	Retired	180	13.90%
	Disabled	75	5.8%
	Not Employed	223	17.2%
	Unknown	10	0.8%
Sex[b]	Female	690	53.1%
	Male	609	46.9%
Smoking[b]	Yes	227	17.5%
	Quit	212	17.3%
	Never	786	60.5%
	Unknown	66	5.1%

[a]Continuous data presented as mean ± standard deviation (S.D.).

[b]Categorical data presented as number (n) and percentage (%).

Table 2

Summary of Functional and Non-Functional Outcome Measures

Scores		Number (n)	Mean ± S.D.	Median	Range
Functional Scores	PROMIS PF CAT	1217	44.9 ± 10.2	46.0	15.3 – 73.3
	PROMIS UE CAT	1197	35.6 ± 10.0	34.9	14.3 – 56.3
	qDASH	1023	42.7 ± 24.1	43.2	0.0 – 97.7
Non-Functional Scores	PROMIS Anxiety CAT	1251	53.3 ± 9.9	53.6	34.1 – 84.9
	PROMIS PI CAT	1235	59 ± 7.9	58.9	39.6 – 81.0

Table 3

Pearson Correlation Coefficients

	PF	UE	qDASH	Anxiety	PI
PROMIS Physical Function CAT (PF)	*1.00*	-	-	-	-
PROMIS Upper Extremity CAT (UE)	0.71 (strong) p <0.05	*1.00*	-	-	-
Quick DASH (qDASH)	−0.73 (strong) p <0.05	−0.85 (strong) p <0.05	*1.00*	-	-
PROMIS Anxiety CAT (Anxiety)	−0.46 (moderate) p <0.05	−0.48 (moderate) p <0.05	0.53 (moderate) p <0.05	*1.00*	-
PROMIS Pain Interference CAT (PI)	−0.60 (strong) p <0.05	−0.65 (strong) p <0.05	0.76 (strong) p <0.05	0.55 (moderate) p <0.05	*1.00*

Table 4

Identification of Potential Confounding Variables to be Included in the Multivariable Model

	Age		Employment			Tobacco User			Sex		
	Pearson Coefficient	**p-value**	**F-value**	**d.f.**	**p-value**	**F-value**	**d.f.**	**p-value**	**F-value**	**d.f.**	**p-value**
PROMIS Physical Function CAT (PF)	−0.21	**<0.05**	30.94	6	**<0.05**	8.16	3	**<0.05**	16.59	1	**<0.05**
PROMIS Upper Extremity CAT (UE)	−0.04	0.13	11.02	6	**<0.05**	9.69	3	**<0.05**	15.48	1	**<0.05**
Quick DASH (qDASH)	0.03	0.4	13.24	6	**<0.05**	12.87	3	**<0.05**	19.95	1	**<0.05**

Abbreviations: d.f. - degrees of freedom; F-value - F-statistic value from one-way ANOVA

Factors associated with **bolded** p-values were included in the multivariable regression model.

Table 5

Multivariate Linear Regression Analysis

	PROMIS PF CAT			PROMIS UE CAT			qDASH		
Factor	**Coefficient**	**95% C.I.**	**p-value**	**Coefficient**	**95% C.I.**	**p-value**	**Coefficient**	**95% C.I.**	**p-value**
Age	−0.08	−0.12 – −0.04	***<0.05***	N/A	N/A	N/A	N/A	N/A	N/A
PROMIS Non-Functional Score									
Anxiety CAT	−0.19	−0.25 – −0.13	***<0.05***	−0.17	−0.22 – −0.11	***<0.05***	0.31	0.18 – 0.43	***<0.05***
Pain Interference CAT	−0.59	−0.66 – −0.52	***<0.05***	−0.69	−0.76 – −0.62	***<0.05***	2.06	1.90 – 2.22	***<0.05***
Sex[a]	−0.83	−1.79 – 0.14	0.09	−0.84	−1.77 – 0.08	0.07	2.57	0.46 – 4.67	***<0.05***
Smoking Status[b]									
Quit	0.06	−1.53 – 1.64	0.95	−0.36	−1.88 – 1.17	0.64	−2.24	−5.64 – 1.17	0.20
Never	0.12	−1.15 – 1.39	0.85	0.25	−0.99 – 1.49	0.69	−1.96	−4.75 – 0.83	0.17
Working Status[c]									
Part Time	−1.14	−3.04 – 0.77	0.24	−0.88	−2.73 – 0.97	0.35	−0.17	−4.43 – 4.08	0.94
Retired	−4.78	−6.50 – −3.06	***<0.05***	−2.55	−3.92 – −1.18	***<0.05***	4.40	1.20 – 7.61	***<0.05***
Disabled	−6.24	−8.33 – −4.14	***<0.05***	−1.17	−3.19 – 0.85	0.26	5.17	0.78 – 9.57	***<0.05***
Unemployed	−2.42	−3.68 – −1.15	***<0.05***	−1.56	−2.80 – −0.32	***<0.05***	3.29	0.52 – 6.06	***<0.05***
Adjusted R^2	0.45			0.46			0.61		

Abbreviations: N/A - not applicable given non-significant Pearson correlation coefficient analysis; C.I. - confidence interval

Definition of reference groups:

[a]Female,

[b]Active smoker

[c]Full time work.