



Original research

Timed Up and Go test is predictive of Patient-Reported Outcomes Measurement Information System physical function in patients awaiting total knee arthroplasty

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ABSTRACT

Background: The Patient Reported Outcomes Measurement Information System (PROMIS) Computerized Adaptive Test (CAT) physical function rapidly assesses self-reported function capability. The Timed Up and Go (TUG) test is often used in clinical practice, but administration may be impeded by space and patient limitations. PROMIS CAT can potentially address these limitations, but we lack evidence if TUG and health indicators are predictors of PROMIS CAT. This study assessed whether TUG, body mass index (BMI), numeric pain rating scale (NPRS), and smoking status were predictors of PROMIS CAT in total knee arthroplasty (TKA) candidates.

Methods: Sixty-five TKA candidates completed the PROMIS CAT physical function test using an iPad application. TUG, NPRS, BMI, and smoking status were obtained at the clinic visit or from medical records. Univariate and multiple regression analyses identified the strongest predictors of PROMIS CAT. **Results:** TUG was the best predictor of PROMIS CAT physical function based on simple regression ($r = -0.43$, 95% CI = -0.62 to -0.20) or multiple regression ($\beta = -0.45$, 95% CI = -0.73 to -0.17) analyses. BMI and NPRS did not incrementally help predict the PROMIS score beyond TUG. Smoking status did not contribute to the prediction of the PROMIS CAT score.

Conclusions: The findings suggest that the PROMIS CAT physical function is not a surrogate for the TUG performance-based measure in candidates for TKA. However, TUG was the best predictor of PROMIS physical function compared with BMI, NPRS, and smoking status. Clinicians should consider both patient-reported and performance-based measures when evaluating function for TKA outcomes.

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Introduction

Total knee arthroplasty (TKA) surgery is the most frequent inpatient hospital procedure with more than 700,000 surgeries performed annually in the United States [1,2]. The demand for TKA

is expected to rise in the future, and even with conservative projections, the number of TKA cases per year is expected to reach 1.5 million by 2050 [3]. As the number of TKA cases rise, there are greater pressures on surgeons and health-care systems to demonstrate that the benefits outweigh the associated costs [4]. Recovery of physical function is an important outcome of TKA and may be measured using patient-reported outcomes or performance-based outcomes [5,6]. Both are used to evaluate outcomes after TKA; however, orthopedic surgeons who use outcome measures tend to rely primarily on patient-reported outcomes which may not fully characterize the patient's physical function due to influences such as level of pain [5,7]. There is a lack of widespread collection and use of patient-reported outcomes by orthopedic surgeons due to real and perceived barriers [8]. With the typical hospital stay of

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only 1 to 3 days for TKA, the collection of patient outcomes must be routine and efficient in the outpatient surgery clinic.

The Patient Reported Outcomes Measurement Information System (PROMIS), developed by the National Institutes of Health, is appealing for tracking outcomes due to its brevity and well-established measurement properties [9–11]. Physical function, 1 of 4 domains available with PROMIS, includes questions relevant to activities performed with the upper extremity, lower extremity, and spinal region, as well as instrumental activities of daily living [12]. The PROMIS physical function domain can be administered with a Computerized Adaptive Test (CAT) via an iPad application [9]. Using item response theory methods and CAT, the participant's answer to a question related to physical function leads to the selection of the following question from the item bank that is at a higher or lower level of function [10]. In this way, the concept of physical function is determined by the participant's answers to approximately 4 to 6 questions [13]. PROMIS measures have been designed to maximize comparability across clinical conditions; therefore, the PROMIS physical function is an assessment of universal function rather than region-specific function such as the Knee Injury and Osteoarthritis Outcome Score (KOOS) [14]. A recent study found the PROMIS CAT physical function to be a responsive tool for detecting treatment effects in adult reconstruction patients and to be consistently more responsive than the short version of the KOOS (KOOS JR) [15]. To date, the relationship between PROMIS CAT physical function outcomes and performance-based outcome measures has not been established in people with knee osteoarthritis (OA) who are candidates for TKA.

The Timed Up and Go (TUG) is a recommended measure of function, balance, and walking ability for people with knee OA and one of the most commonly used performance-based outcome measures for TKA [5,16,17]. Physical therapists are more likely to use performance-based measures to characterize function after TKA than orthopedic surgeons [5]. Performance-based measures, such as the TUG, show greater responsiveness in the acute stage after TKA than patient-reported outcome measures [7]. Thus, the TUG may assist in early identification of patients who may need additional rehabilitation to reduce the potential for poor outcomes after surgery [7].

Currently, there is a lack of available evidence comparing the PROMIS CAT with the TUG test. Therefore, the purpose of this study was to assess the strength of the relationship between the PROMIS CAT physical function domain and the TUG in persons with knee OA who were candidates for TKA. Pain, body mass index (BMI), and smoking status also impact outcomes after TKA [18–20]; therefore, we also evaluated these factors as potential predictors of PROMIS physical function.

Material and methods

This was an observational study that included a cross-sectional comparison of measures from patients who were candidates for primary TKA, based on the recommendation of the orthopedic surgeons.

Participants

Participants (N = 65) were recruited from a university-affiliated orthopedic surgery clinic between August 2015 and March 2016. Participants were required to have a diagnosis of end-stage knee OA (Kellgren-Lawrence grade 4) [21] and to be candidates for primary TKA, as determined by the orthopedic surgeons. Exclusion criteria included the following: (1) age less than 18 years, (2) non-English-speaking individuals, (3) previous major knee surgeries or TKA, (4) forms of arthritis other than OA such as traumatic or rheumatic

Table 1

Demographic characteristics of patients with knee osteoarthritis (n = 65).

Characteristic	Value ^a
Age (y)	62.6 ± 8.9
Female sex (%)	40 (61.5)
Race/ethnicity	
Black	20 (30.8%)
Latino/Hispanic	2 (3.1%)
Native American	4 (6.2%)
White	38 (58.5%)
Unknown	1 (1.5%)
Smoking status	
Never	32 (49.2%)
Quit	23 (35.4%)
Current	10 (15.4%)

^a Values are reported as mean ± SD or percentage (%) of total sample.

arthritis, and (5) comorbidities such as severe cardiac, respiratory, or neurological impairments that prevented ambulation. The study was approved by the institutional review board. Written informed consent was obtained from all participants.

Measures

Patient demographic and clinical characteristics

The patient's self-reported age, sex, race/ethnicity, and smoking status were obtained from the electronic medical record. BMI was calculated from the measurements of height and weight made at the clinic visit.

Numeric pain rating scale

Participants were asked to indicate the intensity of their current pain by using an 11-point numeric scale, ranging from 0 (no pain) to 10 (worst pain) [22]. The numeric pain rating scale (NPRS) has been shown to be reliable, valid, and responsive for measuring chronic pain conditions [23–25]. The general population has been reported to have a pain average ranging from 1 to 3 on the NPRS, whereas people with OA typically have average scores ranging from 5 to 6 [11].

Timed Up and Go

The time in seconds was recorded for the participant to stand up from a standard chair with armrests, walk 3 meters at a comfortable and safe pace, turn, walk back to the chair, and sit down. Each participant performed the test 3 times, and the average of 3 trials was calculated. The TUG test has been shown to have excellent test-retest reliability (ICC = 0.97) [26,27]. TUG scores tend to be normally distributed in community dwelling adults and do not show ceiling effects [28].

PROMIS CAT physical function domain

The participant completed the PROMIS CAT physical function domain administered via an iPad application [9]. PROMIS CAT physical function score is reported as the T-score (mean = 50, standard deviation [SD] = 10), and higher scores represent higher levels of physical function [29]. The PROMIS CAT physical function domain has demonstrated validity (known-group and ecological) for people with OA when compared with a sample from the general population and has excellent test-retest reliability (ICC > 0.90) [11].

Data analysis

Statistical analyses were performed using JMP Pro 12.0 (SAS Institute Inc., Cary, NC).

Descriptive statistics were used to describe the sample characteristics. Separate linear regression analyses and multiple

Table 2
Descriptive statistics from measurements of patients with knee osteoarthritis.

Variable	Mean \pm SD	Range
PROMIS physical function (n = 61)	38.9 \pm 7.3	27–68
TUG, s (n = 64)	16.7 \pm 7.7	7.5–42.2
NPRS, 0–10 points (n = 64)	6.85 \pm 2.45	1–10
BMI, kg/m ² (n = 62)	32.6 \pm 5.6	22.7–47.3

The PROMIS values given in the table are reported as T-scores.

regression analyses were performed to identify the best individual and combined predictor of PROMIS physical function from TUG, NPRS, BMI, and smoking status. In the analyses, smoking status was analyzed using an indicator variable parameterization with the N category (“never smoked”) as the reference category. Thus, the parameter estimates for the C (“current smoker”) and Q (“quit smoking”) categories refer to average PROMIS physical function differences between individuals in each of these categories and the never smokers (N). The type I error rate was set at 0.05 for all statistical significance tests.

Results

Demographic data and descriptive statistics

We recruited 65 participants (40 females and 25 males) with an average age of 62.6 years (Table 1). As indicated in Table 1, the greatest proportion of subjects were white (58.5%) and had never smoked (49%). Fifteen percent (n = 11) of participants were classified as current smokers, whereas 35% (n = 23) were classified as former smokers who quit.

Current pain on the NPRS was 6.85 \pm 2.45 and TUG was 16.7 \pm 7.7 s (Table 2). On average, the BMI was 32.6 \pm 5.6 kg/m², and 37 participants had a BMI of >30 kg/m², which classified them as obese. Based on the World Health Organization’s subcategories of obesity, 19 were of class 1 (BMI of 30 to <35), 8 were of class 2 (BMI of 35 to <40), and 10 were of class 3 (BMI of 40 or higher) [30].

The average T-score for the PROMIS CAT physical function domain was 38.9 \pm 7.3, which falls below the T-score of 50 or “average” score for the general population [11]. PROMIS CAT data were missing from 4 participants due to an internet connectivity problem on the day of their visit (Table 2).

Simple regression and correlation analyses

TUG was the best predictor of PROMIS physical function, based on simple regression and correlation analyses (Table 3). There was a moderate negative correlation ($r = -0.43$, 95% CI = -0.62 to -0.20) between PROMIS CAT physical function and TUG. PROMIS had a weaker negative correlation with NPRS ($r = -0.30$, 95% CI = -0.51 to -0.05) and BMI ($r = -0.31$, 95% CI = -0.52 to -0.05). Smoking status was unrelated to PROMIS physical function score ($P = .2467$).

Table 3
Simple regression and correlation analyses to predict PROMIS physical function from TUG, NPRS, BMI, and smoking status.

Variables	Parameter estimate ($\hat{\beta}$) 95% CI	Simple correlation (r) 95% CI	P value
TUG—PROMIS (n = 60)	-0.42 (-0.64 to -0.19)	-0.43 (-0.62 to -0.20)	$\leq .0005$
NPRS—PROMIS (n = 60)	-0.88 (-1.63 to -0.13)	-0.30 (-0.51 to -0.05)	$\leq .0217$
BMI—PROMIS (n = 58)	-0.41 (-0.75 to -0.07)	-0.31 (-0.52 to -0.05)	$\leq .0183$
Smoking status—PROMIS (n _N = 32, n _Q = 23, n _C = 8)	N: 40.07 (37.39–42.75); Q vs N: -1.11 (-5.23 to 3.01); C vs N: -4.94 (-10.79 to 0.09)		$\leq .2467$

CI, confidence interval; Smoking Status: N, never smoked; Q, quit smoking; C, current smoker.

Smoking Status was analyzed using an indicator variable parameterization with N = never smoked as the reference category.

Multiple linear regression analyses

Table 4 provides the results of multiple linear regression analyses, which indicated that the TUG was the best individual predictor of PROMIS CAT physical function, accounting for about 14% of the PROMIS score variance. NPRS, BMI, and smoking status did not help predict the PROMIS physical function score beyond the information provided by the TUG test.

Discussion

The primary aim of this study was to assess the convergent validity of the PROMIS CAT physical function and the TUG in persons with knee OA who are candidates for TKA. There was only moderate concurrent validity between the PROMIS CAT physical function and the TUG in persons with knee OA who were candidates for TKA. This relationship and the finding that TUG accounted for only 14% of the PROMIS score variance implies that these instruments are measuring different aspects of physical function. Driban et al. [29] reported similar results for correlations between PROMIS physical function and gait speed ($r = -0.43$, 95% CI = -0.53 to -0.31) and 6-minute walk times ($r = 0.46$, 95% CI = 0.34 – 0.56) for people with symptomatic knee OA. Driban et al. [29] also found that PROMIS physical function correlated well with Medical Outcomes Short Form-36 (SF-36) physical function ($r = 0.79$, 95% CI = 0.73 – 0.84) but not with the Western Ontario and McMaster Universities Arthritis Index (WOMAC) function ($r = -0.48$, 95% CI = -0.58 to -0.36). These findings indicate that the PROMIS physical function is not a surrogate for performance-based tests, such as the TUG, when assessing physical function in patients with knee OA. The PROMIS physical function measure is designed to measure the problems from whole body disease, not joint-specific issues [29]. For patients with knee OA, the PROMIS physical function items may be more appropriate for assessing global outcomes of an exercise intervention, such as a walking program.

A recent study demonstrates that performance-based outcomes more accurately track recovery of function after TKA surgery. Mizner et al. [7] found that patients tended to overestimate their self-reported functional abilities early after TKA compared with their performance on functional tests. In their longitudinal study of 100 patients, the self-reported measures did not reflect an acute worsening of function after surgery, whereas the TUG captured a decrease in functional performance in patients between preoperative and 1-month postoperative visits (average TUG increase = 1.2 s, effect size = -0.43) and performance improvements between preoperative and the 12-month postoperative visits (average TUG decrease = 2.2 s, effect size = 0.79) and between 1-month and 12-month postoperative visits (average TUG decrease = 3.2 s, effect size = 1.17) [7]. There was poor concurrent validity between the performance-based outcomes and the patient-reported function, as measured by the KOS Activities of Daily Living Scale (KOS-ADL) and the Short Form-36 physical component summary (SF-36 PCS) [7]. The patients’ self-reported measures did not reflect the acute

Table 4
Model summary data from separate linear regression analyses to predict PROMIS physical function from the set of independent variables.

Variable, N = 57	Multiple regression coefficient ($\hat{\beta}$), 95% CI	Semipartial R^2	P value
TUG	−0.45 (−0.73 to −0.17)	0.135	≤.0023
NPRS	−0.25 (−1.08 to −0.59)	0.005	≤.5572
BMI	−0.19 (−0.53 to 0.14)	0.018	≤.2482
Smoking status	N: 39.60 (34.83–43.38); Q vs N: −2.61 (−6.39 to 1.17); C vs N: −4.58 (−9.89 to 0.73)	0.050	≤.1587

CI, confidence interval; Smoking Status: N, never smoked; Q, quit smoking; C, current smoker.

Smoking Status was analyzed using an indicator variable parameterization with N = never smoked as the reference category.

worsening of physical performance between the preoperative and 1-month postoperative phase.

Pain, as rated by the NPRS, showed poor relationship with PROMIS CAT physical function and did not help predict the PROMIS physical function score beyond the TUG. This indicates that PROMIS physical function is weakly influenced by local pain in people with knee OA. In contrast, self-reported measures of physical function made using knee arthritis-specific instruments such as the WOMAC physical function and the KOS-ADL tend to be more strongly influenced ($r = 0.53$ – 0.74) by the amount of pain experienced by people who have had TKA [7,31]. As pain subsides, the perception of the functional ability increases, even in the presence of continued impairments such as quadriceps weakness, joint stiffness, and swelling [7].

BMI also showed a weak relationship with PROMIS CAT physical function and did not help predict the PROMIS physical function score beyond the TUG. To our knowledge, this is the first study to use the PROMIS CAT to examine this relationship in people with knee OA. Previous studies have found weak or no association between self-reported measures of physical function and BMI in older adults and people with knee OA [32,33]. This suggests that BMI may not be directly related to function or the relationship may not be as simple as that considered on the surface.

Our results should be interpreted within the limitations of our study. This was a university-based orthopedic surgery clinic study, and this cannot speak to the generalizability of the results to other clinical settings. Other physical performance tests such as the stair climb test or the six-minute walk test may show a stronger relationship to PROMIS CAT physical function but may not be feasible in an outpatient surgical clinic. This study did not measure all known factors that could influence PROMIS CAT physical function. These include sociodemographic, mental, emotional, and psychosocial factors that can have a very large impact on patient outcomes with TKA [18,34,35]. There were no other self-reported measures such as KOOS or KOOS JR. Our sample only included those participants who could understand English. Other languages, such as Spanish, should be included in future research. Longitudinal studies are needed to examine the use of PROMIS CAT physical function for tracking TKA outcomes.

Conclusions

This article is the first to examine the relationship between PROMIS CAT physical function and measures known to impact outcomes of TKA. The PROMIS CAT physical function is not a surrogate for the TUG, a performance-based measure. The TUG was the best predictor of PROMIS physical function when compared with BMI, NPRS, and smoking status in candidates for TKA, but the TUG

accounted for only 14% of the PROMIS score variance. This study reinforces the growing body of literature that indicates the importance of obtaining both patient-reported and performance-based measures when evaluating function in people with knee OA for TKA outcomes.

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