[RESEARCH REPORT]

TREVOR A. LENTZ, PT, SCS[1,2] • **JASON M. BENECIUK,** PT, PhD, MPH[3] • **JOEL E. BIALOSKY,** PT, PhD[3]
GIORGIO ZEPPIERI, JR., PT, MPT, SCS[2] • **YUNFENG DAI,** MS[4] • **SAMUEL S. WU,** PhD[4] • **STEVEN Z. GEORGE,** PT, PhD[3]

Development of a Yellow Flag Assessment Tool for Orthopaedic Physical Therapists: Results From the Optimal Screening for Prediction of Referral and Outcome (OSPRO) Cohort

● **STUDY DESIGN:** Clinical measurement, cross-sectional.

● **BACKGROUND:** Pain-associated psychological distress adversely influences outcomes for patients with musculoskeletal pain. However, assessment of pain-associated psychological distress (ie, yellow flags) is not routinely performed in orthopaedic physical therapy practice. A standardized yellow flag assessment tool will better inform treatment decision making related to psychologically informed practice.

● **OBJECTIVES:** To describe the development of a concise, multidimensional yellow flag assessment tool for application in orthopaedic physical therapy clinical practice.

● **METHODS:** A 136-item yellow flag item bank was developed from validated psychological questionnaires across domains related to pain vulnerability (negative mood, fear avoidance) and resilience (positive affect/coping). Patients seeking physical therapy with neck, back, knee, or shoulder pain completed the item bank. Iterative statistical analyses determined minimal item sets meeting thresholds for identifying elevated vulnerability or low resilience (ie, upper or lower quartile, as indicated). Further item reduction yielded a concise yellow flag assessment tool to assess 11 psychological constructs measuring pain-associated psychological distress. Correlations between the assessment tool and individual psychological questionnaires were measured and compared between anatomical regions. Concurrent validity was

assessed by determining variance explained in pain and disability scores by the assessment tool.

● **RESULTS:** Subjects with elevated vulnerability and decreased resilience were identified with a high degree of accuracy (minimum of 85%) using a 17-item tool. Correlations were moderate to high between the 17-item tool and individual psychological questionnaires, with no significant differences in correlations between different anatomical regions. Shorter 10- and 7-item versions of the assessment tool allow clinicians the flexibility to assess for yellow flags quickly with acceptable trade-offs in accuracy (81% and 75%, respectively). All versions of the tool explained significant additional variance in pain and disability scores (range, 19.3%-36.7%) after accounting for demographics, historical variables, and anatomical region of pain.

● **CONCLUSION:** Concise assessment of yellow flags is feasible in outpatient physical therapy settings. This multidimensional tool advances assessment of pain-associated psychological distress through the addition of positive affect/coping constructs and estimation of full questionnaire scores. Further study is warranted to determine how this tool complements established risk-assessment tools by providing the option for efficient treatment monitoring. *J Orthop Sports Phys Ther 2016;46(5):327-345. Epub 21 Mar 2016. doi:10.2519/jospt.2016.6487*

● **KEY WORDS:** pain, psychology, screening

Pain-associated psychological distress adversely influences functional outcomes and is a predictor of disability and health care utilization for patients with musculoskeletal pain.[6,22,24,44,45] Multiple studies have shown that psychological factors may be more strongly

associated with change in pain intensity, number of physician visits, and physical disability than physical factors such as strength and range of motion.[10,21,42] Yet, despite this consistent evidence, assessment of pain-associated psychological distress (ie, yellow flags) is not routinely performed as a standard part of orthopaedic physical therapy practice.[11,23,41] This may be related to the considerable confusion about which specific psychological factors should be assessed and how to best incorporate findings from the initial and follow-up assessments into clinical decision-making processes.[3,8,38,46,49] For example, identifying the presence of depressive symptoms could indicate

the need for referral to another health care provider (eg, clinical psychologist). However, more common in orthopaedic physical therapy practice is that elevated pain-associated psychological distress indicates the need for a modified treatment approach to prevent delayed recovery or transition to chronicity.[29,37] Psychologically informed practice is an approach for secondary prevention of chronic musculoskeletal pain that emphasizes routine identification of modifiable psychological risk factors and modified treatment to address those factors.[37] Identifying patients who are likely to have a delayed recovery and are appropriate for psychologically informed practice approaches has potential for reducing health care costs and individual functional burdens associated with musculoskeletal pain conditions, by providing the most appropriate treatment for the right patient at the right time.[56,57]

Efficient yellow flag assessment can be achieved with multidimensional tools capable of providing an overall assessment of pain-associated psychological distress.[7] For example, the STarT Back Screening Tool is primarily intended to be used for risk-stratification purposes, where risk allocation is predominantly determined by responses to psychologically based items.[17] Similarly, the Örebro Musculoskeletal Pain Screening Questionnaire has been promoted as a useful tool for collecting information on yellow flags, primarily based on prognostic capabilities for clinical and nonclinical outcomes.[17,20,27] Although both instruments consist of items that identify the presence of overall pain-associated psychological distress, neither provides detailed information on any individual psychological construct. This may be an issue clinically, because full-length unidimensional questionnaires may be of interest to clinicians who wish to monitor patient response to psychologically informed interventions.

Another limitation is that these instruments focus primarily on factors that confer vulnerability to pain, including maladaptive coping strategies and negative-coping cognitions (eg, catastrophizing or fear avoidance). This scope reduces the utility of these tools for identifying other important psychological factors to address each patient. Furthermore, recent research has identified that adaptive coping strategies and positive-coping cognitions (eg, self-efficacy and pain acceptance) have the potential to attenuate the impact of these vulnerability factors.[4,16,32,34,40,48,53] Specifically, positive-coping cognitions and emotional states are thought to confer resilience to pain, which is characterized by psychological flexibility and resourcefulness to adaptively cope with psychological distress.[12,40] Like elevated vulnerability, low levels of resilience may represent a psychological risk factor for poor clinical outcomes that can be targeted through direct physical therapy intervention. Importantly, vulnerability and resilience factors are not mutually exclusive or necessarily representative of 2 distinct ends of the same spectrum.[16,35] Clinical studies in chronic musculoskeletal pain conditions have supported this position by demonstrating vulnerability and resilience factors to be distinct yet related constructs.[43,50] Thus, the independent contributions of both vulnerability and resilience factors should be considered in routine yellow flag screening.

The development of a multidimensional yellow flag assessment tool that is applicable across common musculoskeletal conditions and concisely estimates patient performance on a broad range of questionnaires that capture vulnerability and resilience factors would have direct relevance to orthopaedic physical therapy settings. For example, such an assessment tool would be an important addition to clinical practice to better inform treatment decision making related to treatment monitoring for patients determined to be at high risk for poor outcomes by existing risk-assessment tools.[17,27] Therefore, the purpose of this paper was to describe the development of a concise, multidimensional yellow flag assessment tool inclusive of both vulnerability and resilience factors for application in orthopaedic physical therapy clinical practice. Associations between the resulting assessment tool and validated single-construct psychological questionnaires will be explored, as well as differences in these associations by anatomical region of pain. Concurrent validity will be assessed by determining variance explained in pain and disability questionnaire scores by the assessment tool after accounting for demographics, historical variables, and anatomical region of pain.

METHODS

Overview

THIS PAPER REPORTS ON A PRIMARY aim of the Orthopaedic Physical Therapy-Investigative Network (OPT-IN) and the Optimal Screening for Prediction of Referral and Outcome (OSPRO) cohort study. The OPT-IN is a research network supported by the Orthopaedic Section of the American Physical Therapy Association, with the purpose of performing multicenter clinical projects that examine diagnosis/classification, prognosis, and/or patient-centered treatment outcomes in patients with musculoskeletal conditions commonly managed by orthopaedic physical therapists. The OSPRO cohort study is a specific project within the OPT-IN that is focused on creating concise and standard tools to enhance assessment by orthopaedic physical therapists. The OSPRO cohort study comprises separate developmental (cross-sectional) and validation (longitudinal) phases. This paper describes a planned cross-sectional analysis from the development phase for creation of a multidimensional yellow flag assessment tool (OSPRO-YF). The predictive validation of this tool involves recruitment of a separate longitudinal cohort and will be reported at a later date. The University of Florida Health Science Center Institutional Review Board (IRB-01) approved this study, and informed consent was obtained from each participant.

Pain-Associated Psychological Distress Domains and Measures

An a priori decision was made to include 3 separate domains of pain-associated psychological distress: 2 related to vulnerability (negative mood and fear avoidance)[5,13,26] and 1 related to resilience (positive affect/coping).[53,54,64] It was not our intent to conduct a thorough systematic review of the literature to identify an exhaustive list of yellow flag measures or items; rather, we generated an item pool representing certain psychological constructs within each of the 3 domains. Therefore, we identified validated questionnaires representative of individual constructs within each domain. Questionnaire selection was informed by a recent special issue on psychologically informed practice and included those commonly recommended for psychological assessment across a variety of musculoskeletal pain conditions. Not all questionnaires could be used due to practical reasons and consideration of patient burden. The final yellow flag item pool consisted of 136 unique questions compiled from 10 validated questionnaires (described below) assessing 11 psychological constructs (depression, trait anxiety, anger, fear-avoidance beliefs for physical activities, fear-avoidance beliefs for work, pain catastrophizing, pain-related fear of movement, pain-related anxiety, pain self-efficacy, rehabilitation self-efficacy, and pain acceptance).

Negative Mood

Patient Health Questionnaire The Patient Health Questionnaire-9 (PHQ-9) assesses the degree of depressive symptoms.[25] The PHQ-9 consists of 9 items with a potential score range of 0 to 27, with higher scores indicating elevated depressive symptoms.

State-Trait Anxiety Inventory The trait portion of the State-Trait Anxiety Inventory (STAI) assesses the degree of dispositional anxiety symptoms.[52] The trait portion of the STAI consists of 20 items with a potential score range of 20 to 80, with higher scores indicating elevated levels of anxiety.

State-Trait Anger Expression Inventory The trait portion of the State-Trait Anger Expression Inventory (STAXI) assesses the degree of dispositional anger symptoms.[51] The trait portion of the STAXI consists of 10 items with a potential score range of 10 to 40, with higher scores indicating elevated levels of anger.

Fear Avoidance

Fear-Avoidance Beliefs Questionnaire The Fear-Avoidance Beliefs Questionnaire (FABQ) assesses the degree of fear-avoidance beliefs specific to low back pain.[60] Modified versions of the FABQ were used to assess patients with neck, shoulder, and knee conditions by replacing the word *back* with the appropriate body region. The FABQ physical activity subscale (FABQ-PA) consists of 4 items with a potential score ranging from 0 to 24 and the FABQ work subscale (FABQ-W) consists of 7 items with a potential score ranging from 0 to 42, with higher scores indicating higher levels of fear-avoidance beliefs for both subscales. The FABQ-W and FABQ-PA were analyzed as separate questionnaires in this study.

Pain Catastrophizing Scale The Pain Catastrophizing Scale (PCS) assesses the degree of exaggerated negative orientation toward actual or anticipated pain experiences and catastrophic cognitions due to musculoskeletal pain.[55] The PCS consists of 13 items, with a potential score ranging from 0 to 52, with higher scores indicating higher levels of pain catastrophizing.[55]

Tampa Scale of Kinesiophobia The Tampa Scale of Kinesiophobia-11 (TSK-11) assesses the degree of fear of movement and injury or reinjury.[63] The TSK-11 consists of 11 items with a potential score ranging from 11 to 44, with higher scores indicating greater fear of movement and injury or reinjury due to pain.

Pain Anxiety Symptoms Scale The Pain Anxiety Symptoms Scale-20 (PASS-20) assesses the degree of pain-related anxiety symptoms for individuals with pain disorders.[30] The PASS-20 consists of 20 items, with a potential score ranging from 0 to 100, with higher scores indicating elevated symptoms of pain-related anxiety.

Positive Affect/Coping

Pain Self-Efficacy Questionnaire The Pain Self-Efficacy Questionnaire (PSEQ) assesses the degree of self-efficacy beliefs in the context of pain.[36] The PSEQ consists of 10 items, with a potential score ranging from 0 to 60, with higher scores indicating elevated levels of pain-related self-efficacy.

Self-Efficacy for Rehabilitation Outcome Scale The Self-Efficacy for Rehabilitation Outcome Scale (SER) assesses the degree of self-efficacy associated with performing various tasks during rehabilitation.[61] The SER consists of 12 items, with a potential score range of 0 to 120, with higher scores indicating elevated levels of self-efficacy during rehabilitation.

Chronic Pain Acceptance Questionnaire The Chronic Pain Acceptance Questionnaire (CPAQ) assesses the degree of pain acceptance from a functional perspective by focusing on behavioral aspects of pain coping.[31] We modified the CPAQ by removing the term *chronic* from most items so that it would also be appropriate for patients with nonchronic pain conditions. The CPAQ consists of 20 items, with a potential score range of 0 to 120, with higher scores indicating an increased level of pain acceptance.

Testing of Yellow Flag Items

Participants All participating OPT-IN clinical sites were located in Florida for the development phase. This included 3 outpatient clinics in the University of Florida Health System (Gainesville, FL) and 8 in the Brooks Health System (Jacksonville, FL). Sites within these health systems were selected based on different sociodemographic strata and representation of urban and rural communities.

A convenience sample of participants was recruited from participating OPT-IN clinical sites during their initial outpatient physical therapy evaluation. Eligibility criteria for inclusion in the

OSPRO cohort study were intentionally broad, so as to develop an assessment tool with wide clinical application. Narrow eligibility criteria would have excluded a significant number of patients commonly seen by orthopaedic physical therapists, resulting in limited application of the assessment tool.

Patients between 18 and 75 years of age were eligible to participate in the study if they (1) were seeking outpatient physical therapy treatment for musculoskeletal pain; (2) had primary complaints involving the cervical spine, lumbar spine, shoulder, or knee; and (3) were able to read and comprehend the English language.

Patients were excluded from study participation for any diagnosis indicative of (1) widespread chronic pain syndrome (eg, fibromyalgia or irritable bowel syndrome), (2) neuropathic pain syndrome (eg, complex regional pain syndrome or diabetic neuropathy), (3) psychiatric history (currently under the care of a mental health care provider or taking multiple psychiatric medications), (4) cancer (currently receiving treatment for active cancer), or (5) neurological disorder (eg, stroke, spinal cord injury, or traumatic brain injury).

Study participants completed a standard intake form that included age, sex, race, ethnicity, employment status, litigation status, marital status, educational level, insurance provider type, self-reported health status, and surgical history. Historical data included anatomical location of the pain, onset of symptoms (gradual, sudden, traumatic), duration of symptoms, number of previous episodes of pain, and previous treatments. Patients were instructed to answer questions regarding the condition for which they were currently seeking treatment. All data were entered into a web-based electronic records database (REDCap; Vanderbilt University, Nashville, TN).

Sample-Size Estimate

There are no definitive parameters for sample-size estimates in psychometric studies, but a common recommendation is a minimum of 100 subjects, with larger sample sizes acknowledged as better.[28,47,58] Therefore, the goal for the development cohort was to recruit a minimum of 400 subjects, for approximately 100 per anatomical region (neck, low back, knee, and shoulder). The rationale for this sample size was that it should be sufficient to provide precise estimates of the entire cohort and adequate power to test the generated assessment tool across different anatomical regions.
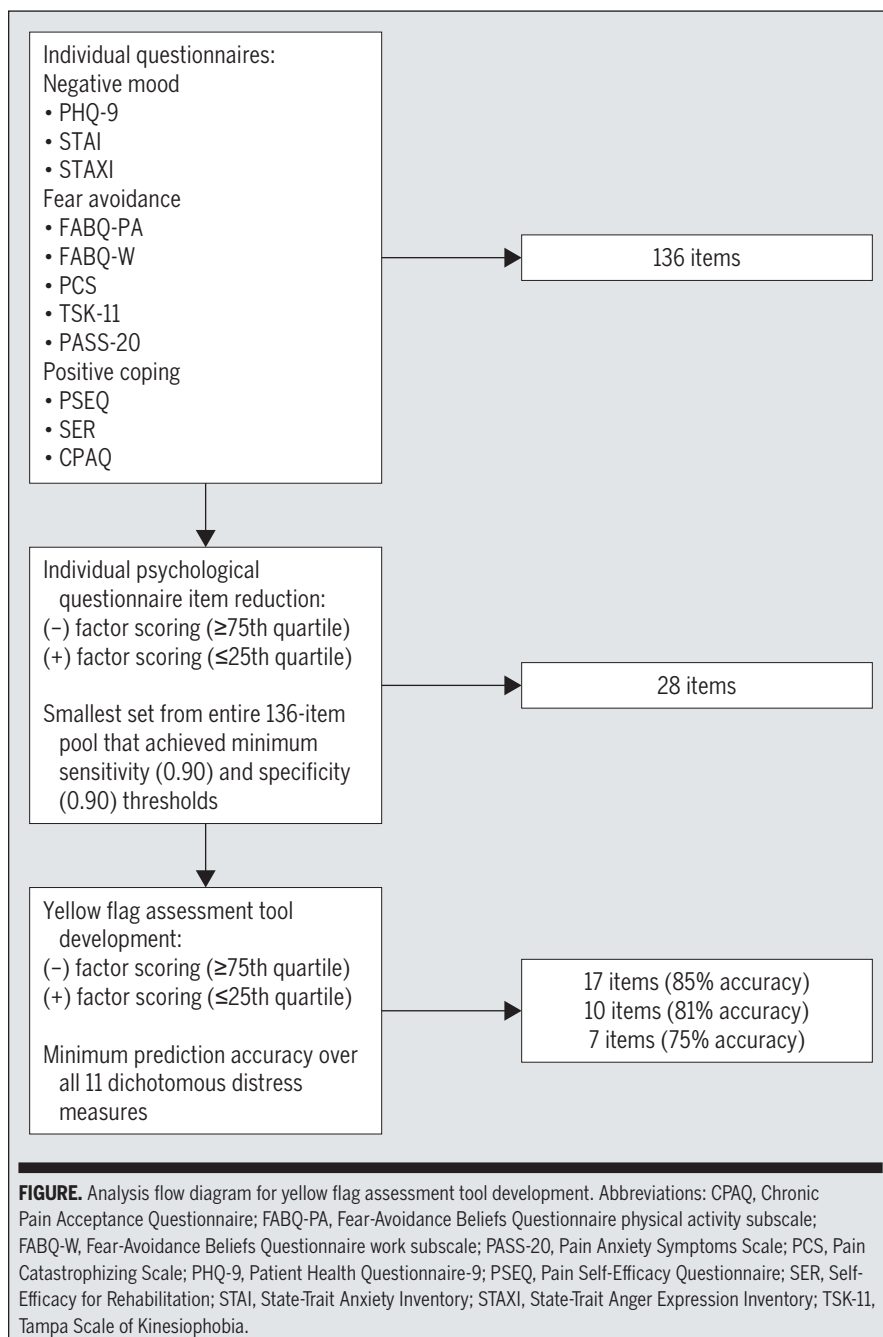
Statistical Analysis

Descriptive statistics were generated for demographic and historical information. Yellow flag item reduction was performed in 2 separate steps. The first step identified optimal reduced item sets for individual psychological constructs, and the second step further reduced the item sets to derive a concise assessment tool that could be used to accurately assess elevated pain-associated psychological distress across all 11 constructs. The **FIGURE** outlines the steps for the development of the yellow flag assessment tool.

Item Reduction for Individual Psychological Constructs Pain-associated psychological distress was represented by elevated scores on vulnerability measures and decreased scores on resilience measures. For each questionnaire, we operationally defined elevated vulnerability and decreased resilience (conceptually a yellow flag) as scoring in the upper quartile (75% or greater) for negative mood (PHQ-9, trait portion of the STAI, STAXI) and fear avoidance (FABQ-PA, FABQ-W, PCS, TSK-11, PASS-20) questionnaires, or in the lower quartile (25% or less) for positive affect/coping questionnaires (PSEQ, SER, CPAQ), respectively, across the entire sample. We used quartile scores, rather than established questionnaire cutoff scores, for 2 reasons. First, many cutoff scores reported in the literature for these questionnaires were developed specifically for low back pain or for general chronic pain conditions. In the development of an assessment tool

applicable to a wide range of patients presenting to outpatient orthopaedic physical therapy, these cutoffs may not be appropriate. Second, we valued consistency in developing cutoff scores for each questionnaire. Because some of the questionnaires we utilized did not have an established cutoff score or had multiple reported cutoff scores, we decided to use a consistent approach to determining elevated psychological involvement, which potentially would alleviate concerns of scoring threshold variability across different musculoskeletal conditions and body regions. This specific approach was informed by prior literature that identified patients with higher percentile scores on psychological measures to have higher treatment resistance and persistence of pain-related disability.[56]

For each questionnaire, we determined the optimal reduced item set comprising items from the entire 136-item pool that was best able to identify individuals in the upper quartile for negative-mood and fear-avoidance questionnaire scores and in the lower quartile for positive affect/coping questionnaire scores. Items from the entire pool were selected to maximize the accuracy with which each reduced item set could identify the primary underlying psychological distress construct (eg, pain catastrophizing, anger, anxiety) represented by each questionnaire. Because many of these measures are known to be correlated with one another, items from other questionnaires may provide better discrimination in optimal reduced item sets. Restricting the analysis to items within the parent questionnaire would exclude items that had better accuracy for identifying constructs from other questionnaires. This approach has the benefit of reducing the number of items necessary to provide optimum accuracy. The optimal reduced item set was defined a priori as the smallest set to achieve minimal sensitivity (0.90) and specificity (0.90) thresholds for identifying elevated vulnerability or decreased resilience. Sensitivity and specificity were determined by logistic regression,

Individual questionnaires:
Negative mood
• PHQ-9
• STAI
• STAXI
Fear avoidance
• FABQ-PA
• FABQ-W
• PCS
• TSK-11
• PASS-20
Positive coping
• PSEQ
• SER
• CPAQ

136 items

Individual psychological
questionnaire item reduction:
(−) factor scoring (≥75th quartile)
(+) factor scoring (≤25th quartile)

Smallest set from entire 136-item
pool that achieved minimum
sensitivity (0.90) and specificity
(0.90) thresholds

28 items

Yellow flag assessment tool
development:
(−) factor scoring (≥75th quartile)
(+) factor scoring (≤25th quartile)

Minimum prediction accuracy over
all 11 dichotomous distress
measures

17 items (85% accuracy)
10 items (81% accuracy)
7 items (75% accuracy)

FIGURE. Analysis flow diagram for yellow flag assessment tool development. Abbreviations: CPAQ, Chronic Pain Acceptance Questionnaire; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire work subscale; PASS-20, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; SER, Self-Efficacy for Rehabilitation; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory; TSK-11, Tampa Scale of Kinesiophobia.

regression analyses to determine the accuracy of the weighted linear combination of scores in the entire k-item pool for identifying patients with elevated vulnerability or decreased resilience for each of the original 11 distress measures (dichotomized based on original full questionnaire quartile score). The overall accuracy of the k-item tool was defined as the minimum predicted accuracy across all 11 distress measures. For example, if the accuracy of the k-item pool for identifying elevated vulnerability as measured by the TSK-11 was 87%, but accuracy for the remaining 10 measures was above 90%, the overall accuracy for the k-item bank would be reported as 87%. For derivation of the concise assessment tool, backward deletion was employed to find the smallest assessment tool that had minimum overall accuracy of 85% for identifying elevated vulnerability or decreased resilience across all 11 distress measures. Specifically, by leaving 1 item out of the pool of k items, we had k potential tools of $(k − 1)$ items, and we removed items one at a time so that the remaining items had the highest accuracy. In other words, the first step of this iterative process would determine minimum accuracy of all k items derived by the initial item reduction. Subsequent steps would remove one item at a time so that the remaining item set would have the next highest minimum accuracy. This process would then be continued until deriving the smallest assessment tool that satisfied the given minimum overall accuracy threshold of 85%. In an exploratory step, this process was extended to derive additional assessment tools with minimum accuracy thresholds of 80% and 75%, to explore further options for shorter, more efficient assessment tools while maintaining acceptable accuracy.

Correlations Between Yellow Flag Assessment Tool and Psychological Questionnaires Spearman correlations were calculated between the yellow flag assessment tool and the total score of each original psychological questionnaire. Correlation coefficients were then com-

in which weighted linear combinations of the item-set scores were used to predict the presence of pain-associated psychological distress as operationally defined. We built the optimal reduced item sets by starting with the single item that had the highest predicted accuracy for the given construct, and sequentially added items until sensitivity and specificity thresh-

olds were met. The optimal reduced item sets were obtained by exhaustive iterative search.

Item Reduction for Yellow Flag Assessment Tool Next, the reduced item sets were compiled into a pool of k items, which was used to derive a more concise assessment tool. This step was accomplished by using separate logistic

pared among anatomical regions of pain to determine if the instrument performed similarly across anatomical regions. These analyses were repeated for each version of the assessment tool derived in the exploratory step.

Concurrent Validity Concurrent validity of the assessment tool was examined by determining variance explained in pain and disability scores by the assessment tool, after accounting for common demographic factors. Pain in the involved anatomical region was measured by a numeric pain-rating scale. An average of best, worst, and current pain was used for analyses. Subjects also completed joint-specific disability measures based on their primary anatomical region of pain. Questionnaires included the Neck Disability Index, Oswestry Disability index, International Knee Documentation Committee Subjective Knee Evaluation Form, and Shoulder Pain and Disability Index. Disability measure scores were standardized (z-score) for all analyses. We explored 2 different scoring methods for the yellow flag assessment tool. The unweighted method used the raw sum of assessment tool items, whereas the weighted method used a process of weighting each item so that the sum of items provided the best prediction for each psychological outcome in logistic regression.

Separate hierarchical linear regression analyses were performed to determine the influence of anatomical region of pain, yellow flag assessment tool score, and their interaction on average pain intensity and disability, after accounting for common demographic and historical variables. In the first step of the model, demographic (age, sex) and historical (pain duration, work-related pain, surgery for pain) variables were entered, followed by anatomical region (low back, neck, shoulder, and knee) variables in the second step, and yellow flag assessment tool score in the third step. The anatomical region-by-yellow flag assessment tool score interaction term was added in the fourth step to determine whether anatomical region moderated the relationship between as-

TABLE 1	DEMOGRAPHICS FOR THE OSPRO COHORT: DEVELOPMENT OF A YELLOW FLAG ASSESSMENT TOOL*

Variable/Category	Overall (n = 431)
Mean ± SD age, y	44.8 ± 15.5
Median (range) age, y	47 (18-75)
Sex	
Male	170 (39.4)
Female	261 (60.6)
Race	
American Indian/Alaska Native	2 (0.5)
Asian	13 (3.1)
Black or African American	92 (21.7)
White	316 (74.7)
Income	
<$20000	98 (23.4)
$20000-$35000	58 (13.8)
$35001-$50000	47 (11.2)
$50001-$70000	58 (13.8)
>$70000	158 (37.7)
Education	
Less than high school	20 (4.6)
Graduated from high school	58 (13.5)
Some college	140 (32.5)
Graduated from college	112 (26.0)
Some postgraduate course work	31 (7.2)
Completed postgraduate degree	70 (16.2)
Insurance	
Private	264 (61.7)
Medicare	60 (14.0)
Medicaid	49 (11.4)
Workers' compensation	15 (3.5)
Disability	3 (0.7)
Uninsured	5 (1.2)
Other	32 (7.5)

Abbreviation: OSPRO, Optimal Screening for Prediction of Referral and Outcome.
Values are n (%) unless otherwise indicated.

sessment tool score and pain or function. For all models, anatomical region was dummy coded with low back as the reference category. Separate analyses were performed for weighted and unweighted scores of each of the 17-, 10-, and 7-item versions of the assessment tool.

RESULTS

THE STUDY INCLUDED 431 PATIENTS with neck (n = 93), shoulder (n = 108), low back (n = 119), or knee (n = 111) conditions. Median pain duration for current episode was 90 days (range,

TABLE 2	Symptom Characteristics for the OSPRO Cohort: Development of a Yellow Flag Assessment Tool*	
Variable/Category		**Overall (n = 431)**
Anatomical region		
Neck		93 (21.6)
Low back		119 (27.6)
Shoulder		108 (25.1)
Knee		111 (25.8)
Mean ± SD pain duration, d		380.3 ± 988.9
Median (range) pain duration, d		90 (2-9125)
Onset of symptoms		
Gradual		206 (48.9)
Sudden		150 (35.6)
Traumatic		65 (15.4)
Previous episodes over the past year		
Yes		247 (58.4)
No		176 (41.6)
Work-related symptoms		
Yes		67 (15.6)
No		363 (84.4)
Surgery for primary complaint		
Yes		103 (24.0)
No		327 (76.0)

Abbreviation: OSPRO, Optimal Screening for Prediction of Referral and Outcome.
*Values are n (%) unless otherwise indicated.

2-9125 days), with 49% reporting gradual onset of symptoms. Additional demographic information and symptom characteristics are listed in **TABLES 1** and **2**, respectively. Descriptive summaries of all individual psychological questionnaire scores are provided in **TABLE 3**. There were 40 subjects (less than 10%) with at least 1 piece of missing data. Where an individual questionnaire item was missing, the mean score of each item was used to replace the missing values.

Item Reduction for Individual Psychological Questionnaires

For each questionnaire, the optimal reduced item set that achieved minimal thresholds for sensitivity and specificity is listed in **TABLE 4**. This process identified a total of 28 items. Reduced item scores

for each construct were positively correlated (r = 0.79 to 0.97) with their parent total questionnaire scores (**TABLE 5**). Optimal reduced item sets for most constructs included items exclusive to the associated parent questionnaire. However, item sets for the anxiety and kinesiophobia questionnaires also included items from questionnaires measuring depression and pain catastrophizing, respectively.

Item Reduction for Yellow Flag Assessment Tools

Further reduction to identify a concise assessment tool yielded 17 items with minimal accuracy values of 85% (**APPENDIX A**). When grouped by psychological domain, the 17-item OSPRO-YF included 6 items from negative mood questionnaires, 6 items from fear-avoidance questionnaires,

and 5 items from positive affect/coping questionnaires. Further item reduction yielded 10-item and 7-item assessment tool versions with 81% and 75% accuracy, respectively. For the 17-item OSPRO-YF version, items representing each questionnaire were retained; however, this was not the case for the 10- and 7-item versions. All OSPRO-YF versions included at least 1 item representative of each psychological domain, regardless of the number of items.

Estimating Questionnaire Scores From Yellow Flag Assessment Tools

The OSPRO-YF items can be used to identify elevated vulnerability above the 75th percentile or decreased resilience below the 25th percentile, as well as to estimate the overall score of each of the original 11 psychological questionnaires. As a result, the OSPRO-YF is not scored like a conventional screening tool. Regression weights for assessment tool items listed in **APPENDICES B** and **C** can be used to construct weighted linear combinations of items to estimate 11 psychological questionnaire scores in categorical and continuous metrics. Scoring instructions and examples are listed in the footnotes for **APPENDICES B** and **C**.

Correlation of Yellow Flag Assessment Tool Scores With Psychological Questionnaires

Correlations between psychological questionnaires and OSPRO-YF total scores varied. Correlation coefficients ranged from 0.42 to 0.79 for the 17-item version, from 0.35 to 0.81 for the 10-item version, and 0.32 to 0.69 for the 7-item version. Measures for pain acceptance (r = −0.69 to −0.81) and pain catastrophizing (r = 0.69 to 0.73) had the highest correlation with OSPRO-YF total scores. Conversely, measures for anger (r = 0.32 to 0.42) and fear-avoidance beliefs associated with work (r = 0.48 to 0.53) had the lowest correlations.

Furthermore, correlations between the 17-item OSPRO-YF version and psychological questionnaires were similar for all anatomical regions. Compared to patients with spine or shoulder pain,

TABLE 3	**DESCRIPTIVE SUMMARY OF INDIVIDUAL PSYCHOLOGICAL QUESTIONNAIRE SCORES FOR THE OVERALL COHORT AND BY ANATOMICAL REGION**					
Variable	**Overall (n = 431)**	**Neck (n = 93)**	**Low Back (n = 119)**	**Shoulder (n = 108)**	**Knee (n = 111)**	***P* Value**
PHQ-9						.155
Mean ± SD	5.0 ± 5.5	5.6 ± 5.7	5.6 ± 6.2	4.6 ± 4.9	4.2 ± 5.2	
Median (range)	3 (0-27)	4 (0-27)	4 (0-27)	3 (0-18)	2 (0-24)	
STAI						.561
Mean ± SD	35.5 ± 10.9	36.3 ± 12.3	36.4 ± 11.4	35.1 ± 9.5	34.3 ± 10.5	
Median (range)	33 (20-75)	32 (20-75)	34 (20-73)	34 (21-56)	32 (20-71)	
STAXI						.663
Mean ± SD	15.3 ± 4.8	15.2 ± 5.1	15.4 ± 5.2	15.6 ± 4.7	15.0 ± 4.3	
Median (range)	14 (10-38)	14 (10-36)	14 (10-36)	15 (10-38)	14 (10-32)	
FABQ-PA						.331
Mean ± SD	13.9 ± 6.1	13.8 ± 6.0	13.2 ± 6.1	14.5 ± 6.4	14.1 ± 5.8	
Median (range)	14 (0-24)	13.5 (1-24)	13 (0-24)	16 (0-24)	15 (0-24)	
FABQ-W						.012*
Mean ± SD	11.0 ± 11.9	13.3 ± 12.2	11.5 ± 11.6	11.0 ± 11.9	8.6 ± 11.5	
Median (range)	7 (0-42)	10.5 (0-42)	8 (0-42)	6 (0-42)	2 (0-42)	
PCS						.104
Mean ± SD	13.0 ± 12.3	13.8 ± 12.7	14.8 ± 13.4	12.7 ± 11.6	10.9 ± 11.2	
Median (range)	9 (0-52)	10 (0-47)	11 (0-52)	10 (0-45)	6 (0-43)	
TSK-11						.578
Mean ± SD	22.2 ± 6.7	22.4 ± 7.5	22.9 ± 7.0	22.2 ± 6.5	21.2 ± 5.5	
Median (range)	22 (11-44)	21 (11-40)	22 (11-44)	22 (11-40)	21 (11-35)	
PASS-20						.027†
Mean ± SD	24.5 ± 20.2	28.3 ± 21.9	27.3 ± 21.6	21.4 ± 18.6	21.3 ± 17.9	
Median (range)	20 (0-89)	23.5 (0-81)	21 (0-89)	15 (0-89)	18 (0-87)	
PSEQ						.132
Mean ± SD	43.1 ± 14.3	42.1 ± 15.1	41.0 ± 14.8	43.7 ± 14.5	45.4 ± 12.7	
Median (range)	46 (0-60)	45 (0-60)	44 (4-60)	47 (7-60)	48 (7-60)	
SER						.967
Mean ± SD	104.0 ± 20.8	103.2 ± 22.2	103.8 ± 20.8	102.4 ± 22.5	106.3 ± 18.0	
Median (range)	113 (21-120)	113 (24-120)	113 (33-120)	112.5 (21-120)	113 (36-120)	
CPAQ						.141
Mean ± SD	73.3 ± 20.3	73.0 ± 21.9	70.3 ± 20.5	73.2 ± 21.3	77.0 ± 17.0	
Median (range)	74 (6-120)	71.5 (6-114)	71 (15-113)	74 (17-119)	76 (21-120)	

Abbreviations: CPAQ, Chronic Pain Acceptance Questionnaire; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire work subscale; PASS-20, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; SER, Self-Efficacy for Rehabilitation; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory; TSK-11, Tampa Scale of Kinesiophobia.
*Significant difference between mean for subjects with neck pain compared to subjects with knee pain.
†Significant difference between mean for subjects with neck and low back pain compared to subjects with knee and shoulder pain.

patients with knee pain demonstrated weaker correlations between total scores on the 7-item and 10-item versions and positive-coping questionnaires. However, despite some differences between anatomical regions, correlations between these versions and positive-coping constructs remained moderate (r = –0.42 to –0.53) for patients with knee pain.

	ACCURACY OF THE BEST PREDICTOR SETS FOR IDENTIFYING SCORES WITHIN THE SELECTED FULL QUESTIONNAIRE QUARTILE					
TABLE 4						
Domain/Dependent Variable	**Item 1**	**Item 2**	**Item 3**	**Accuracy**	**Sensitivity**	**Specificity**
Negative mood						
PHQ-9 ≥8	PHQ-9 Q1	PHQ-9 Q5	PHQ-9 Q7	93.8	94.1	93.7
STAI ≥43	STAI Q16A	PHQ-9 Q6	STAI Q17	91.2	90.5	91.4
STAXI ≥18	STAXI Q7	STAXI Q3	STAXI Q8	91.4	92.6	91.0
Fear avoidance						
FABQ-PA ≥18	FABQ Q4	FABQ Q2	FABQ Q3	93.7	94.0	93.6
FABQ-W ≥20	FABQ Q10	FABQ Q9	...	91.4	95.4	90.1
PCS ≥21	PCS Q11	PCS Q3	...	93.2	92.0	93.7
TSK-11 ≥26	TSK-11 Q8	TSK-11 Q10	PCS Q9	89.7	92.6	88.6
PASS-20 ≥36	PASS-20 Q10	PASS-20 Q18	PASS-20 Q11	91.9	94.4	91.0
Positive affect/coping						
PSEQ ≤33	PSEQ Q9	...	...	90.4	90.9	90.3
SER ≤97	SER Q2	SER Q9	...	94.6	95.3	94.4
CPAQ ≤60	CPAQ Q14A	CPAQ Q9	CPAQ Q3	90.9	92.7	90.3

Abbreviations: CPAQ, Chronic Pain Acceptance Questionnaire; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire work subscale; PASS-20, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; SER, Self-Efficacy for Rehabilitation; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory; TSK-11, Tampa Scale of Kinesiophobia.

Concurrent Validity

Results of the hierarchical regression analyses are listed in **TABLE 6**. Both weighted and unweighted OSPRO-YF scores were correlated with pain and function measures across anatomical regions, and the strengths of these correlations were not significantly different based on scoring method. Therefore, we used unweighted scoring for all validity analyses reported in this paper. All versions of the tool explained significant additional variance in pain (range, 19.3%-25.2%) after accounting for demographics, historical variables, and anatomical region of pain. Results were similar for disability measures, where the OSPRO-YF scores explained significant additional variance (range, 25.8%-36.7%). For pain and disability, OSPRO-YF versions with a greater number of items consistently explained greater variance than versions with fewer items. For all analyses, interactions were not significant, indicating

similar concurrent validity across anatomical regions.

DISCUSSION

THIS STUDY DESCRIBES THE DEVELOPment of a concise assessment tool that allows for accurate estimate of individual questionnaire scores for depressive symptoms, anxiety, anger, fear-avoidance beliefs, kinesiophobia, catastrophizing, self-efficacy, and pain acceptance. It is designed for use by those with an interest in estimating multiple individual psychological questionnaire scores without burdening the patient by completing each full instrument. An important strength of the OSPRO-YF is that it includes assessment of positive affect and coping constructs, which are not considered in existing multidimensional tools. Our analysis is consistent with contemporary approaches to reducing existing validated questionnaires to develop more manageable clini-

cal assessment options while maintaining acceptable accuracy for assessing underlying psychological constructs.[33,39] The assessment tool was associated with pain and joint-specific disability measures in multivariate analyses that controlled for demographics, historical variables, and anatomical region of pain, suggesting good concurrent validity. Similar concurrent validity and strength of associations with individual psychological questionnaire scores across anatomical regions suggest that this tool, especially the 17-item version, is appropriate for use in patients with knee, shoulder, neck, and low back pain.

Existing multidimensional tools, such as the STarT Back Screening Tool and Örebro Musculoskeletal Pain Screening Questionnaire, were developed to identify patients at increased risk for poor disability outcomes or accumulated sick leave, respectively, based on multiple physical and psychological prognostic factors.[17,27] These tools are useful for identifying patients who may require early, targeted secondary treatment pathways,[18,19] but they are limited in their capacity to dictate which specific psychological factors should be addressed. The OSPRO-YF complements existing risk-stratification approaches by providing a viable option for assessing more psychological factors. This level of assessment may help to better direct psychologically informed treatment and/or monitor treatment responses for patients determined to be at risk for poor outcomes by the STarT Back Screening Tool or Örebro Musculoskeletal Pain Screening Questionnaire.[17,27]

Another important strength of this tool is that it is ideally suited for integration with electronic medical records to provide decision support in clinical practice. Leveraging electronic medical records as a method for improving efficiency and quality through decision support is a growing trend in health care,[59] and computer-assisted scoring is consistent with precedents set by other commonly used questionnaires, such as the Medical Outcomes Study 36-Item Short-Form Health Survey. It provides for accurate, valid, and reliable estimates of full questionnaire scores, as

TABLE 5	SPEARMAN CORRELATION COEFFICIENTS BETWEEN THE ORIGINAL TOTAL SCORE (BASED ON WHOLE INSTRUMENT) AND THE REDUCED ITEM SET TOTAL SCORE, GROUPED BY DOMAIN										

	Reduced Item Set Total Score										
Original Total Score	**PHQ-9**	**STAI**	**STAXI**	**FABQ-PA**	**FABQ-W**	**PCS**	**TSK-11**	**PASS-20**	**PSEQ**	**SER**	**CPAQ**
PHQ-9	0.882	0.641	0.336								
STAI	0.640	0.843	0.403								
STAXI	0.334	0.394	0.852								
FABQ-PA				0.966	0.195	0.246	0.346	0.313			
FABQ-W				0.189	0.942	0.337	0.418	0.358			
PCS				0.275	0.346	0.904	0.760	0.715			
TSK-11				0.458	0.353	0.522	0.791	0.605			
PASS-20				0.328	0.369	0.682	0.710	0.927			
PSEQ									0.867	0.639	0.695
SER									0.544	0.900	0.566
CPAQ									0.685	0.569	0.885

Abbreviations: CPAQ, Chronic Pain Acceptance Questionnaire; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire work subscale; PASS-20, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; SER, Self-Efficacy for Rehabilitation; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory; TSK-11, Tampa Scale of Kinesiophobia.

well as categorical estimates for scores above the 75th quartile for negative mood and fear-avoidance questionnaires, or below the 25th percentile for positive affect/coping questionnaires. For those without electronic medical records capabilities, assessment tool equations can be easily incorporated into computerized scoring interfaces and spreadsheets. Limitations associated with the computer requirement are largely outweighed by improved depth and concision of the new assessment tool compared to current screening methods necessary to provide the same information. An alternative method of scoring is to evaluate items associated with each construct more informally to assess likelihood of psychological distress, as individual items included in the assessment tool were highly correlated with overall scores on the parent questionnaire.

When interpreting this study, there are several limitations to consider. First, we recruited a convenience sample and did not track the total number of patients screened. Therefore, we cannot report on the number of subjects approached for this

study, the number that were ineligible, or the number that were eligible but did not consent to participation. This raises concerns about generalizability of the sample when compared to a cohort assembled by consecutive sampling, particularly as it relates to the exclusion criterion for psychiatric history. Our eligibility criteria for study inclusion were intentionally broad and, as a result, there is a reasonable chance that this sample was representative of the general outpatient population. However, the sampling limitation should be appropriately considered when interpreting the study results. Second, we only included patients seeking physical therapy with neck, shoulder, low back, or knee pain in the development cohort. Future studies are necessary to determine if this tool is appropriate for yellow flag assessment in different musculoskeletal pain populations (eg, pelvic pain or widespread chronic pain). Third, we accomplished item reduction through an iterative process; however, we acknowledge that there are other analytical methods available to generate and administer concise assess-

ment tools, such as Rasch analysis, factor analysis, and computer adaptive testing. We decided on the current approach given that a goal of this study was to provide an assessment tool that was widely available and applicable to those without computer adaptive testing capabilities. Therefore, the initial psychometric analyses focused on the methods described in this paper.

A final limitation is the use of quartile cutoff scores for individual questionnaires to operationally define the presence of elevated vulnerability or reduced resilience. Although sensitive to sample distribution and characteristics, this approach was necessary, as no universally accepted cutoffs were available in our patient population for most of the measures we used. Moreover, using a standard cutoff mitigated differences across anatomical regions. The quartile cutoff scores used in this analysis were neither consistently greater nor less than those already reported in the literature. This variation is likely due to a wide range of patient populations (nonclinical[1] versus clinical[9,25,62] and primary care[9,25] versus chronic pain man-

		Pain Intensity						Disability					
		17 Items		**10 Items**		**7 Items**		**17 Items**		**10 Items**		**7 Items**	
Step	Measure	B	R^2	B	R^2	B	R^2	B	R^2	B	R^2	B	R^2
1	Intercept	1.51*	0.06*	1.76[†]	0.06*	1.82[†]	0.06*	−2.02[†]	0.11[†]	−1.79[†]	0.11[†]	−1.64[†]	0.11[†]
	Age	0.02[†]		0.02*		0.02*		0.01[†]		0.01[†]		0.01[†]	
	Sex[‡]												
	Female	0.65*		0.62*		0.65*		0.31[†]		0.29[†]		0.31[†]	
	Pain duration, wk	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
	Work-related pain[‡]												
	Yes	−0.39		−0.43		−0.46		−0.13		−0.16		−0.17	
	Surgery for pain[‡]												
	Yes	−0.49*		−0.50*		−0.53*		0.33[†]		0.33[†]		0.32[†]	
2	Anatomical region[‡]		0.08		0.08		0.08		0.11		0.11		0.11
	Neck	−0.78		−0.59		−0.53		−0.18		−0.14		−0.18	
	Shoulder	−0.16		0.11		0.08		0.13		0.17		0.10	
	Knee	−0.60		−0.43		−0.18		−0.08		0.10		0.11	
3	Assessment tool score	0.06[†]	0.25[†]	0.11[†]	0.24[†]	0.16[†]	0.24[†]	0.04[†]	0.47[†]	0.07[†]	0.44[†]	0.10[†]	0.51[†]
4	Assessment tool score-by-region interaction[‡]		0.26		0.25		0.25		0.48		0.45		0.52
	Neck	0.02		0.03		0.04		0.01		0.01		0.02	
	Shoulder	0.01		−0.01		−0.01		<−0.01		−0.01		<−0.01	
	Knee	<0.01		−0.01		−0.04		0.01		<0.01		<−0.01	

*P<.05.
[†]P<.001.
[‡]Reference groups: male sex, no work-related pain, no surgery for pain, low back anatomical region, and assessment tool-by-low back interaction.

agement[55,62]) as well as methodologies (distribution based[2,55] versus derived from reference standards[15,25]) that have been used to develop existing cutoff values. For questionnaires with a reference-standard approach that have been used in clinical samples (eg, PHQ-9[25] and FABQ-W[15]), we found similar cutoff thresholds. However, we acknowledge that our approach was distribution based, and there may be limitations in applying these quartile cutoffs to other settings. One way to mitigate this concern is to estimate total questionnaire scores, and this scoring information has been provided for those who prefer a continuous metric.

This study reports on the development and use of the OSPRO-YF for assessing a range of psychological factors that will

support decision making in clinical practice. Future OPT-IN studies will assess the predictive capabilities of this tool for poor clinical outcomes and excessive health care utilization due to pain-associated psychological distress in addition to evaluating its capabilities for treatment-monitoring purposes. The ongoing OSPRO validation phase will include longitudinal data collection and national partners. This phase involves recruitment of a separate cohort and follow-up to determine pain, function, quality of life, and health care utilization outcomes. The 17-item yellow flag assessment tool will be included as a predictor of these outcomes, alone and in combination with the recently reported review-of-systems tool.[14] This phase will also examine key psychometric properties

of the tool, such as reliability, respondent burden, and comparisons to established screening tools. In addition, supplementary analyses will be completed to determine if modifications are necessary to enhance the generalizability of the yellow flag tool or to improve its performance across different anatomical regions.

CONCLUSION

THIS STUDY PROVIDES PROOF OF PRINciple that the OSPRO-YF allows for concise multidimensional yellow flag assessment in physical therapy settings. Specifically, the OSPRO-YF accurately estimates selected quartile thresholds and full-length questionnaire scores from negative coping, negative mood, and positive

affect/coping domains. Further study is warranted to determine how this tool can be used for predicting outcomes and/or for treatment monitoring of patients identified as high risk for poor outcomes. ◉

■ KEY POINTS

FINDINGS: A 136-item bank was used to develop the OSPRO-YF, which is a concise, multidimensional 17-item yellow flag assessment tool capable of estimating 11 total questionnaire scores indicating elevated vulnerability and decreased resilience. The OSPRO-YF demonstrated high accuracy (85%) and good concurrent validity across the anatomical regions included in this study.

IMPLICATIONS: Comprehensive yellow flag assessment in physical therapy can be accomplished with a high degree of accuracy for predicting individual questionnaire scores.

CAUTION: The current study did not determine which items are most important for predicting clinical outcomes and health care utilization. Future studies are necessary to provide important direction for use in clinical practice.

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APPENDIX A

OSPRO-YF ASSESSMENT TOOL

Negative Mood Domain

Over the last 2 weeks, how often have you been bothered by any of the following problems?

	Not at All	Several Days	More Than Half the Days	Nearly Every Day
1. Poor appetite or overeating*†	0	1	2	3

Read each statement and circle the appropriate number to the right of the statement to indicate how you generally feel.

	Almost Never	Sometimes	Often	Almost Always
2. I am content	1	2	3	4
3. Some unimportant thoughts run through my mind and bother me*	1	2	3	4
4. I am a hotheaded person*†	1	2	3	4
5. When I get mad, I say nasty things	1	2	3	4
6. It makes me furious when I am criticized in front of others	1	2	3	4

Fear-Avoidance Domain

Circle the number next to each question that best corresponds to how you feel.

	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
7. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body*†	1	2	3	4

Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

	Not at All	To a Slight Degree	To a Moderate Degree	To a Great Degree	All the Time
8. I can't seem to keep it out of my mind*†	0	1	2	3	4

Circle the number from 0 to 6 to indicate how much physical activities affect your current pain.

	Completely Disagree					Completely Agree
9. Physical activity might harm my painful body region	0	1	2	3	4	5	6
10. I cannot do physical activities which (might) make my pain worse*†	0	1	2	3	4	5	6
11. My work is too heavy for me*†	0	1	2	3	4	5	6

APPENDIX A

Use the rating scale below to indicate how often you engage in each of the following thoughts or activities.

	Never						Always
12. During painful episodes it is difficult for me to think of anything besides the pain	0	1	2	3	4	5	6

Positive Affect/Coping Domain
Please rate how confident you are that you can do the following things at present, despite the pain.

	Not at All Confident						Completely Confident
13. I can live a normal lifestyle, despite the pain	0	1	2	3	4	5	6

Please rate the truth of each statement as it applies to you.

	Never True						Always True
14. It's OK to experience pain*	0	1	2	3	4	5	6
15. I lead a full life even though I have chronic pain*	0	1	2	3	4	5	6
16. Before I can make any serious plans, I have to get some control over my pain	0	1	2	3	4	5	6

Please rate your degree of certainty in performing various tasks during rehabilitation based on the following statements.

	I Cannot Do It										Certain I Can Do It
17. My therapy no matter how I feel emotionally*†	0	1	2	3	4	5	6	7	8	9	10

Abbreviation: OSPRO-YF, Optimal Screening for Prediction of Referral and Outcome cohort yellow flag assessment tool.
*Items included in the 10-item version.
†Items included in the 7-item version.

APPENDIX B

TABLE

Assessment Tool Item Regression Coefficient Weights Used to Construct Equations for the Identification of Yellow Flags*

Psychological Variables/Items Selected	Coefficient of Weighting From Logistic Regression for Screening Tool Items																	Cutoff Value	Accuracy, %
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
PHQ-9																			
17	1.870	0.483	0.396	0.342	-0.155	0.402	0.036	0.094	0.059	0.077	0.008	0.265	-0.327	0.299	-0.026	0.071	-0.289	3.087	85.9
10	1.937	...	0.445	0.322	...	...	0.138	0.262	...	0.139	0.054	...	...	0.194	-0.167	...	-0.310	1.231	87.6
7	1.921	...	...	0.349	...	...	0.121	0.273	...	0.131	0.053	...	...	...	...	...	-0.297	0.528	86.1
STAI																			
17	0.487	2.145	1.945	0.636	-0.230	0.332	0.172	0.562	-0.075	0.080	-0.066	0.003	0.041	0.232	-0.144	-0.113	-0.238	9.149	85.4
10	0.849	...	1.414	0.476	...	...	0.201	0.474	...	-0.006	-0.048	...	...	0.123	-0.166	...	-0.231	2.517	81.0
7	0.835	...	...	0.507	...	...	0.140	0.519	...	-0.015	-0.020	...	...	...	...	...	-0.196	0.112	75.8
STAXI																			
17	0.209	0.045	0.330	3.678	1.613	2.002	-0.021	-0.292	-0.188	0.045	0.106	0.190	-0.185	-0.091	0.037	-0.042	0.324	14.544	91.3
10	0.352	...	0.497	2.600	...	...	0.003	0.166	...	0.071	0.018	...	...	-0.136	-0.004	...	0.087	5.215	85.5
7	0.398	...	...	2.652	...	...	0.025	0.282	...	0.067	0.025	...	...	...	...	...	0.061	5.477	84.1
FABQ-PA																			
17	0.170	-0.277	-0.219	-0.116	0.041	0.113	0.137	-0.374	1.906	1.500	0.017	0.531	-0.081	0.021	-0.032	-0.067	0.106	14.163	90.5
10	-0.179	...	-0.160	0.179	...	...	0.167	0.122	...	1.102	0.039	...	...	0.049	-0.173	...	0.105	5.113	83.0
7	-0.164	...	...	0.181	...	...	0.184	0.141	...	1.098	0.032	...	...	...	...	...	0.066	5.316	81.3
FABQ-W																			
17	-0.242	-0.318	0.127	-0.001	0.724	-0.306	0.326	0.315	0.196	0.096	1.164	0.007	-0.208	0.267	-0.104	0.005	-0.056	3.236	90.5
10	-0.293	...	0.143	0.206	...	...	0.319	0.352	...	0.178	1.093	...	...	0.256	-0.214	...	-0.073	3.016	88.8
7	-0.213	...	...	0.232	...	...	0.297	0.311	...	0.159	1.073	...	...	...	...	...	-0.077	2.708	87.6
PCS																			
17	0.400	-0.475	0.170	-0.107	0.947	-0.218	0.848	1.984	0.172	0.069	0.095	0.167	0.087	0.092	0.021	-0.338	-0.256	4.326	87.0
10	0.372	...	0.223	0.307	...	...	0.758	1.865	...	0.106	0.056	...	...	-0.013	0.033	...	-0.233	3.968	86.8
7	0.389	...	...	0.319	...	...	0.750	1.875	...	0.102	0.049	...	...	...	...	...	-0.226	3.272	87.4
TSK-11																			
17	-0.087	-0.159	0.107	0.311	-0.055	-0.299	1.761	0.495	0.373	0.113	0.036	0.410	-0.249	0.087	0.100	-0.209	-0.130	4.534	88.5
10	-0.066	...	-0.011	0.269	...	...	1.701	0.721	...	0.282	0.116	...	...	-0.004	-0.090	...	-0.116	3.870	87.1
7	-0.044	...	...	0.259	...	...	1.707	0.751	...	0.286	0.119	...	...	...	...	...	-0.143	4.378	82.3

Table continues on page 343.

TABLE

ASSESSMENT TOOL ITEM REGRESSION COEFFICIENT WEIGHTS USED TO CONSTRUCT EQUATIONS FOR THE IDENTIFICATION OF YELLOW FLAGS* (CONTINUED)

Psychological Variables/ Items Selected	Coefficient of Weighting From Logistic Regression for Screening Tool Items																	Cutoff Value	Accuracy, %
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
PASS-20																			
17	-0.061	-0.349	0.604	0.297	-0.205	0.226	0.917	0.604	-0.142	-0.032	-0.012	1.167	-0.072	-0.182	0.018	-0.328	-0.152	3.083	91.6
10	0.039	…	0.251	0.233	…	…	0.911	0.962	…	0.020	0.077	…	…	-0.348	-0.032	…	-0.098	2.063	82.5
7	0.081	…	…	0.224	…	…	0.898	1.088	…	0.038	0.072	…	…	…	…	…	-0.176	2.662	84.1
PSEQ																			
17	-0.094	0.422	0.285	0.031	0.239	0.060	0.348	-0.314	-0.006	0.034	0.037	0.374	-1.273	-0.172	-0.259	-0.111	-0.242	-5.269	86.4
10	0.158	…	0.086	0.075	…	…	0.394	0.137	…	0.164	0.100	…	…	-0.341	-0.601	…	-0.260	-3.889	84.5
7	0.254	…	…	0.056	…	…	0.437	0.373	…	0.176	0.146	…	…	…	…	…	-0.391	-1.359	80.6
SER																			
17	0.091	0.419	0.137	0.551	-0.577	0.002	-0.169	0.043	-0.127	0.199	0.080	-0.128	-0.385	-0.140	-0.368	-0.020	-1.254	-13.185	85.9
10	0.242	…	0.000	0.260	…	…	-0.071	0.040	…	0.174	0.063	…	…	-0.153	-0.528	…	-1.237	-12.413	90.4
7	0.326	…	…	0.234	…	…	0.039	0.206	…	0.188	0.140	…	…	…	…	…	-1.256	-9.380	87.4
CPAQ																			
17	-0.036	-0.209	0.079	0.403	0.011	-0.040	0.234	0.169	0.144	0.208	-0.009	0.151	-0.430	-0.581	-0.914	-1.121	-0.113	-8.699	86.4
10	-0.039	…	0.060	0.158	…	…	0.364	0.330	…	0.300	0.115	…	…	-0.541	-0.776	…	-0.116	-3.390	83.5
7	0.123	…	…	0.130	…	…	0.406	0.526	…	0.249	0.152	…	…	…	…	…	-0.311	-0.271	75.3

Abbreviations: CPAQ, Chronic Pain Acceptance Questionnaire; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire work subscale; PASS-20, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; SER, Self-Efficacy for Rehabilitation; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory; TSK-11, Tampa Scale of Kinesiophobia.

Instructions for constructing and interpreting equations: item responses are multiplied by their associated regression weight depending on the assessment tool version used. Responses to questions 2 and 16 are reverse scored before being multiplied by their regression weight. To reverse score question 2, subtract the item response from 6. To reverse score question 16, subtract the item response from 5. To determine the presence of a yellow flag for depression, the equation would be calculated as follows (item responses in parentheses are artificially generated): 1.921(2) + 0.349(3) + 0.121(3) + 0.273(4) + 0.131(4) + 0.053(4) − 0.297(3) = 6.189. Because the equation total is greater than the cutoff value, this result would signify a yellow flag for depression. The accuracy of this equation for identifying a yellow flag for depression is 86.1%.

APPENDIX C

TABLE — Assessment Tool Item Regression Weights Used to Construct Equations for the Estimation of Original Psychological Questionnaire Total Score*

Psychological Variables/ Items Selected	Intercept	Coefficient of Weighting From Linear Regression for Screening Tool Items																	RMSE
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
PHQ-9																			
17	2.535	3.371	0.680	0.825	0.178	-0.193	0.439	0.235	0.184	-0.143	0.139	0.160	0.248	-0.223	0.248	-0.158	-0.008	-0.360	2.987
10	3.698	3.670	...	0.927	0.234	...	...	0.349	0.418	...	0.131	0.198	...	...	0.163	-0.290	...	-0.411	3.094
7	4.324	3.864	...	...	0.403	...	...	0.357	0.565	...	0.141	0.227	...	...	...	...	...	-0.445	3.215
STAI																			
17	18.083	1.271	5.782	4.338	0.620	0.363	0.613	-0.123	0.718	-0.174	0.184	0.309	0.307	0.039	0.149	-0.393	-0.056	-0.459	5.247
10	30.568	3.235	...	5.319	1.355	...	...	0.289	1.309	...	0.069	0.372	...	...	0.078	-0.782	...	-0.791	7.016
7	34.984	4.193	...	...	2.315	...	...	0.294	2.232	...	0.128	0.446	...	...	...	...	...	-0.980	8.263
STAXI																			
17	2.447	0.097	0.131	0.440	3.464	1.889	2.152	0.091	-0.030	0.030	0.009	-0.039	0.044	-0.010	0.021	-0.071	-0.031	0.073	1.927
10	6.775	0.503	...	1.109	4.793	...	...	0.214	0.349	...	0.061	-0.136	...	...	0.044	-0.126	...	-0.047	3.021
7	7.892	0.693	...	...	4.992	...	...	0.205	0.519	...	0.068	-0.125	...	...	...	...	...	-0.070	3.149
FABQ-PA																			
17	2.351	0.152	0.047	-0.022	-0.212	-0.140	0.112	0.049	-0.063	1.826	1.534	-0.011	0.117	-0.143	0.081	0.144	0.026	0.055	1.974
10	6.070	0.138	...	-0.031	-0.140	...	...	0.331	0.142	...	2.214	0.105	...	...	0.186	-0.076	...	0.042	3.663
7	6.269	0.142	...	...	-0.145	...	...	0.316	0.082	...	2.207	0.103	...	...	...	...	...	0.066	3.676
FABQ-W																			
17	1.652	-0.859	-0.102	0.215	-1.197	1.656	-0.037	0.809	1.194	0.633	-0.104	4.645	-0.054	-0.575	0.375	-0.112	0.146	0.000	6.126
10	3.880	-0.715	...	0.396	-0.437	...	...	0.900	1.417	...	0.151	4.637	...	...	0.378	-0.406	...	-0.114	6.350
7	4.049	-0.585	...	...	-0.361	...	...	0.896	1.428	...	0.157	4.656	...	...	...	...	...	-0.130	6.405
PCS																			
17	5.462	0.929	0.003	0.975	0.331	0.381	-0.147	1.833	5.929	0.125	-0.030	0.127	0.966	0.036	-0.373	-0.108	-0.262	-0.487	5.287
10	6.506	1.012	...	0.972	0.527	...	...	2.045	6.522	...	0.083	0.222	...	...	-0.532	-0.174	...	-0.540	5.434
7	5.764	1.211	...	...	0.678	...	...	2.123	6.947	...	0.129	0.259	...	...	...	...	...	-0.703	5.585
TSK-11																			
17	14.146	0.000	-0.180	0.184	-0.216	0.059	0.368	3.510	0.636	0.503	0.387	0.330	0.392	-0.066	-0.095	-0.096	-0.039	-0.239	3.730
10	15.511	0.003	...	0.202	-0.072	...	...	3.667	0.927	...	0.609	0.381	...	...	-0.123	-0.177	...	-0.255	3.879
7	14.857	0.080	...	...	-0.033	...	...	3.710	1.062	...	0.630	0.402	...	...	...	...	...	-0.329	3.902

APPENDIX C

TABLE

Assessment Tool Item Regression Weights Used to Construct Equations for the Estimation of Original Psychological Questionnaire Total Score* (continued)

Psychological Variables/ Items Selected	Intercept	Coefficient of Weighting From Linear Regression for Screening Tool Items																	RMSE
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
PASS-20																			
17	9.815	0.215	-0.159	1.905	0.932	0.184	0.452	3.703	2.992	-0.099	0.457	0.479	6.423	0.244	-0.455	-0.116	-0.969	-0.840	9.501
10	15.781	0.654	…	1.710	1.521	…	…	4.995	6.608	…	0.815	1.012	…	…	-1.478	-0.346	…	-1.045	12.307
7	12.920	1.057	…	…	1.840	…	…	5.238	7.580	…	0.940	1.114	…	…	…	…	…	-1.482	12.683
PSEQ																			
17	12.900	0.158	-0.772	0.551	0.113	-1.112	0.453	-0.402	-0.007	0.295	-0.448	-0.310	-0.832	4.804	0.177	0.892	0.425	0.864	5.979
10	19.030	-1.082	…	0.915	-0.157	…	…	-1.067	-1.622	…	-1.021	-0.627	…	…	1.050	3.065	…	1.456	8.622
7	33.149	-1.720	…	…	-0.052	…	…	-1.735	-2.900	…	-1.317	-0.939	…	…	…	…	…	2.478	10.127
SER																			
17	36.132	-0.439	-1.172	0.287	-1.431	0.344	0.005	-1.149	-0.643	0.403	-0.899	-0.063	0.321	1.587	0.709	1.135	-0.051	6.795	10.557
10	37.695	-1.047	…	0.351	-1.241	…	…	-1.258	-0.816	…	-0.920	-0.116	…	…	0.915	1.839	…	6.979	10.809
7	46.666	-1.472	…	…	-1.215	…	…	-1.698	-1.732	…	-1.116	-0.318	…	…	…	…	…	7.659	11.355
CPAQ																			
17	32.870	-0.567	0.351	-0.905	-0.715	-0.258	1.432	-0.890	-1.133	0.020	-0.702	0.140	-1.350	1.212	2.074	3.279	3.720	0.712	7.856
10	46.223	-1.050	…	-0.639	-0.382	…	…	-1.575	-2.709	…	-1.485	-0.474	…	…	2.966	4.266	…	1.092	10.473
7	67.399	-2.292	…	…	-0.586	…	…	-2.692	-5.392	…	-1.997	-0.983	…	…	…	…	…	2.869	13.922

Abbreviations: CPAQ, Chronic Pain Acceptance Questionnaire; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FABQ-W, Fear-Avoidance Beliefs Questionnaire work subscale; PASS-20, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; PHQ-9, Patient Health Questionnaire-9; PSEQ, Pain Self-Efficacy Questionnaire; RMSE, regression mean square error; SER, Self-Efficacy for Rehabilitation; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory; TSK-11, Tampa Scale of Kinesiophobia.

*Instructions for constructing and interpreting equations: item responses are multiplied by their associated regression weight depending on the assessment tool version used. Responses to questions 2 and 16 are reverse scored before being multiplied by their regression weight. To reverse score question 2, subtract the item response from 5. To reverse score question 16, subtract the item response from 6. Scoring example: if the 7-item assessment tool version is used to estimate the total PHQ-9 score, the equation would be calculated as follows (item responses in parentheses are artificially generated): $4.324 + 3.864(2) + 0.403(3) + 0.357(3) + 0.565(4) + 0.141(4) + 0.227(4) − 0.445(3) = 16.729$.

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