Original Research

The Functional Arm Scale for Throwers (FAST)—Part I

The Design and Development of an Upper Extremity Region-Specific and Population-Specific Patient-Reported Outcome Scale for Throwing Athletes

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Background: Upper extremity (UE) region-specific, patient-reported outcome (PRO) scales assess injuries to the UE but do not account for the demands of overhead throwing athletes or measure patient-oriented domains of health-related quality of life (HRQOL).

Purpose: To develop the Functional Arm Scale for Throwers (FAST), a UE region-specific and population-specific PRO scale that assesses multiple domains of disablement in throwing athletes with UE injuries. In stage I, a beta version of the scale was developed for subsequent factor identification, final item reduction, and construct validity analysis during stage II.

Study Design: Descriptive laboratory study.

Methods: Three-stage scale development was utilized: Stage I (item generation and initial item reduction) and stage II (factor analysis, final item reduction, and construct validity) are reported herein, and stage III (establishment of measurement properties [reliability and validity]) will be reported in a companion paper. In stage I, a beta version was developed, incorporating National Center for Medical Rehabilitation Research disablement domains and ensuring a blend of sport-related and non–sport-related items. An expert panel and focus group assessed importance and interpretability of each item. During stage II, the FAST was reduced, preserving variance characteristics and factor structure of the beta version and construct validity of the final FAST scale.

Results: During stage I, a 54-item beta version and a separate 9-item pitcher module were developed. During stage II, a 22-item FAST and 9-item pitcher module were finalized. The factor solution for FAST scale items included pain ($n = 6$), throwing ($n = 10$), activities of daily living ($n = 5$), psychological impact ($n = 4$), and advancement ($n = 3$). The 6-item pain subscale crossed factors. The remaining subscales and pitcher module are distinctive, correlated, and internally consistent and may be interpreted individually or combined.

Conclusion: This article describes the development of the FAST, which assesses clinical outcomes and HRQOL of throwing athletes after UE injury. The FAST encompasses multiple domains of disability and demonstrates excellent construct validity.

Clinical Relevance: The FAST provides a single UE region-specific and population-specific PRO scale for high-demand throwers to facilitate measurement of impact of UE injuries on HRQOL and clinical outcomes while quantifying recovery for comparative effectiveness studies.

Keywords: outcomes; disablement; impairment; disability; function; pain; societal limitation

The throwing motion, particularly in baseball and softball pitchers, places stress through the shoulder and elbow.[3,21,30,31] Repetitive throwing may lead to chronic overuse injuries at the shoulder and elbow, such as atraumatic instability, impingement, rotator cuff and labral tears, biceps lesions, ulnar neuropathy, and ulnar collateral ligament tears.[9,10,12,30,31,60,62] Studies demonstrate that a high percentage of upper extremity (UE) injuries in baseball and softball result from throwing, and many are associated with pitching.[11,17,39,40,43] UE injuries account for

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36.3% of all game and practice injuries in collegiate softball, and 18.2% of these result in 10 or more days of activity time loss.[39] In Major League Baseball, UE injuries account for 55.9% of all injuries, and 48.4% are attributed to throwing.[11] Because throwing is such a significant functional activity of baseball and softball, injuries to the throwing arm represent a large proportion of injuries at all levels of participation and may result in significant disability, both sport-related and non–sport-related.

Patient-reported outcome (PRO) scales enable the assessment of health-related quality of life (HRQOL).[58] HRQOL "refers to the physical, psychological, and social domains of health, seen as distinct areas that are influenced by a person's experiences, beliefs, expectations, and perceptions."[56] Disablement models provide a framework for assessing HRQOL through operational reduction of this comprehensive concept into separate and measurable domains.[49,50] The National Center for Medical Rehabilitation Research (NCMRR) disablement model includes 5 domains: pathophysiology, impairment, functional limitation, disability, and societal limitations.[15,49] Clinician assessment of injuries to the throwing arm and rehabilitative outcomes are based on clinical measurements of impairment (eg, pain, range of motion, strength) and functional limitations (eg, ability to throw, throwing distance, throwing velocity).[47,48] Measurement of HRQOL, through the use of PRO scales, is needed specifically for throwing athletes to capture aspects of sport and daily life that are meaningful to this unique population.

Currently, there are numerous region-specific PRO scales available to assess a wide spectrum of UE injuries in multiple populations.[26,46] UE PROs have been developed to evaluate disorders of the entire arm, shoulder, elbow, and wrist and hand,[5-8,13,22,27,35,38,42] and these scales are more sensitive in detecting changes in health status related to an arm injury than general health scales.[41,53] Region-specific scales that assess the entire arm are as sensitive in detecting changes from injury and treatment as more joint-specific scales, such as those targeting the shoulder or elbow.[5] Typically, region-specific UE scales emphasize the domains of impairment (eg, pain, strength, motion) and function (eg, lifting an object, reaching overhead)[4,8,41] when considering the disablement model. Disability and societal limitations are often assessed using generic or general health scales,[58] such as the Medical Outcomes Study Short Form–36 (SF-36),[6,52] hence requiring the use of more than 1 instrument.

Although there are many UE PRO scales, most were not developed with high-functioning athletes, such as high-demand throwing athletes, in mind. Thus, they may inadequately assess the full health-related impact of UE injuries on these athletes.[16] For example, pitchers with ulnar collateral ligament tears are often pain-free and are able to complete high-demand activities of daily living (ADLs) and even submaximal throwing, but they experience significant symptoms and functional limitations with full-effort throwing. Subsequently, these athletes may experience significant disability, which is difficult to detect using general and region-specific scales. A scale specific to throwing and sports participation may be more sensitive for detecting meaningful changes in the HRQOL of throwers. The Kerlan-Jobe Orthopaedic Clinic (KJOC) Overhead Athlete Shoulder and Elbow scale is a region-specific and population-specific PRO scale designed for overhead athletes, such as throwers.[1,18,34] However, the focus of the KJOC on functional status represents only 1 disablement domain of health, limiting its ability to assess one's status in other important domains of health, including emotional and social factors. Development of a UE region-specific PRO scale for throwers that assesses HRQOL by measuring multiple disablement domains may be useful in directing treatment and evaluating the effectiveness of interventions in this population.

The broad, long-term objective of developing the Functional Arm Scale for Throwers (FAST) was to create a UE region-specific and population-specific PRO scale based on a whole-person health care disablement model to measure HRQOL in high-demand baseball and softball players with injuries to their throwing arm. In this 2-part series, we describe the 3-stage process used to develop the FAST and establish its measurement properties. In this article, we describe stages I and II of the scale development process. Stage I included generating items for a beta version of the FAST with broad disablement domains and sport-related and non–sport-related items. Stage II identified dimensions measured by the scale, reduced the number of items, and analyzed the reduced scale's construct validity. Stage III, reported in our companion paper, established the reliability and validity of the FAST.

METHODS

Scale Design and Development

Development of the FAST, a UE region-specific and population-specific PRO scale, was divided into 3 stages (Figure 1): stage I, item generation and initial item reduction; stage II, factor analysis, final item reduction, and construct validity; and stage III, establishment of scale measurement properties (reliability and validity).[23,27,53] This article reports on stages I and II. Stage I consisted of 3 phases: phase I, item generation and classification consensus; phase II, expert panel: item importance and initial item reduction; and phase III, focus group: interpretability. Stage II consisted of 2 phases: phase I, factor analysis and final item reduction and phase II, construct validity. Stage III is addressed in our companion paper.[28]

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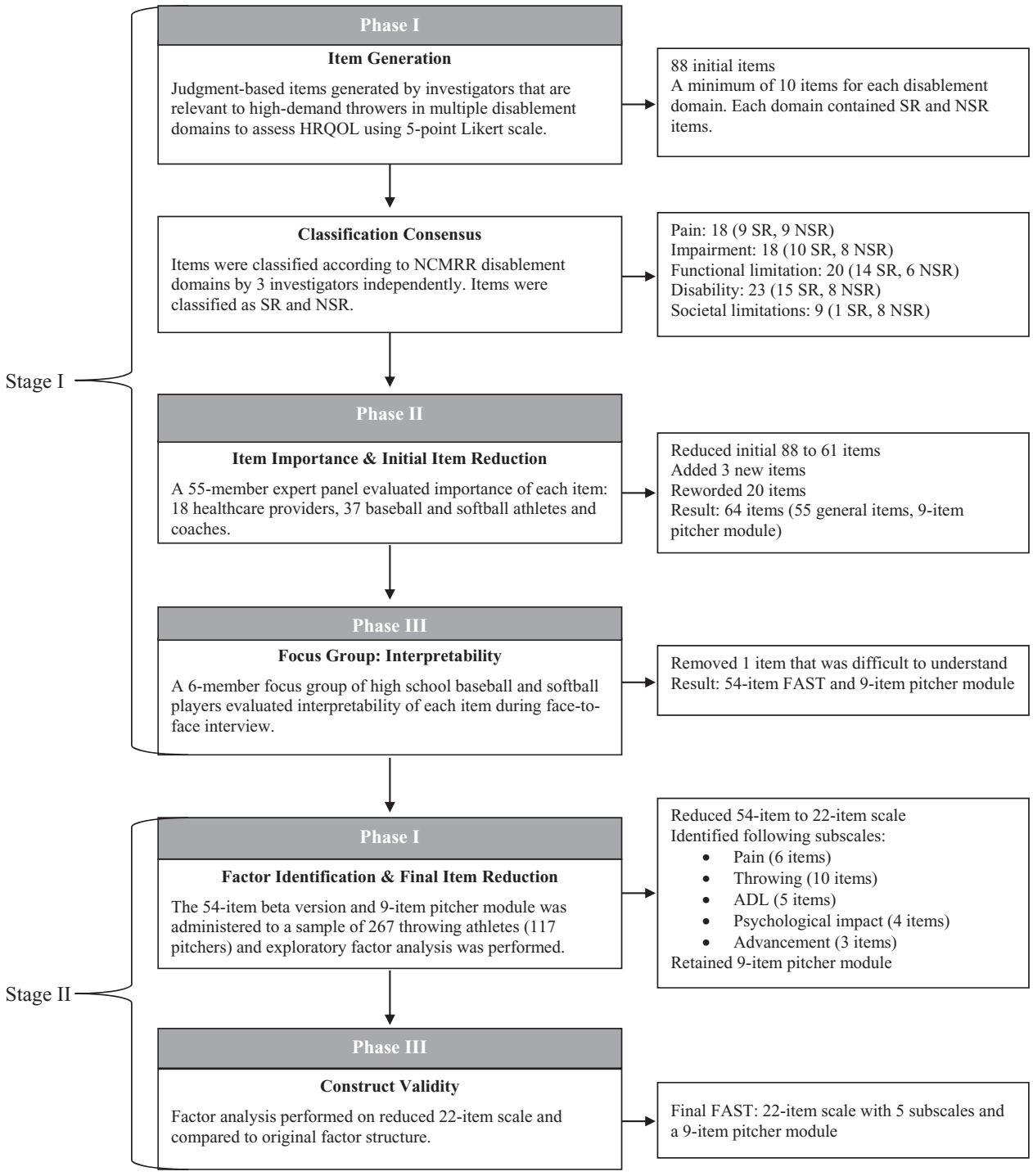

Figure 1. Flowchart of stages I and II of the scale development detailing the initial item generation and subsequent empirical and judgment-based steps of item reduction to produce the beta version (stage I) and reduced version (stage II) of the Functional Arm Scale for Throwers (FAST). ADL, activities of daily living; HRQOL, health-related quality of life; NCMRR, National Center for Medical Rehabilitation Research; NSR, non–sport-related; SR, sport-related.

Stage I: Phase I, Item Generation and Classification Consensus (Judgment-Based)

Item Generation. A review of published UE PRO scales was performed, evaluating general content, disablement domain coverage, inclusion of sport-specific items, and items specific to UE symptoms and function during high-demand throwing. Our goal was to develop a UE region-specific and population-specific PRO scale with the following criteria: (1) assessed the entire UE (shoulder,

elbow, wrist/hand), (2) included sport-related and non–sport-related items, (3) assessed the impact of UE injuries or conditions across multiple domains of health, (4) included an adequate number of items specific to symptoms (eg, stiffness prior to throwing) and function (eg, ability to maintain throwing velocity) in high-demand throwing athletes, (5) could be utilized to assess HRQOL without concurrent use of a general or generic scale, and (6) demonstrated acceptable patient and clinician friendliness and utility. None of the scales in the published literature met all of these criteria.

Furthermore, we were concerned with the ceiling effects that high-demand throwing athletes encounter when using existing scales. Ceiling effects limit the usefulness of a scale for evaluating outcomes when participants perform near maximum at baseline, even when injured.[16,32] Therefore, it is important to have a scale that captures disability during maximal effort in addition to ADLs. We generated 88 judgment-based items thought to be important to high-demand throwers and included a broad spectrum of health domains for assessment of HRQOL with a single scale. All item responses were based on a 5-point Likert-type scale.

Classification Consensus. Classification of items into disablement domains defined by the NCMRR was completed by consensus. Three authors independently classified each item into one of the following disablement domains: pain, impairment, functional limitation, disability, and societal limitation. Although pain is considered an impairment by the NCMMR,[15] numerous UE PRO scales have pain-specific subscales.[2,14,33,37,45,59,61] Therefore, pain was identified as a category independent from (but not orthogonal to) other impairments (eg, stiffness, weakness) so that this subscale could be compared with other pain subscales. The same authors independently classified each question as sport-related or non–sport-related.

The same authors met and reviewed their independent classifications of each item to achieve group consensus and definitively classify each item into the appropriate disablement domain and as sport-related or non–sport-related. When there was disagreement about a specific item, there was group discussion until consensus was reached.

Stage I: Phase II, Expert Panel: Item Importance and Initial Item Reduction (Data-Based)

Item Importance. Phase II determined the importance of each item and empirically reduced the number of items. A 55-member expert panel evaluated the importance of each item. The panel consisted of 18 health care providers (10 athletic trainers [11 ± 9 years experience], 7 physical therapists [17 ± 7 years experience], 1 orthopaedic surgeon [18 years experience]) and 19 baseball athletes (10 ± 5 years experience), 14 softball athletes (8 ± 4 years experience), and 4 coaches (16 ± 9 years experience). More athletic trainers and physical therapists were intentionally included on the panel based on the notion that these health care professionals are most likely engaged in regular treatment and rehabilitation and would be using the scale to inform clinical decision-making at the point of care. For each item, the panel members rated "how important the item is in determining the impact of the thrower's arm injury on his/her health-related quality of life" using a 5-point Likert-type scale, where 1 represented "not important" and 5 represented "extremely important." Panelists could also provide comments and suggestions for improving each item.

Pain. Pain was defined as "a physical suffering or discomfort caused by illness or injury"[44] and included items to assess pain. Examples of pain items included the following: "How much does the pain from your arm limit your throwing motion?" "How painful is your arm the day after throwing?" "How much pain or discomfort do you have in your arm with daily activities involving reaching?" Eighteen randomly ordered, pain-specific items were evaluated by the panel.

Impairment. Impairment was defined as "the loss or abnormality at the tissue, organ, or body system level"[44] and included items to assess impairments, such as loss of strength, loss of motion, and stiffness. Eighteen randomly ordered impairment items were evaluated by the panel.

Functional Limitation. Functional limitation was defined as "restrictions in the basic performance of the individual"[44] and included items to assess functional limitation, such as decreased throwing accuracy and velocity and inability to pick up heavy objects. Twenty randomly ordered functional limitation items were evaluated by the panel.

Disability. Disability was defined as "a limitation in performing roles, tasks, and activities expected of an individual in social and physical environments"[44] and included items to assess disability, such as inability to fulfill the role of an athlete, friend, or student and inability to participate in practices or games. Twenty-three randomly ordered disability items were evaluated by the panel.

Societal Limitation. Societal limitation was defined as "the restrictions resulting from social policy or barriers, which limit fulfillment of roles or deny access to services and opportunities associated with full participation in society"[44] and included items to assess societal limitation, such as loss of scholarship due to injury, loss of job, and loss of insurance. Nine randomly ordered societal limitation items were evaluated by the panel.

Initial Item Reduction. An empirically based reduction of items on the beta version of the FAST was achieved by calculation of mean item scores. Items were sorted in descending order within each disablement domain based on mean importance. Those items with the lowest mean scores were considered for elimination. Expert panelist mean importance scores were not ranked across domains to avoid elimination of an entire domain. Therefore, item reduction became quasi-empirical since judgment was used to determine the appropriate balance of items in disablement domains and inclusion of sport-related and non–sport-related items.

Stage I: Phase III, Focus Group: Interpretability (Judgment-Based)

Interpretability. Phase III assessed interpretability of each item. A 6-member focus group of young athletes (3 baseball and 3 softball players; mean age, 16.5 ± 0.9 years

[range, 16-17 years]; 10.5 ± 1.8 years experience [range, 8-12 years]) was utilized. Interpretability of each item was evaluated through face-to-face interviews, and each item was individually reviewed with focus group members who were asked, "Do you understand what this item is asking?" and "If not, how would you change it so that you could understand it better?"

Stage II: Phase I, Factor Analysis and Final Item Reduction

The goal of phase I was to reduce the beta version of the FAST to fewer than 25 items and lessen clinician and patient burden while preserving the variance characteristics and factor structure of the beta version. Data were obtained from a convenience sample of throwing athletes at all competition levels from across the United States. After data were collected on 267 athletes, a confirmatory factor analysis of the beta version was considered, but there is no evidence that NCMMR disablement domains constitute empirically discrete factors, and we had no hypotheses about how the sport-related and non–sport-related dimensions would interact with the disablement domains. An exploratory factor analysis using maximum likelihood and direct oblimin rotation was therefore conducted to identify dimensions measured by the scale. The pitcher module was excluded because it was explicitly intended as a separate dimension and completed only by pitchers. Items were selected from each subscale based on distributional characteristics (mean, variance, nonmissing) and factor loading. Cronbach alpha was calculated for each subscale, and items that decreased alpha were considered for exclusion. Subscale and total scale interitem correlations and item-to-scale correlations were also examined.

Stage II: Phase II, Construct Validity

In phase II, after the final item reduction and after data had been collected on 557 athletes, a confirmatory factor analysis approach was adopted to both determine whether scale reduction had altered the original factor structure and attempt to cross-validate the structure originally derived from the 267 athletes to the final sample of 557 athletes. An asymptotically distribution-free estimation procedure was used to accommodate the ordinal metric of the data. A "pain" subscale was prespecified so that this construct could be modeled independently in light of its prevalence among similar functional scales and its salience to both athletes and clinicians. Goodness-of-fit indices were calculated for the model. Spearman correlation coefficients between the subscale scores were calculated using scores derived from the factor structure (rather than as estimated within the model) because the pain subscale was not explicitly estimated in the model, and the pitcher module items (completed only by pitchers) were not included in the model. Cronbach alpha was calculated for each of the revised subscales. Finally, to evaluate the loss of information attributable to item reduction, the proportion of variance in each of the 54-item beta version subscales accounted for by the truncated subscales, as well as the truncated total FAST scale, was calculated.

RESULTS

Stage I: Phase I, Item Generation and Classification Consensus (Judgment-Based)

Item Generation. Eighty-eight items were initially generated (see Appendix A). A minimum of 18 items was generated for each disablement domain, except societal limitations, which had only 9 items. After final item reduction, the goal was to retain at least 5 items in each domain.

Classification Consensus. Consensus resulted in the following item classifications: 18 pain (9 sport-related, 9 non–sport-related), 18 impairment (10 sport-related, 8 non–sport-related), 20 functional limitation (14 sport-related, 6 non–sport-related), 23 disability (15 sport-related, 8 non–sport-related), and 9 societal limitation (1 sport-related, 8 non–sport-related).

Stage I: Phase II, Expert Panel: Item Importance and Initial Item Reduction (Data-Based)

Item Importance. Items assessing pain were rated as most important (mean, 3.88), followed by functional limitation (mean, 3.84), disability (mean, 3.52), impairment (mean, 3.44), and societal limitation (mean, 2.29).

Initial Item Reduction. The total number of items was reduced from 88 to 61. Based on expert panel feedback, some items were modified and 3 items were added, so the total number of items after preliminary item reduction was 64. Twenty items were also reworded to improve their interpretability. At completion of this stage, the FAST consisted of 55 items and a 9-item pitcher module. Items were randomly ordered to blind for disablement domains and redistributed during phase III.

Stage I: Phase III, Focus Group: Interpretability (Judgment-Based)

Interpretability. The focus group confirmed their understanding of all items except 1, which was considered confusing. This item was removed from the scale. The final beta version of the FAST consisted of 54 items and the 9-item pitcher module (Appendix A).

Stage II: Phase I, Factor Analysis and Final Item Reduction

A convenience sample of 267 injured (n = 122) and uninjured (n = 145) male baseball (n = 192) and female softball (n = 75) players (age, 19.5 ± 1.1 years; 11.9 ± 4.8 years experience) from multiple competitive levels (high school, n = 18; college, n = 249) was used in stage II. All completed the 54-item beta version of the FAST, and 118 pitchers (baseball, n = 105; softball, n = 13) also completed the 9-item pitcher module.

TABLE 1
Factor Loadings for Each Factor[a]

Item	Throwing	ADL	Psychological Impact	Advancement
Q1 How weak does your arm feel during throwing?	0.898			
Q2 How painful is your arm during "game speed" throwing?[b]	0.874			
Q3 How much has your arm injury limited your ability to throw "long toss"?	0.918			
Q4 How much has your throwing accuracy decreased since your arm injury?	0.860			
Q5 How much have you modified your behavior to avoid making your arm injury worse?	0.787			
Q6 How painful is your arm during 50%-75% effort throwing?[b]	0.827			
Q7 Has your arm injury decreased how long you can continue throwing during a single practice or game?	0.846			
Q8 How much strength have you lost in your arm as a result of your arm injury?	0.755			
Q9 How satisfied are you with the way your arm is now functioning?	0.669			
Q10 How much pain do you have in your injured arm prior to your start, following your warm-up?[b]	0.582			
Q11 How much pain or discomfort do you have in your arm if you use it for activities that last longer than 30 minutes?[b]		0.908		
Q12 How much pain or discomfort do you have in your arm with daily activities involving reaching?[b]		0.864		
Q13 How stiff is your arm at night?		0.689		
Q14 How much are you limited when lifting your arm overhead to get dressed?		0.691		
Q15 How much pain or discomfort do you have in your arm at night?[b]		0.442		
Q16 Has your life been more stressful because of your arm injury?			0.852	
Q17 How much of the time does your arm injury interfere with things that are important to you, other than sports?			0.874	
Q18 Has your enjoyment of life decreased since your arm injury?			0.663	
Q19 Since your arm injury, do you have a more negative outlook on life?			0.687	
Q20 How much has your arm injury limited your ability to advance in baseball or softball?				0.957
Q21 Have your sport accomplishments decreased since your arm injury?				0.926
Q22 How much has your playing time gone down since the injury to your arm?				0.872

[a]Values represent factor loadings. ADL, activities of daily living.
[b]Item on pain subscale.

Exploratory factor analysis of the 54-item beta version yielded 4 item clusters (factors). Examination of each factor resulted in the following subscale names (number of items): throwing (21 items), ADL (10 items), psychological impact (7 items), and advancement (9 items). Seven items were discarded because they failed to load on any factors and were not correlated among themselves. Inspection of these items revealed they were from the societal limitation domain and rarely given a score other than "none" or "not at all"; they contributed no variance to the analysis.

To reduce the 54-item beta version and to retain the factor solution, factor loadings and item response distributions were examined within each factor using Cronbach alpha. Poorly loading items and items that lowered alpha were considered for exclusion. The 54-item beta version of the scale was reduced to 22 items (Appendices A and B). All 9 items were retained in the pitcher module (Appendices A and B).

Stage II: Phase II, Construct Validity

The factor structure derived from the 54-item beta scale collected on data from the initial 267 athletes was imposed on the 22-item reduced scale using the final sample of 557 athletes. A confirmatory factor analysis of the reduced 22-item scale showed that the 54-item factor structure was preserved. The prespecified pain scale was modeled by allowing correlated error terms in the measurement model to represent the hypothesis that the unique variances in those items addressing pain overlap; that is, they measure something in common other than the latent constructs that are represented in the model. Factor loadings for the reduced 22-item scale in 557 athletes are provided in Table 1, and correlations between subscales are provided in Table 2. The factor loading represents correlations between the factors (eg, throwing, ADL) and the individual items. A visual representation of the model is provided in Appendix C. The number of items retained in each truncated subscale and the associated Cronbach alphas were as follows: throwing (10, $\alpha = 0.95$), ADL (5, $\alpha = 0.84$), psychological impact (4, $\alpha = 0.85$), and advancement (3, $\alpha = 0.94$). The pain subscale included 6 items that crossed factors ($\alpha = 0.85$). Cronbach alpha for the 9-item pitcher module was 0.95. Ten items were sport-related, and 12 were non–sport-related. The proportions of variance in the original subscales accounted for by the truncated subscales were: throwing (95%), ADL (92%), psychological impact (76%), and advancement (76%). The 6-item pain subscale accounted for 94% of the variance in the original 11 pain-related items.

Confirmatory factor analysis of the reduced 22-item scale yielded a goodness-of-fit index of 0.991, an adjusted

TABLE 2
Spearman Correlation Coefficients Between Factors and Pitcher Module[a]

Subscale	ADL	Psychological Impact	Advancement	Pain	Pitcher Module
Throwing	0.740	0.732	0.812	0.899	0.923
ADL		0.659	0.611	0.854	0.545
Psychological Impact			0.786	0.689	0.702
Advancement				0.719	0.818

[a]ADL, activities of daily living.

goodness-of-fit index of 0.988, normed fit index of 0.990, and root mean square residual of 0.043, all indicating an excellent fit of the model to the data.

Scale Scoring

Scoring of the FAST was modeled after the Disabilities of the Arm, Shoulder, and Hand (DASH)[51] outcome measure to normalize the score on a scale of 0 to 100 points, where a higher score indicates lower HRQOL. The formula to calculate the total score for the FAST is as follows: ([sum of n responses/n] − 1) × 25. This transformation will make the FAST score easier to compare with other measures that use a 0- to 100-point scale. This same procedure is used to calculate a separate score on a scale of 0 to 100 points for the 9-item pitcher module.

DISCUSSION

The FAST was designed to be a UE region-specific and population-specific PRO scale to assess the impact of UE disorders in high-demand throwing athletes. After rigorous scale development, stages I and II resulted in the 22-item FAST, with a 9-item pitcher module, that evaluates whole-person HRQOL across the spectrum of disablement. The FAST contains sport-related and non–sport-related items that are grouped to create a total scale score and a separate pitcher module. Subscale scores for pain, throwing, ADL, psychological impact, and advancement can also be calculated. Results of stages I and II established excellent construct validity of the FAST.

While there are many outcomes scales available for use in patients with shoulder conditions, few were designed for athletes or specialty categories, such as throwers. Furthermore, our purpose in developing the FAST was to create a scale that is easy to implement and use by physicians and surgeons to monitor progress over time and by health care providers engaged in regular treatment and rehabilitation to engage in patient-centered care. This was important because lack of time is one of the primary barriers to the use of PRO scales.[19,29,55,57] A good self-report scale minimizes demand on patients, which should improve response validity and response rate.[20,53,54] Several strategies were used to enhance patient and clinician friendliness of the FAST, thus minimizing burden.

The first strategy used to create a patient-friendly scale was to include our target population, baseball and softball players, in the development of the FAST. Their inclusion was one way to assure that patient perspective was captured early and throughout development. Patient perspective on the content and wording of items should produce a scale more relevant to the population of interest, addressing the "lack of relevance" barrier reported by those who do and do not use PRO scales.[29,57] We solicited input from competitive throwers of various ages to assess interpretability of FAST items. Finally, an expert panel was used to assist in reducing the total number of items on the scale. Collectively, these efforts help to make the FAST a patient-friendly PRO scale.

In addition to being patient friendly, the FAST is also designed to be clinician friendly. A scale that is clinician friendly minimizes the burden of scale administration on health care providers and their staff as well as researchers.[54] Characteristics of clinician-friendly scales include the following: a self-administered scale, involves little clinician effort in recording and analyzing data, and limits the need for time-consuming staff assistance.[54] The primary strategy used to create the FAST as a clinician-friendly scale was to limit the number of items, simplify scoring, and capture generic and specific health, thus minimizing the need to administer multiple PRO scales. Most PRO scales capture aspects of health that are either generic to health, in general, or specific to a particular body region or injury. The FAST, by design, evaluates health through both generic and specific lenses, with the inclusion of sport-related and non–sport-related items. Together, the strategies used in development help make the FAST a clinician-friendly PRO scale.

Apart from being patient and clinician friendly, the design and development of the FAST, using a multistage process that included patients, expert panels, and researchers, is important to review. The methods used to design and develop the FAST directly impact the scope of use and application of the scale. Furthermore, given the plethora of UE PRO scales, it was important to create a scale that is different from existing scales and highly relevant to the throwing athlete population.

A distinctive feature of the FAST is that it includes sport-related and non–sport-related items for the purpose of evaluating the impact of the UE conditions on both general and specific health, allowing for more comprehensive assessment to help physicians and health care providers in clinical and return-to-play decisions. Because competitive athletes focus on sport participation, it is important to ask questions related to their sport when considering injury impact. Most region-specific scales for the UE include few items pertaining to sport and the activities most affected by injury. The FAST includes sport-related items across multiple health domains to measure aspects important for participation in sport. Impairment and functional limitation questions specific to throwing athletes were included so subtle changes related to injury and treatment can be detected and measured over time. The demands on the UE during ADL are less affected by injury than during sport-specific activities, such as full-effort throwing. Scales

focusing on UE symptoms and function during ADL may be insufficient to detect deficits and measure changes in throwing over time.

Assessment of non–sport-related activities is also valuable. Non–sport-related items address the impact of injuries on ADL, capturing important health domains such as disability and societal limitations. The inclusion of non–sport-related items should improve the FAST's ability to evaluate the impact of UE disorders on overall HRQOL, giving a broader sense of the impact of the injury on health. Furthermore, non–sport-related items in the FAST diminish the need for concurrent use of general or generic scales, reducing the burden on the patient and clinician and increasing utility of the instrument.[54]

A key piece of the development of the FAST was the analytical methods used to repeatedly evaluate all potential scale items to identify their fit with our intent to create a UE region-specific and population-specific PRO scale that captured a broad spectrum of disability. While item generation was based on the disablement model framework, it was essential to explore and confirm our factor structure to accurately describe the aspects of health that the FAST evaluates. An exploratory factor analysis of the 54-item beta version of the FAST was performed to determine how many factors (ie, subscales) would emerge and which items these factors would comprise. Our intent was to identify item clusters that might serve as valid and reliable subscales that could be scored and used to measure the multidimensional impact of UE disorders on health over time. An exploratory factor analysis is guided by data to obtain empirical evidence about the internal structure of a measurement scale. The 4-factor solution (throwing, ADL, psychological impact, and advancement) clustered items in a way that was intuitively appealing and interpretable. Of note is that the factor structure analysis identified items related to societal limitations that were rarely endorsed, and even when endorsed, failed to correlate with one another. These items were removed, and this does limit the ability of the FAST to evaluate social implications of UE disorders on health status. However, the FAST does contain items pertaining to how a UE disorder affects patients' advancement in sport, an important issue for many throwing athletes. For patients expected to return to throwing but still experiencing activity and participation limitations, the advancement subscale evaluates whether patients perceive the injury as limiting their potential.

Once the factors were identified, it was important to reduce the number of items on the scale. Creating a scale containing fewer than 25 items was targeted for ease of administration and to ensure retention of the 4-factor solution derived using the larger scale. The item reduction process described earlier yielded 22 items. We then imposed the original factor structure on the abbreviated scale using confirmatory factor analysis to determine whether the item reduction altered the nature of the information being gathered. This allowed us not only to test for preservation of the original subscales but also to use a more appropriate estimation procedure (asymptotically distribution-free) to accommodate the ordinal data and to model a fifth cross-factor construct (pain). Neither of these analysis options is available in exploratory factor analysis.

An exploratory factor analysis, such as that used on the 54-item beta version of the FAST, identifies clusters of items that tend to correlate with one another, that is, measure the same attribute. The model that describes the data arises from the internal structure of the data. Confirmatory factor analysis requires the researcher to hypothesize a model in advance, including the number of factors, whether these factors are correlated, and which items reflect which factors. We imposed the model derived from exploratory analysis of the 54-item beta version of the FAST on the 22-item reduced version to determine whether item reduction had altered the structure of the data, and, further, whether the structure was stable (replicable) when 290 new athletes were added to the dataset. The results indicated that the original 4-factor solution, along with the correlated item errors to account for the pain subscale, fit the 22-item FAST scale nicely.

During the item importance and initial item reduction phase of stage I, which included an expert panel, it become apparent that a separate pitcher module was needed. The pitching motion is one of the fastest, highest load UE motions, and, as a result, pitchers are at the greatest risk for UE injury compared with any other position on a baseball or softball team. Therefore, it was important to have items that specifically addressed the unique demands of a pitcher. Initially, the pitcher module should be administered in conjunction with the FAST scale to get a holistic picture of the impact of the UE disorder on a pitcher's health. During the early phases of rehabilitation of a pitcher, the FAST total may be more helpful to clinicians since it incorporates non–sport-related items, which may be most affected immediately after injury or surgery. As the pitcher progresses through rehabilitation and begins a return to throwing program, the pitcher module will provide a more sensitive measure of HRQOL.

Through our robust development process, we produced the FAST UE region-specific and population-specific PRO scale that consists of 22 items that are sport-related and non–sport-related, with a separate 9-item pitcher module that evaluates whole-person HRQOL across the spectrum of disablement. Because there are numerous UE PRO scales currently in use, comparison of the FAST with other scales may help in distinguishing the FAST. The KJOC, like the FAST, is a region-specific and population-specific PRO scale designed for overhead athletes, such as throwers.[1,18,34] The KJOC was designed to evaluate functional status of the UE in overhead athletes.[1] Of the 10 scale items, 5 target physical function in games and practices and 5 target competition in sport.[1] There are several differences between the FAST and the KJOC. While the KJOC provides insight into the health status of throwing athletes, all the scale items fall under 1 factor, function, which provides a narrow glimpse into the health of the athlete.[1] In contrast, the FAST captures a broader spectrum of health, with items related to pain, throwing, ADL, psychological impact, and advancement. If used in isolation, the KJOC fails to capture broad domains of health (environmental, emotional, social factors), requiring the

use of additional scales and increased burden on the patient and clinician.[58] Furthermore, the FAST includes a pitcher module that allows for focused attention on those athletes with the highest throwing volume and injury rates. In addition to differences in content, the FAST and KJOC also differ in terms of design. The FAST uses Likert-style responses whereas the KJOC uses visual analog scale (VAS) responses. While literature supports the validity of the VAS, the benefit over Likert-style response options is small.[24] Time and effort to score and complete the VAS and the Likert-type scales differ in that the VAS requires measuring each response with a ruler to get the scale score whereas the Likert-type score value is simply the score selected. Given that lack of time is a frequently documented barrier to using PRO scales,[19,29,55,57] designing a scale with a more clinician-friendly measurement system, such as the Likert scale, is recommended.[24,46]

Other commonly used instruments for UE shoulder disorders are the DASH[5,25,27] and Pennsylvania Shoulder Score (PSS).[36-38] While the FAST and KJOC are designed to evaluate high-functioning patient populations, the DASH and PSS were designed for more general populations. In brief, the DASH consists of 30 items, with a separate 4-item module to evaluate sport and performing arts activities.[51] The PSS is a 20-item scale with separate subscales for pain, function, and satisfaction.[37] Both the DASH and PSS have been deemed reliable and valid in multiple populations with UE disorders. An important distinction between the DASH and PSS and the FAST is that the former scales do not contain sport-related items and, thus, miss evaluating aspects of quality of life that are highly relevant to these patients. Lack of perceived relevance is not only a barrier to PRO scale use,[29,57] it also limits the ability to capture meaningful health changes over time. Furthermore, while more research is needed related to PRO scales and ceiling and floor effects in general, there has been a report of ceiling effects in athletes who were measured with the DASH, which may affect its use in this population.[25] Based on these comparisons, the FAST may be the most appropriate PRO scale to use with UE-injured throwing athletes.

Limitations

This study is not without limitations. While we strived to create a scale applicable to the spectrum of throwing athletes, our population largely focused on collegiate baseball throwers involved in organized sport. The applicability of the FAST in older, recreational populations warrants further study.

CONCLUSION

We completed a 3-stage scale development process for the FAST and report on stage I (item generation and initial item reduction) and stage II (factor analysis, final item reduction, and construct validity) in this article. The FAST consists of 22 items that are scored to create a total scale score and 5 subscale scores (pain, throwing, ADL, psychological impact, and advancement) related to the disablement of throwing athletes. A separate 9-item pitcher module was also created. The FAST achieved its purpose of being a patient- and clinician-friendly PRO scale that provides insight into a throwing athlete's health status relative to sport-related and non–sport-related areas. A companion paper describes stage III (measurement properties) of the development process. The long-term objective of this research is to improve the HRQOL of throwers with UE injuries by optimizing our ability to assess the impact of their injury and the care they receive.

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APPENDIX A

TABLE A1
Initial Items on the FAST (n = 88) and Item Reduction to the 54-Item Beta Version and 22-Item Final Version with a 9-Item Pitcher Module[a]

	Item	NCMRR Domain	Sport/Non-Sport Item	54-Item Beta Version	9-Item Pitcher Module	22-Item Final Version	Subscale
1	How much are you limited when lifting your arm overhead to get dressed?	Functional limitation	NSR	X		X	ADL
2	How stiff is your arm at night?	Impairment	NSR	X		X	ADL
3	How much pain or discomfort do you have in your arm with daily activities involving reaching?	Impairment and pain	NSR	X		X	ADL and pain
4	How much pain or discomfort do you have in your arm if you use it for activities that last longer than 30 minutes?	Impairment and pain	NSR	X		X	ADL and pain
5	How much pain or discomfort do you have in your arm at night?	Impairment and pain	NSR	X		X	ADL and pain
6	How much has your arm injury limited your ability to advance in baseball or softball?	Disability	SR	X		X	Advancement
7	How much has your playing time gone down since the injury to your arm?	Disability	SR	X		X	Advancement
8	Have your sport accomplishments decreased since your arm injury?	Disability	SR	X		X	Advancement
9	How much does your arm injury interfere with things that are important, other than sports?	Disability	NSR	X		X	Psychological impact
10	Since your arm injury, do you have a more negative outlook on life?	Impairment	NSR	X		X	Psychological impact
11	Has your life been more stressful because of your arm injury?	Impairment	NSR	X		X	Psychological impact
12	Has your enjoyment of life decreased since your arm injury?	Societal limitation	NSR	X		X	Psychological impact
13	How much have you modified your behavior to avoid making your arm injury worse?	Disability	NSR	X		X	Throwing
14	How satisfied are you with the way your arm is now functioning?	Functional limitation	NSR	X		X	Throwing
15	How much has your arm injury limited your ability to throw “long toss”?	Functional limitation	SR	X		X	Throwing
16	How much has your throwing accuracy decreased since your arm injury?	Functional limitation	SR	X		X	Throwing
17	Has your arm injury decreased how long you can continue throwing during a single practice or game?	Functional limitation	NSR	X		X	Throwing
18	How much strength have you lost in your arm as a result of your arm injury?	Impairment	NSR	X		X	Throwing
19	How weak does your arm feel during throwing?	Impairment	SR	X		X	Throwing
20	How much pain do you have in your injured arm prior to your start, following your warm-up?	Impairment and pain	SR	X		X	Throwing and pain
21	How painful is your arm during “game speed” throwing?	Impairment and pain	SR	X		X	Throwing and pain
22	How painful is your arm during a 50-75% effort throwing?	Impairment and pain	SR	X		X	Throwing and pain
23	How much has your pitch count decreased since your arm injury?	Functional limitation/pitcher	SR		X		
24	How much has your arm injury limited the speed of your pitches?	Functional limitation/pitcher	SR		X		

(continued)

TABLE A1 (continued)

	Item	NCMRR Domain	Sport/Non-Sport Item	54-Item Beta Version	9-Item Pitcher Module	22-Item Final Version	Subscale
25	How much has your arm injury limited your ability to throw "bullpen" sessions?	Functional limitation/pitcher	SR		X		
26	How much has your arm injury limited your ability to "hit" your spots?	Functional limitation/pitcher	SR		X		
27	How much have your overall pitching statistics been hurt since your arm injury?	Functional limitation/pitcher	SR		X		
28	How much has your arm injury limited your ability to throw different types of pitches?	Functional limitation/pitcher	SR		X		
29	How limited is your ability to pitch your turn in the rotation?	Functional limitation/pitcher	SR		X		
30	Has your "feel" for pitching decreased since your arm injury?	Functional limitation/pitcher	SR		X		
31	Do you need more time to recover between outings since your arm injury?	Functional limitation/pitcher	SR		X		
32	How much has your arm injury limited your ability to take part in activities outside of your sport in which you want to participate?	Disability	NSR	X			
33	How much has your ability to exercise and stay fit been limited by your arm injury?	Disability	NSR	X			
34	Has your arm injury limited your ability to play with your family or friends?	Disability	NSR	X			
35	Has your confidence decreased since your arm injury?	Disability	NSR	X			
36	Has this arm injury changed your personal relationships with friends, family, or significant others?	Disability	NSR				
37	How limited are you in participating in family-related activities?	Disability	NSR				
38	Has this arm injury impacted you financially?	Disability	NSR				
39	How limited are you in playing your sport as a result of your arm injury?	Disability	SR	X			
40	How much has your injury limited your ability to keep your position on the team?	Disability	SR	X			
41	Since your arm injury, does it take you longer to warm up before throwing?	Disability	SR	X			
42	How limited are you in playing your position as a result of your arm injury?	Disability	SR				
43	Are you limited in your ability to participate in games?	Disability	SR				
44	How limited are you in activities such as preparing a meal since your arm injury?	Functional limitation	NSR				
45	How much has your arm injury limited your ability to open a door?	Functional limitation	NSR				
46	How limited are you in driving a car because of your arm injury?	Functional limitation	NSR				
47	How limited are you in turning a key since your arm injury?	Functional limitation	NSR				
48	How limited are you in opening a tight or new jar since your arm injury?	Functional limitation	NSR				
49	How limited are you in performing your normal household activities?	Functional limitation	NSR				
50	How much loss of motion do you have in your arm as a result of your injury?	Functional limitation	SR	X			
51	How much has stiffness in your arm limited your throwing performance?	Functional limitation	SR	X			
52	How much has your athletic performance changed when compared to your preinjury performance?	Functional limitation	SR				
53	How much has your recovery rate between outings been affected since your injury?	Functional limitation	SR				

(continued)

TABLE A1 (continued)

	Item	NCMRR Domain	Sport/Non-Sport Item	54-Item Beta Version	9-Item Pitcher Module	22-Item Final Version	Subscale
54	How limited are you in throwing at 75%-90% effort since your arm injury?	Functional limitation	SR	X			
55	How much have you modified your throwing motion since the injury to your arm?	Functional limitation	SR	X			
56	Has your ability to maintain a throwing program of "light catch" changed because of your injury?	Functional limitation	SR				
57	Are you limited in your ability to participate in baseball/softball practice and games as a result of your arm injury?	Functional limitation	SR				
58	How much has your ability to maintain proper throwing "mechanics" been affected by your arm injury?	Functional limitation	SR				
59	How much has the number of pitches thrown changed since your injury?	Functional limitation	SR				
60	Has your energy level decreased since your arm injury?	Functional limitation	NSR	X			
61	Has your arm injury caused you to become more cautious during sport participation?	Functional limitation	SR				
62	How much weakness do you have in your arm during normal daily activities?	Impairment	NSR	X			
63	How stiff is your arm 2 hours after throwing?	Impairment	SR				
64	How stiff is your arm while throwing?	Impairment	SR	X			
65	How much does weakness in your arm limit your throwing motion?	Impairment	SR	X			
66	How stiff is your arm prior to throwing?	Impairment	SR	X			
67	How weak does your arm feel immediately after throwing?	Impairment	SR	X			
68	How stiff is your arm the day after throwing?	Impairment	SR	X			
69	How much pain or discomfort do you have in your arm while at rest?	Impairment and pain	NSR	X			
70	How much pain or discomfort do you have in your arm if you use it for eating, dressing, or bathing?	Impairment and pain	NSR				
71	How much pain or discomfort do you have in your arm if you use it for carrying heavy objects?	Impairment and pain	NSR				
72	How much pain or discomfort do you have in your arm if you use it for washing or blow-drying your hair?	Impairment and pain	NSR				
73	How much pain or discomfort do you have in your arm while performing normal activities?	Impairment and pain	NSR	X			
74	How much pain or discomfort do you have in your arm when lifting weights?	Impairment and pain	NSR				
75	How painful is your arm during a 75%-90% effort throwing?	Impairment and pain	SR	X			
76	How painful is your arm the day after throwing?	Impairment and pain	SR	X			
77	How much does the pain from your arm limit your throwing motion?	Impairment and pain	SR	X			
78	How much pain do you have in your injured arm prior to your warm-up?	Impairment and pain	SR				
79	How much pain do you have in your injured arm prior to thr first pitch?	Impairment and pain	SR				
80	How difficult has it been for you to get around in public because of the injury to your arm?	Societal limitation	NSR	X			
81	Are you treated worse by people you meet because of the injury to your arm?	Societal limitation	NSR	X			
82	Are you treated worse by family members because of the injury to your arm?	Societal limitation	NSR	X			
83	Has your view of your importance in society changed since your arm injury?	Societal limitation	NSR	X			

(continued)

TABLE A1 (continued)

Item	NCMRR Domain	Sport/Non-Sport Item	54-Item Beta Version	9-Item Pitcher Module	22-Item Final Version	Subscale
84 Are you treated worse by friends because of the injury to your arm?	Societal limitation	NSR	X			
85 Have you felt depressed since your arm injury?	Societal limitation	NSR	X			
86 Has this injury affected the way that your teammates view you?	Societal limitation	SR	X			
87 Has this arm injury hurt you financially? (ie, loss of money, job, scholarship or health insurance)	Societal limitation	SR	X			
88 How much has your contribution to the team decreased since your arm injury?	Societal limitation	SR	X			

[a]ADL, activities of daily living; FAST, Functional Arm Scale for Throwers; NCMRR, National Center for Medical Rehabilitation Research; NSR, non–sport-related; SR, sport-related

APPENDIX B

Final 22-Item Version of the Functional Arm Scale for Throwers (FAST) and the 9-Item Pitcher Module

Functional Arm Scale for Throwers© (FAST©)

ID: ———— Today's date: ————————

This questionnaire asks about how your arm (shoulder, upper arm, elbow, forearm, write, hand, fingers) feels. It asks about how your arm condition affects your ability to throw and to function in sport and daily activities.

Instructions: Please answer every question based on your arm condition **during the last week** by circling the number for the appropriate response. If you did not engage in an activity in the past week, please answer questions based on your estimate of how your arm condition would affect your ability to engage in the activity.

Pitchers, please be sure to complete the pitcher-specific section at the end.

	Completely	Extremely	Moderately	Slightly	Not Satisfied at All
1. How satisfied are you with the way your arm is now functioning?	1	2	3	4	5
	None	Mild	Moderate	Severe	Extreme
2. How much pain do you have in your injured arm prior to your start, following your warm-up?	1	2	3	4	5
3. How much pain or discomfort do you have in your arm at night?	1	2	3	4	5
4. How much strength have you lost in your arm as a result of your arm injury?	1	2	3	4	5
5. How much pain or discomfort do you have in your arm with daily activities involving reaching?	1	2	3	4	5
6. How much pain or discomfort do you have in your arm if you use it for activities that last longer than 30 minutes?	1	2	3	4	5
	Not at All	Slightly	Moderately	Severely	Extremely
7. How much has your arm injury limited your ability to advance in baseball or softball?	1	2	3	4	5

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	Not at All	Slightly	Moderately	Severely	Extremely
8. How much have you modified your behavior to avoid making your arm injury worse?	1	2	3	4	5
9. Since your arm injury, do you have a more negative outlook on life?	1	2	3	4	5
10. How much does your arm injury interfere with things that are important, other than sports?	1	2	3	4	5
11. How stiff is your arm at night?	1	2	3	4	5
12. How much has your playing time gone down since the injury to your arm?	1	2	3	4	5
13. How much are you limited when lifting your arm overhead to get dressed?	1	2	3	4	5
	No, Not at All	Yes, Slightly	Yes, Moderately	Yes, Severely	Yes, Extremely
14. Has your enjoyment of life decreased since your arm injury?	1	2	3	4	5
15. Has your arm injury decreased how long you can continue throwing during a single practice or game?	1	2	3	4	5
16. Have your sports accomplishments decreased since your arm injury?	1	2	3	4	5
17. Has your life been more stressful because of your arm injury?	1	2	3	4	5
	Not at All	Slightly	Moderately	Severely	Unable to Throw
18. How much has your arm injury limited your ability to throw “long toss”?	1	2	3	4	5
19. How much has your throwing accuracy decreased since your arm injury?	1	2	3	4	5
20. How weak does your arm feel during throwing?	1	2	3	4	5
21. How painful is your arm during “game speed” throwing?	1	2	3	4	5
22. How painful is your arm during 50-75% effort throwing?	1	2	3	4	5

Pitcher Module (All Pitchers MUST Complete this Section)

The following questions are to determine the impact of a baseball/softball pitcher’s arm injury on pitching-specific functional performance.

	Not at All	Slightly	Moderately	Severely	Unable to Perform
1. How much has your arm injury limited the speed of your pitches?	1	2	3	4	5
2. How much has your arm injury limited your ability to throw “bullpen” sessions?	1	2	3	4	5
3. How much has your arm injury limited your ability to “hit” your spots?	1	2	3	4	5
4. How limited is your ability to pitch your turn in the rotation?	1	2	3	4	5
5. How much have your overall pitching statistics been hurt since your arm injury?	1	2	3	4	5
6. How much has your pitch count decreased since your arm injury?	1	2	3	4	5
7. How much has your arm injury limited your ability to throw different types of pitches?	1	2	3	4	5
8. Has your “feel” for pitching decreased since your arm injury?	1	2	3	4	5
9. Do you need more time to recover between outings since your arm injury?	1	2	3	4	5

APPENDIX C

FAST confirmatory factor analysis model during construct validity phase. Question numbers (eg, Q2, Q6) correspond to question numbers in Table 1. ADL, activities of daily living.