[Orthopaedic Surgery]

Development and Validation of the Elbow Demand Rating Scale

Carl W. Nissen, MD,*^{†‡} Emily A. O'Hara, MS, MA,[†] Mark McCarthy, ATC,[†] and Regina Kostyun, ATC, MEd[†]

Background: Overhead sports place the greatest strain on the elbow of any of the upper extremity joints. Unfortunately, athlete-specific functional outcome tools do not exist for the elbow.

Hypotheses: The Elbow Demand Rating Scale (EDS) will demonstrate strong reliability and validity properties: (1) test-retest reliability with a 2-week EDS administration, (2) internal reliability of the subscales, and (3) construct validity through lower scores for patients with elbow injuries.

Study Design: Prospective case-control study.

Methods: Patients with (n = 19) and without elbow injuries (n = 19) completed the EDS during their routine clinical appointment and 2 weeks later. Clinicians completed the functional portion of the EDS.

Results: The EDS demonstrated strong test-retest reliability and construct validity. Internal reliability was moderate ($\alpha = 0.50$). Exploratory analyses further supported construct validity using demographic survey questions regarding elbow pain and symptoms.

Conclusion: Overall, the EDS demonstrated moderate to strong psychometric properties in a patient population with elbow injuries, and its use is supported for young athletes.

Clinical Relevance: The EDS provides clinicians working with adolescent and young adult athletes a scale to direct care and determine intervention success or failure.

Keywords: elbow; joint assessment; injury; elbow assessment

Evidence-based medicine has demonstrated the importance of valid and reliable clinical evaluations of activity and functional levels after injury or surgery. Formal evaluations have been performed for many years in most medical disciplines. The American Academy of Orthopaedic Surgeons and others have developed several outcome tools to evaluate injuries and surgery, including general outcomes (SF-36) and those specific to the shoulder (Western Ontario Shoulder Instability, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form) and the knee (Tegner, Noyes Knee Rating Assessment).^{7,10-12,15}

Knee ligament injuries can be evaluated with the International Knee Documentation Committee forms. Knee and hip arthroplasty outcomes are also available.^{4,13} Elbow problems are subject to more general outcome tools, for example, the SF-36.^{2,6,7,9,11,16} However, few of these are elbow specific, and none are refined for athletes competing in overhead sports.

Many shoulder rating scales have been validated.^{3,4,7,8} The Constant-Murley, American Shoulder and Elbow Society evaluative tool, and the Western Ontario Shoulder Instability scales are widely utilized.^{3,8,14} There is currently no outcome tool that can measure the functional status of the elbow in the overhead athlete. A single athletic functional outcome tool was developed¹ and tested in overhead athletes who had surgery or injuries to their shoulder or elbow. Compared with previous general outcome tools,⁵ this instrument is a significant advancement for athletes and is an improvement from the standard outcome tool, which asks if they have been able to return to the same level of competition following the injury or procedure.⁶ Despite these improvements, however, inclusion of both the shoulder and the elbow decreases specificity and points out the need for a specific tool for the outcomes of elbow surgeries and injuries.

The purpose of this study was to develop and validate the Elbow Demand Rating Scale (EDS) within a clinical sports

From [†]Elite Sports Medicine, Connecticut Children's Medical Center, Farmington, Connecticut, and [‡]Department of Orthopaedics, University of Connecticut Health Center, Farmington, Connecticut

*Address correspondence to Carl W. Nissen, MD, Elite Sports Medicine, 399 Farmington Ave, Farmington, CT 06032 (e-mail: cnissen@ccmckids.org).

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medicine population of adolescents and adults. Adolescents were included to validate the assessment for a younger population since current methods include only adults. The intention of the EDS is to assist in the evaluation, diagnosis, and determination of the level of function for patients who have sustained an elbow injury. To gain wide acceptance, the EDS should demonstrate strong psychometric properties consisting of (1) test-retest reliability with a 2-week EDS administration, (2) internal reliability within the items of the scale, and (3) construct validity through lower scores for patients with elbow injuries.

MATERIALS AND METHODS

EDS Development

This study was approved by the Institutional Review Board of the Connecticut Children's Medical Center. The Cincinnati Knee Rating Outcome Scale was used as a template. Three subgroups were formed (pain, function, and examination findings). The EDS was reviewed by a college athlete with an elbow injury for face validity and revised by the New England Shoulder and Elbow Society. Members of the society established face and content validity for the EDS and determined a weighting measure for each subgroup.

Participants

Patients with (elbow group) and without elbow injuries (control group) (age range, 12-55 years) were recruited during routine appointments. Inclusion criteria consisted of patients who were currently active and participating in a competitive or recreational sport prior to injury (if applicable). Patients in the elbow group experienced elbow pain or elbow injury and pain. Patients with current or previous elbow injuries were excluded from the control group.

Of the 102 patients approached, 22 did not meet study criteria, and 8 refused to participate owing to time constraints. Of the 72 patients enrolled (70.6% enrollment rate), 43 (10 female patients, 33 male patients) were in the elbow group (mean age, 17.51 ± 6.40 years) and 29 (16 female patients, 13 male patients) were in the control group (mean age, 20.93 ± 7.82 years). A subset of 19 patients in each group completed follow-up measures at 2 weeks. There was no significant difference among the groups based on age ($P = 0.06$); however, a difference was detected between groups based on sex ($P < 0.05$). A significant difference was also noted for age between those who did and did not complete follow-up measures ($P < 0.05$).

Measures

Elbow Rating Scale

The EDS consists of 2 self-reported subscales (pain and function) completed by the participant and a medical examination subscale completed by the clinician. The self-reported pain subscale consisted of 5 items assessing the level of elbow pain while performing daily functioning tasks on a

5-point scale, with scores ranging from 0 to 60 (Appendix A; available at <http://sph.sagepub.com/content/suppl>). The function subscale consisted of 2 items: the frequency of participation scale, which measured sport activity level, and the function scale, which measured the ability to perform sports activity over the past 4 weeks (Appendix B). Each sport activity was classified by elbow demand. Frequency of participation was scored by accounting for the activity demand level, and the total function score was calculated by combining the scores from the 2 scales (Appendix C). Function scores ranged from 5 to 85, with high scores indicating a higher level of elbow function.

The medical examination subscale consisted of 3 objective elbow measurements (mobility, stability, and strength) (Appendix D), and scores ranged from 0 to 98. The total EDS score was calculated by combining the scores from the 3 subscales and ranged from 5 to 243. Depending on the activity level, the participant was given a rating of excellent, good, fair, or poor, with lower scores indicating greater elbow impairment (Appendix E).

Demographic Survey

The demographic survey consisted of 17 questions on age, sex, dominant arm, sport participation, and elbow injury symptoms (Appendix F). Elbow injury symptoms were assessed by 3 questions on the level of pain and 6 questions assessing swelling, stiffness, and locking.

Data Analysis

Test-retest reliability was analyzed using intraclass correlations through readministration of the EDS after 2 weeks. Construct validity was assessed through an independent samples *t* test comparing EDS scores of patients in the elbow and control groups. Exploratory analysis was conducted to examine the relationship between the EDS subscales and patient responses to the demographic survey. Pearson correlation coefficients were used to analyze relationships between the EDS and demographic pain and function questions, and 1-way analysis of variance was used to assess differences in EDS scores for demographic survey questions using a Likert scale.

RESULTS

Post hoc power analysis revealed moderate to strong power for the performed analyses. There were no significant differences in EDS score based on sex and no significant relationship between EDS score and age. There was strong test-retest reliability ($r = 0.90$, $P < 0.00$), indicating that patients responded consistently over time. Moderate internal reliability was demonstrated ($\alpha = 0.50$) through the 3 subscales, with consistency noted between subscales. Strong construct validity was evidenced by significant differences between scores for controls (217.16 ± 20.92) and patients with elbow injuries (190.26 ± 31.65) ($t(70) = 4.34$, $P < 0.00$).

Exploratory analyses further indicated construct validity. Patients who reported higher current levels of elbow function

also had higher EDS scores ($r = 0.62$, $P < 0.00$). There was also a significant moderate relationship between level of pain over the past month and EDS score ($r = -0.38$, $P = 0.00$). Moreover, there were significant differences between patients who reported more severe injury symptoms and EDS scores.

DISCUSSION

The results demonstrate moderate internal reliability and strong test-retest reliability properties for the EDS, supporting the study hypotheses. The EDS may be useful to evaluate longitudinal clinical interventions.

Patients with elbow injuries had significantly lower EDS scores and greater disease symptoms than healthy patients, indicating greater elbow impairment. Moreover, these findings support an inverse relationship between level of pain and EDS score, demonstrating that the EDS is sensitive to the severity of elbow symptoms. There are few upper extremity evaluations that attend solely to elbow injuries. Most validated assessment tools used for athletes evaluate shoulder injuries, and others evaluate overhead injuries with an assessment of the wrist, elbow, and shoulder joints inclusively.^{1,2} In addition, while many measures consist of pain and functional domains,^{9,15} the EDS is unique because it integrates self-report and objective clinical items. As the incidence and types of elbow-specific injuries increase, the availability of an elbow-specific outcome and assessment tool can assist in the care of athletes.^{1,6} Since the recurrence rate of injuries may be as high as 15% (especially in younger athletes), the determination that safe return to sport is possible is essential.

The Kerlan Jobe Orthopaedic Clinic assessment tool¹ was a significant improvement in the evaluation of overhead athletes. However, this tool lacks specificity for the elbow and was designed for younger athletes. The EDS was designed to address these issues. With the KJOC scoring, overhead athletes now have valid and reliable tools to assess functional levels and safety for return to play.

This study has limitations, including a small sample size. Additionally, the majority of the sample was younger athletes (mean age, 18.98 years; range, 12-43 years), which limits the extension of the EDS to older and nonathlete populations.

REFERENCES

1. Alberta F, El Attrache N, Bissell S, et al. The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *Am J Sports Med.* 2010;38(5):903-911.
2. Atroshi I, Gummesson C, Andersson B, Dahlgren E, Johansson A. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: reliability and validity of the Swedish version evaluated in 176 patients. *Acta Orthop Scand.* 2000;71(6):613-618.
3. Constant C, Murley A. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res.* 1987;214:160-164.
4. Greco NJ, Anderson AF, Mann BJ, et al. Responsiveness of the International Knee Documentation Committee Subjective Knee Form in comparison to the Western Ontario and McMaster Universities Osteoarthritis Index, modified Cincinnati Knee Rating System, and Short Form 36 in patients with focal articular cartilage defects. *Am J Sports Med.* 2010;38(5):891-902.
5. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med.* 1996;29(6):602-608.
6. King GJ, Richards RR, Zuckerman JD, et al. A standardized method for assessment of elbow function: Research Committee, American Shoulder and Elbow Surgeons. *J Shoulder Elbow Surg.* 1999;8(4):351-354.
7. Kirkley A, Alvarez C, Griffin S. The development and evaluation of a disease-specific quality-of-life questionnaire for disorders of the rotator cuff: the Western Ontario Rotator Cuff Index. *Clin J Sports Med.* 2003;13(2):84-92.
8. Kirkley A, Griffin S, McLintock H, Nig L. The development and evaluation of a disease specific quality of life measurement tool for shoulder instability: the Western Ontario Shoulder Instability Index (WOSI). *Am J Sports Med.* 1998;26:764-772.
9. L'Insalata JC, Warren RF, Cohen SB, Altchek DW, Peterson MG. A self-administered questionnaire for assessment of symptoms and function of the shoulder. *J Bone Joint Surg Am.* 1997;79(5):738-748.
10. Lingard E, Katz J, Wright R, Sledge C. Validity and responsiveness of the Knee Society Clinical Rating System in comparison with the SF-36 and WOMAC. *J Bone Joint Surg Am.* 2001;83(12):1856-1864.
11. Michener LA, McClure PW, Sennett BJ. American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form, patient self-report section: reliability, validity, and responsiveness. *J Shoulder Elbow Surg.* 2002;11(6):587-594.
12. Noyes FR, Barber-Westin SD, Mooar L, Grood E. *The Noyes Knee Rating System: An Assessment of Subjective, Objective, Ligamentous, and Functional Parameters.* Vol 1. 2nd ed. Cincinnati, OH: Cincinnati Sportsmedicine Research and Education Foundation; 1995.
13. Noyes FR, Stabler C. A classification system for articular cartilage lesions of the knee joint. *Am J Sports Med.* 1989;17(4):505-513.
14. Richards RR, An KN, Bigliani LU, et al. A standardized method for the assessment of shoulder function. *J Shoulder Elbow Surg.* 1994;3:347-352.
15. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res.* 1985;198:43-49.
16. Turchin DC, Beaton DE, Richards RR. Validity of observer-based aggregate scoring systems as descriptors of elbow pain, function, and disability. *J Bone Joint Surg Am.* 1998;80(2):154-162.