PHYSIOTHERAPY THEORY AND PRACTICE
2022, VOL. 38, NO. 8, 1059–1070
https://doi.org/10.1080/09593985.2020.1818341

Cross-cultural adaptation and validation of the Kerlan-Jobe orthopedic clinic shoulder and elbow score for German-speaking overhead athletes

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ABSTRACT

Background: The Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow Score (KJOC) originally developed in English, assesses the functional status of the shoulder and elbow in overhead athletes. To date, no German version of the questionnaire exists.

Objective: The aim of the study was to translate and to culturally adapt the KJOC into German (KJOC-G) and to test its psychometric properties.

Methods: The first part of the study consisted of a translation and cross-cultural adaptation process which was performed in six stages according to international recommendations: Initial translations, synthesis, back translations, expert committee review, pretesting of the prefinal version, and final adaptations. Secondly, reliability, validity, and feasibility of the KJOC-G were assessed in German overhead athletes.

Results: The translation and adaptation process led to minor alterations due to cultural differences while maintaining the general structure and content of the original score. A total of 152 overhead athletes (age 25.0 ± 6.6 years; 87 men/65 women) were included in the main analyses. The internal consistency (Cronbach's alpha = 0.93) and test–retest reliability ($ICC_{2.1}$ = 0.94) of the overall questionnaire were excellent. Moderate correlations with the German version of the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (r = −0.51, $p < .05$) as well as the DASH-sports module (r = −0.54, $p < .05$) suggest moderate construct validity. Known-group method analysis showed the ability of the KJOC-G to discriminate between actively playing symptomatic (score: 71.2 ± 16.0) and asymptomatic (score: 93.1 ± 8.7) athletes.

Conclusion: The KJOC-G score is valid, reliable, and suitable for assessing the functional shoulder and elbow status in German-speaking overhead athletes.

ARTICLE HISTORY
Received 3 December 2019
Revised 23 June 2020
Accepted 26 July 2020

KEYWORDS
Overhead athlete; shoulder; patient-reported outcome; questionnaire; outcome measurement

Introduction

Overhead athletes, performing rapid and powerful movements with the arm above the horizontal, are at high risk to develop upper extremity overuse injuries (Asker et al., 2018; Meister, 2000; Wong, Lin, Ayyala, and Kazam, 2017). In addition, high incidence rates of acute traumatic injuries in the shoulder and elbow joint have been described (Caine, 2010). These issues already affect youth athletes who often perform at the limits of their physical capacity (Kraan et al., 2019). Furthermore, it is a common practice among highly competitive athletes to regularly train and compete despite health problems, and to accept pain and discomfort during play (Mayer et al., 2018).

For this reason, the early detection of subtle limitations and appropriate therapeutic management is necessary. In addition to standard clinical and physical examinations with measures of motion and strength as well as medical imaging, the health-related quality of life assessed by patient-reported outcome measures has become increasingly important for diagnostics, care, and sport rehabilitation (Parsons and Snyder, 2011). One particular advantage of this approach is its multidimensional character as it simultaneously considers physical, psychological, and social perceptions, as well as beliefs of athletes. According to the bio-psycho-social paradigm, the athletes' self-perceived physical capability and functional status is of crucial importance. In case of an injury, integrating the perspective of the patient into the measures gives the clinician a deeper insight leading to better treatment of patients and thus better outcomes (Sciascia, 2013). Furthermore, the individuals' experience can be highly relevant in terms of return-to-sport and return-to-competition evaluations since athletes'

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perceptions might differ from evaluation performed by clinicians.

Numerous reliable upper extremity scores within the scope of sports medicine and orthopedic assessment exist. However, most of them assess activities of daily living (ADL) whereas high-functioning overhead athletes often only notice symptoms or discomfort during sport-specific loading (Gallagher et al., 2017). The Kerlan-Jobe Orthopedic Clinic (KJOC) Shoulder and Elbow Score (Alberta et al., 2010) is one of the most widely used, valid, and reliable clinical outcome measures that is specific to the shoulder and elbow joint in overhead athletes (Merolla, Paladini, and Porcellini, 2018; Peduzzi et al., 2019; Saper et al., 2018). The KJOC is a patient-administered questionnaire consisting of 10 items to measure the functional status of the upper extremity in this high-functioning population. The questionnaire asks athletes to rate their self-perceived ability to perform sport-specific movements (e.g., throwing or hitting a ball). The score can be applied by apparently healthy athletes to assess the functional status of the shoulder and elbow. It can particularly detect overuse injuries in athletes practicing their sports despite of pain. Furthermore, it can be applied by injured athletes as an evaluation tool to assess the effectiveness of an intervention.

So far, the original English questionnaire has been translated into Korean (Oh et al., 2017); Italian (Merolla et al., 2017); Turkish (Turgut and Tunay, 2018); and Norwegian (Fredriksen, 2019). To date, no comparable assessment tool exists in German, although overhead sports are very popular in German-speaking countries like Germany, Austria, and the German part of Switzerland with more than 3.5 million overhead sports club memberships collectively (Deutscher Olympischer Sportbund, 2019; Österreichische Bundes-Sportorganisation, 2019; Swiss Olympic, 2019). Furthermore, previous studies predominantly applied the KJOC score to baseball players (Franz et al., 2013; Kraeutler et al., 2013; Tsuruike, Ellenbecker, and Hirose, 2018), which reduces the applicability to the German-speaking area where baseball is less popular compared to traditional overhead sports like volleyball, tennis, or handball. The aim of this study was to develop a German version of the KJOC score through translation and cross-cultural adaptation. In addition, the reliability and validity of the questionnaire was tested in German-speaking athletes that practiced overhead sports.

Methods

The study protocol was approved by the Ethics Committee of the Faculty of Humanities and Social Sciences of the Humboldt-Universität zu Berlin (HU-KSBF-EK_2018_0007). All participants provided written informed consent. The study was conducted in two phases: First, translation and cross-cultural adaptation of the KJOC from English into German; and second, assessment of reliability and validity of the German questionnaire (Figure 1). The permission was granted by the author of the original questionnaire.

Instrument

The original KJOC questionnaire consists of a demographic cover sheet gathering data on the player's characteristics and injury history. This is followed by 10 questions on shoulder and elbow function during athletic performance focusing on impairments, activity limitations, and participation restrictions of overhead athletes (Alberta et al., 2010). Answers are marked on 10-cm visual analogue scales (VAS). For analysis, the marks on the VAS are measured manually with a standard ruler to the nearest millimeter and recorded in centimeters as a score. The maximum score per item is 10. The sum of the 10 items is calculated and compared to a maximum total score of 100. Higher scores indicate a higher functional status of the shoulder and/or elbow.

Translation and cross-cultural adaptation

The translation and cross-cultural adaptation process was performed in six stages according to the guideline for the process of cross-cultural adaptation of self-report measures proposed by Beaton, Bombardier, Guillemin, and Ferraz (2000): 1) Initial translation from English into German by two bilingual translators whose mother tongue is German, of which one was a physiotherapist and one was a sports sociologist without a medical background; 2) Synthesis of the two translations by producing one common translation. The synthetization group consisted of the two translators and a language-competent physiotherapist; 3) Back Translation of the translated questionnaire into English by two bilingual English native speakers, of which one was a biomechanist with a medical background and one was a mathematician without a medical background; 4) Expert Committee meeting to obtain a prefinal version of the KJOC-G questionnaire. The seven-member expert committee consisted of the four bilingual translators,

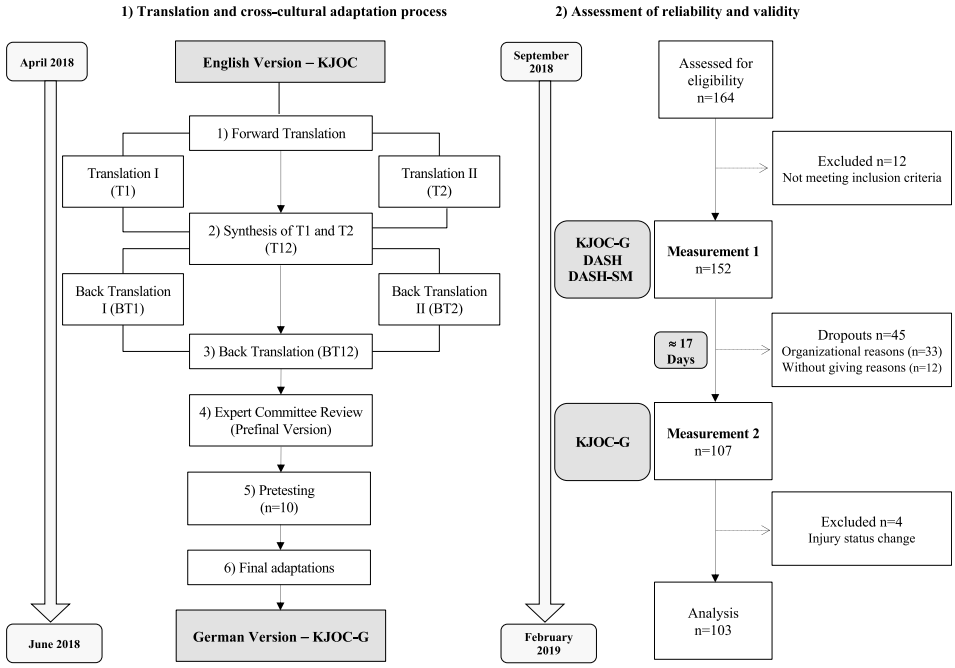

Figure 1. Flowcharts of the two substudies: 1) Translation and cross-cultural adaptation process and 2) Assessment of reliability and validity. (KJOC, Kerlan-Jobe Orthopedic clinic shoulder and elbow score; KJOC-G, German version of the Kerlan-Jobe orthopedic clinic shoulder and elbow score; T, translation; BT, back translation; DASH, disabilities of the shoulder, arm and hand; DASH-SM, disabilities of the shoulder, arm and hand sports module).

a physiotherapist, a methodologist and a language professional (Germanist). Decisions were made to obtain semantic, idiomatic, experiential and conceptual equivalence between the original questionnaire and the German version; 5) Test of the prefinal version in a pretest sample of overhead athletes (handball, volleyball, tennis, basketball, badminton) with each participant completing the pre-final questionnaire and a detailed protocol addressing the comprehensibility and applicability to ensure the preservation of an equivalence of the adapted questionnaire in an applied situation within the target population; and 6) Final adaptations of the questionnaire according to the pretest results and expert committee approval of the final version of the questionnaire (Appendix).

All stages of the translation and cross-cultural adaptation process were documented by detailed written reports and protocols, which can be provided upon request, recording issues, and rationales during the respective translation, synthesis, or discussion process.

Assessment of reliability and validity

Participants and recruitment

Initially, a total of 164 overhead athletes was recruited for the study. The participants were recruited via the outpatient clinics of Charité Berlin and the German Sport University Cologne and by directly contacting several sports clubs. The eligibility criteria were: 1) German-speaking; 2) age between 18 and 45 years; and 3) participation in an overhead sport, such as handball, volleyball, baseball, softball, basketball, water polo, tennis, or badminton at competition level with at least two training sessions per week. We included healthy players and injured players with acute elbow and/or shoulder complaints. Exclusion procedure and reasons for dropouts are illustrated in Figure 1. All participants filled in a demographic data sheet including data about sports participation and injury history. All participants provided written informed consent.

Internal consistency

Internal consistency as a degree of homogeneity of the single items of the KJOC-G score was evaluated using Cronbach's alpha coefficient. Alpha values between 0.70 – 0.90 are considered as a measure of good internal consistency indicating high correlations among the items within the scale while alpha values below 0.70 indicate poor reliability (Nunnally and Bernstein, 1994; Terwee et al., 2007).

Test-retest reliability

The test–retest reliability was assessed by calculating the intraclass correlation coefficient (ICC) with

corresponding 95% confidence intervals (CI) for each item between the KJOC-G test and retest scores. A two-way, random effects single measure absolute agreement $ICC_{2,1}$ was used according to the Shrout and Fleiss nomenclature (Shrout and Fleiss, 1979). ICC values less than 0.5 indicate poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability and values greater than 0.90 indicate excellent reliability (Rosner, 1982).

The time frame of approximately two weeks between the test and retest of the questionnaire was chosen to ensure a period that is long enough to prevent recall bias and short enough to avoid clinical changes (Terwee et al., 2007). Participants reporting status changes due to acute injuries or other circumstances were excluded from test–retest analysis (Figure 1).

Measurement error was expressed with the standard error of measurement (SEM) and calculated with the formula $SEM = SD_{difference} \div \sqrt{2}$, where $SD_{difference}$ is the standard deviation of the mean score change between the two-time points and $\sqrt{2}$ was used since the questionnaires were filled in at two different time points (de Vet, Terwee, Mokkink, and Knol, 2011; Harvill, 1991). Afterward, the SEM was converted into the smallest detectable change (SDC) with the formula $SDC = 1.96 \times \sqrt{2} \times SEM$ reflecting the smallest detectable within-person change in score (Terwee et al., 2007). A Bland–Altman plot (95% limits of agreement) was used to plot the mean difference between the KJOC-G test and retest scores against the mean of the two measures (Bland and Altman, 1986).

Validity

The construct validity of the KJOC-G was examined by correlation with established instruments that measure comparable constructs (Kirshner and Guyatt, 1985; Terwee et al., 2007). All participants completed the German version of the DASH (Disabilities of the Shoulder, Arm, and Hand) and the DASH sports module (DASH-SM) (Germann, Harth, Wind, and Demir, 2003; Germann, Wind, and Harth, 1999) at the initial measurement time point. The DASH is a commonly used highly reliable assessment for symptoms and the functional status of the entire upper extremity in ADL while the DASH-SM assesses symptoms and the functional status of the upper limb in sports settings (Hudak, Amadio, and Bombardier, 1996). The score range of the questionnaires is from 0 to 100, with 0 reflecting no health issues of the upper extremity and 100 corresponding to maximal disability of the arm, shoulder, and/or hand (Offenbacher, Ewert, Sangha, and Stucki, 2003). Construct validity was evaluated using Spearman's rank correlation test. Spearman correlation coefficients of 0.70–0.89 were considered strong, coefficients of 0.40–0.69 were considered moderate and coefficients of 0.10–0.39 were considered weak (Schober, Boer, and Schwarte, 2018).

As a further aspect of construct validity, the known-group method analysis (Portney and Watkins, 2015) (initial measurement), was performed by testing the ability of the KJOC-G to differentiate between asymptomatic, who self-reported their injury status as healthy (Category 1: Playing without any arm trouble) and symptomatic athletes (Category 2: Playing with arm trouble; Category 3: Not playing due to arm trouble). Independent samples t-test and Mann–Whitney *U* test were used to establish evidence of known-group validity. Furthermore, Pearson's effect size r was calculated.

Structural validity was tested by Principal Component Analysis (PCA) with varimax rotation to determine the dimensionality of the overall scale (de Vet, Ader, Terwee, and Pouwer, 2005). Only factors with eigenvalues ≥1 were considered (Guttman, 1954; Kaiser, 1960).

Floor and ceiling effects

Floor or ceiling effects are considered to be present if more than 15% of the participants obtained the lowest or highest possible score within each item. If more than 25% of the items showed floor or ceiling effects, the questionnaire as a whole was considered to have floor or ceiling effects (McHorney and Tarlov, 1995; Terwee et al., 2007).

Feasibility

The time the athletes needed for reading the information and completing the questionnaire was measured during the initial administration of the questionnaire. Furthermore, the time to analyze the questionnaire by one investigator that is to measure the distances for each item and calculate the score was measured in a sub-cohort. All scoring analyses within the study were performed by one examiner using the same ruler for every analysis.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics software for Windows, Version 21.0 (Armonk, NY: IBM Corp). Descriptive statistics were calculated and reported for all relevant measures. The Shapiro–Wilk test was used to assess the

distribution of the data. Statistical significance was set at $p < .05$.

Results

Translation and cross-cultural adaptation

The translation and adaptation process was carried out without major difficulties. In general, the structure of the original questionnaire was maintained. All 10 items of the KJOC were transferred into the German KJOC-G, reflecting areas that are important to the target population of overhead athletes in German-speaking environments (Appendix).

The primary translations into German, as well as the subsequent back translations into English, led to minor linguistic inconsistencies, which were resolved during the meetings of the synthetization group and the expert committee. In addition, we had to consider the characteristics of the German language as, for example, gender-specific terms for athletes and coaches. As a result, we established a gender-neutral language throughout the questionnaire.

Minor linguistic and cultural adaptions included the adjustment of the item which was described in relation to the American league system and required adaptation to the German league system. The terms *'Professional Major League,' 'Professional Minor League,' 'Intercollegiate,'*and *'High School'* were transferred into the German equivalences *'1. Bundesliga,' '2. Bundesliga,' 'Regionalliga,' 'Oberliga,' 'Verbandsliga,' 'Landesliga,' 'Bezirksliga,'* and *'Kreisliga'* with an additional option to list another different or specific league.

The original questionnaire contains a response category which is specifically related to baseball: *"Significant limitation (became relief pitcher, switched to short races for example)."* Due to the limited popularity of baseball in Germany and in reference to the aim to establish a questionnaire for a larger range of overhead sports, the response option was modified to a more general expression: "*Significant limitation, I became a substitute or was only asked to play for short game times."*

Some further expressions were translated based on content rather than a literal translation. For example, the term *'agents'* was transformed into the more suitable expression *'VermittlerInnen'* (English *'fasciliator'* or '*intermediaries*') and *'scholarship'* into *'Förderung'* (*English 'support'* or *'funding'*). The options of expressing sport-specific motions like *'throwing,' 'serve'* and *'stroke'* in the original questionnaire were extended to *'Wurf', 'Schlag,' 'Aufschlag,'* and *'Pass'* (English *'pass'*) to adequately involve relevant actions of throwing sports.

Preliminary testing in the pretest sample of 10 overhead athletes did not reveal any difficulties understanding the KJOC-G. The written protocols of the test participants led to minor revisions of the first version and a final version of the KJOC-G was developed.

Assessment of reliability and validity

A total of 152 (87 males/65 females) professional/semi-professional and amateur overhead athletes (mean age 25.0 ± 6.6 years) with a mean playing experience of 13.3 ± 6.6 years was included in the second part of the study. Particular analyses were performed with subgroups of the cohort. Participant characteristics and KJOC-G scores of subgroups are presented in Table 1.

Internal consistency

The Cronbach's α was 0.930 indicating an excellent internal consistency of the KJOC-G score with homogenous items during the initial administration. Additional analysis of internal consistencies in male and female athletes separately and within different subgroups showed similar results (Table 2).

Test-retest reliability

Of all participants, 103 athletes completed the questionnaire twice with a time interval of 16.8 ± 5.6 days between the two sessions in order to determine the stability of the outcome score over time. The test–retest reliability of the total KJOC-G score was excellent with an ICC of 0.94. Regarding the single items, the test–retest reliability ($ICC_{2.1}$) was good in 9 of 10 items (ICC 0.75–0.85) and lower in item 5 (ICC 0.34), referring to the athletes' relationship with coaches, management, and agents being affected by arm function (Table 3).

The SEM was 1.6 for all participants, 1.2 for asymptomatic athletes and 3.5 for symptomatic athletes indicating small measurement errors. The SDC was 4.3 for all participants, 3.3 for asymptomatic athletes and 9.7 for symptomatic athletes. The Bland–Altman plot showed a small mean difference of −0.4 between KJOC-G test and retest scores (95% limits of agreement – 12,5 to 11.6) (Figure 2).

Validity

The KJOC-G showed moderate and statistically significant correlations with the DASH ($r = -0.51$, $p < .05$) and the DASH-SM ($r = -0.54$, $p < .05$). When analyzing male and female athletes separately, correlation levels varied although the differences did not reach significance. Compared to the results of the whole study population,

Table 1. Demographic data and KJOC-G scores (initial administration) of the 152 overhead athletes participating in the study.

Variable	Data	KJOC-G scores
Number of athletes	152 (100%)	86.2 ± 15.9
Sex		
Males	87 (57.2%)	86.9 ± 14.9
Females	65 (42.8%)	85.2 ± 17.1
Type of overhead sports		
Handball	38 (25.0%)	81.9 ± 18.6
Water Polo	38 (25.0%)	86.8 ± 13.2
Volleyball	24 (15,8%)	84.0 ± 20.1
Basketball	24 (15,8%)	93.5 ± 11.9
Tennis	9 (5.9%)	87.0 ± 14.6
Badminton	5 (3.3%)	93.9 ± 5.8
Baseball	13 (8.6%)	84.1 ± 12.1
Softball	1 (0.7%)	82.8
League		
Professional/semiprofessional (1st/2nd division)	75 (49.3%)	89.1 ± 13.4
Amateur	77 (50.7%)	83.3 ± 17.6
Category		
Asymptomatic Athletes (Playing without arm trouble)	106 (69.7%)	93.1 ± 8.7
Symptomatic Athletes	46 (30.3%)	70.2 ± 17.1
Playing with arm trouble	45 (29.6%)	71.2 ± 16.0
Not playing due to arm trouble	1 (0.7%)	26.6
Current injuries	21 (13.8%)	62.83 ± 19.3
Shoulder	8 (38.1%)	63.0 ± 20.7
Rotator Cuff Tendinopathy	1 (4.8%)	82.9
Impingement	4 (19.1%)	72.5 ± 10.1
Instability	2 (9.5%)	52.3 ± 19.9
Labral Lesion	1 (4.8%)	26.6
Elbow	1 (4.8%)	78.3
Tendinitis	1 (4.8%)	78.3
N/A or unspecified	12 (57.1%)	61.5 ± 19.4
Previous injuries	46 (30.3%)	76.7 ± 19.0
Shoulder	32 (69.6%)	75.8 ± 17.3
Rotator Cuff Tendinopathy	7 (15.2%)	79.2 ± 17.6
Bursitis	6 (13.0%)	82.7 ± 14.3
Impingement	6 (13.0%)	71.4 ± 9.7
Rotator Cuff Tears	2 (4.4%)	85.4 ± 9.2
Labral/Capsular Lesion	2 (4.4%)	61.8 ± 49.8
Instability	3 (6.5%)	63.6 ± 24.1
Luxation	2 (4.4%)	79.7 ± 5.2
Other	4 (8.7%)	74.2 ± 12.2
Elbow	5 (10.9%)	86.9 ± 8.0
Bursitis	1 (2.2%)	99.7
Fracture	1 (2.2%)	82.8
Tendinopathy	3 (6.5%)	84.0 ± 4.9
N/A or unspecified	9 (19.6%)	73.8 ± 25.9

Data are given as mean and standard deviation (±) or as counts and percentages (%).
KJOC-G, German version of the Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow score; N/A, not applicable.

Table 2. Internal consistency of the KJOC-G within different samples using Cronbach's alpha coefficient of test and retest.

Sample	Cronbach's alpha coefficient	
	Test	Retest
All athletes (n = 152/103)	0.93	0.95
Male athletes (n = 87/49)	0.93	0.95
Female athletes (n = 65/54)	0.93	0.95
Professional + semiprofessional athletes (n = 75/54)	0.93	0.93
Amateur athletes (n = 77/49)	0.93	0.96
Asymptomatic athletes (n = 106/74)	0.86	0.85
Symptomatic athletes (n = 46/29)	0.90	0.94

KJOC-G, German version of the Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow score

women showed a higher correlation with the DASH (r = −0.61, $p < .05$) and a lower correlation with the DASH-SM (r = −0.50, $p < .05$). By contrast, male athletes showed a lower correlation with the DASH (r = −0.46, $p < .05$) and a higher correlation with the DASH-SM (r = −0.58, $p < .05$).

Known-group method analysis showed a significant difference in mean KJOC-G scores of 21.9 (95% CI 18.0 to 26.0; $p < .05$) between asymptomatic athletes with the self-assigned playing status 'playing without any arm trouble' (score: 93.1 ± 8.7; n = 106) and symptomatic athletes, with the self-assigned playing status 'playing with arm trouble' (score: 71.2 ± 16.0; n = 45) (Figure 3). Category 3 'Not playing due to arm trouble' was not included in further analyses since only one participant assigned himself to this group. Pearson's effect size r was 0.65 indicating a strong effect.

Table 3. Test–retest reliability ($ICC_{2.1}$) of the KJOC-G scores tested in 103 overhead athletes.

Item number	Test scores	Retest scores	$ICC_{2.1}$	95% CI
1	8.1 ± 2.3	8.0 ± 2.6	0.78	0.69–0.85
2	8.2 ± 2.2	8.3 ± 2.5	0.78	0.70–0.85
3	8.3 ± 2.2	8.5 ± 2.2	0.75	0.65–0.83
4	8.6 ± 2.0	8.6 ± 2.1	0.82	0.74–0.87
5	9.6 ± 1.2	9.5 ± 1.5	0.34	0.16–0.50
6	8.6 ± 2.2	8.7 ± 2.2	0.84	0.77–0.89
7	8.6 ± 2.1	8.6 ± 2.2	0.85	0.79–0.90
8	9.1 ± 1.5	9.1 ± 1.7	0.75	0.65–0.82
9	8.7 ± 2.0	8.9 ± 1.9	0.76	0.67–0.83
10	8.4 ± 2.2	8.5 ± 2.2	0.81	0.74–0.87
Total KJOC-G score	86.2 ± 15.9	86.7 ± 17.6	0.94	0.91–0.96

KJOC-G scores are presented as mean and standard deviation (±).
ICC, intraclass correlation coefficient; CI, confidence interval; KJOC-G, German version of the Kerlan- Jobe Orthopedic Clinic Shoulder and Elbow score.

Regarding the structural validity of the KJOC-G questionnaire, principal component analysis showed one underlying factor of the KJOC-G with an explained variance of 62.5% and an eigenvalue of 6.2. Item 10, related to performance, and item 2, related to pain, contributed with the highest loadings to the underlying factor which could be described as 'functional shoulder and elbow status.' The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.900, representing a relatively good factor analysis and Bartlett's test of Sphericity was significant, indicating that correlations between items were sufficiently large for performing a Principal component analysis.

Floor and ceiling effects

The KJOC-G did not show a floor effect for symptomatic and asymptomatic athletes. No ceiling effect of the questionnaire was observed in symptomatic athletes with less than 25% of the items exceeding the 15% mark (item 5: 60% and item 6: 17.8%). Considering all asymptomatic athletes, 35.8% to 72.6% scored 10 in each item, indicating a ceiling effect in this subgroup.

Feasibility

The average time to complete the questionnaire was 5:32 ± 2:03 min (n = 148). The time to analyze the questionnaire was 1:58 ± 0:42 min (n = 15).

Discussion

This study shows the first standardized approach to translate and culturally adapt the original KJOC score into German and provides evidence for its psychometric properties within a large sample of German-speaking overhead athletes. The results of the study show that the German version of the KJOC is a reliable and valid questionnaire to assess the shoulder and elbow in German overhead athletes.

Our results indicate that the German version of the KJOC has excellent internal consistency within the total

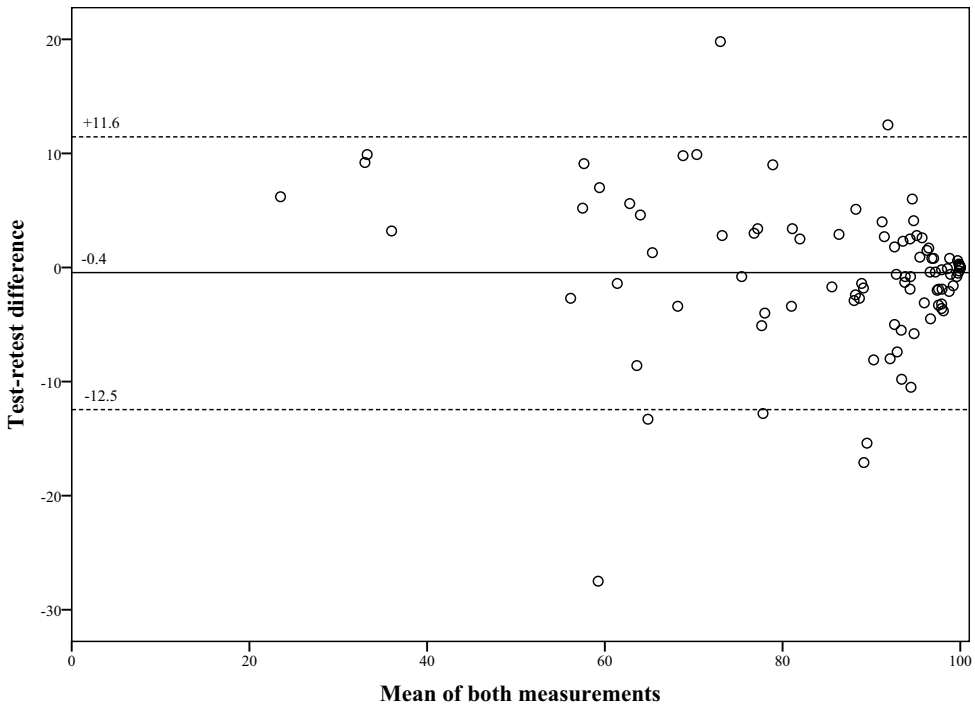

Figure 2. Bland-Altman plot showing the test-retest results of 103 participants who completed the KJOC-G twice. Solid line: Mean difference between KJOC-G test and retest scores. Horizontal dashed lines: 95% limits of agreement. (KJOC-G, German version of the Kerlan-Jobe orthopedic clinic shoulder and elbow score).

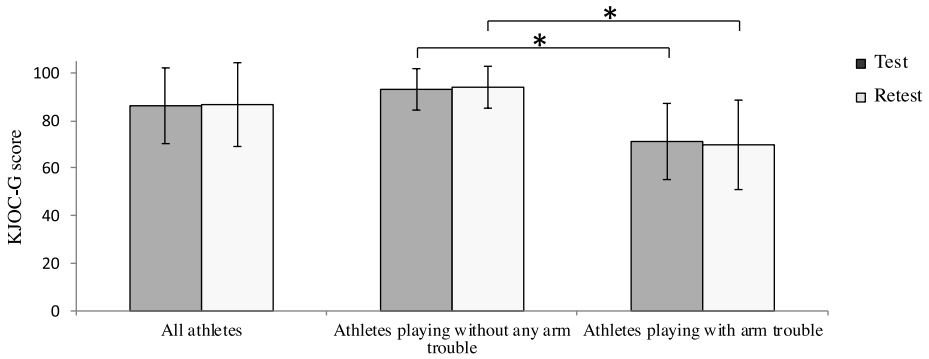

Figure 3. Comparison of mean scores and standard deviations (±) of the KJOC-G among all actively playing athletes (n = 151) and among the categories of the current status of their arm 'Playing without any arm trouble' (n = 106) and 'Playing with arm trouble' (n = 45) at test and retest. (KJOC-G, German version of the Kerlan-Jobe orthopedic clinic shoulder and elbow score). * significant difference (p <.05)

study population (Cronbach's alpha = 0.93) and within the subgroups (Alpha values between 0.85 and 0.96). These results are in accordance with previous translations of the KJOC (Fredriksen, 2019; Merolla et al., 2017; Oh et al., 2017).

Test–retest reliability ($ICC_{2.1}$) of the total KJOC-G score was excellent with an ICC of 0.94. This result is in accordance with the original English questionnaire with an ICC of 0.88 (Alberta et al., 2010), the Italian KJOC with an ICC of 0.99 (Merolla et al., 2017) and with the Norwegian KJOC-N with an ICC of 0.98 (Fredriksen, 2019). Test–retest reliability for the single items was good with exception of item 5 (ICC = 0.34). This item queries if the athlete's arm problems affected the relationship with coaches, management, and agents. The reason for this lower test–retest reliability may be due to the fact that many participants were not playing under contracts with 50.7% playing on amateur level. However, as item 5 may be relevant for high-level athletes, we decided to keep it in the questionnaire. Our results are in accordance with the analysis of the original questionnaire, showing the poorest test–retest reliability in item 5 in a cohort of intercollegiate and professional overhead athletes (Alberta et al., 2010). Concerning the construct validity, the application of the DASH and the DASH-SM as related measures to assess the correlation with the KJOC can be discussed. While these instruments are considered as comparable tools, the DASH relating to ADLs and the DASH-SM with only four general sport-related questions may not be as sensitive and specific for the high-functioning population of overhead athletes as the KJOC-G. Thus, we did not expect high correlations. Nevertheless, they are currently the only available German instruments suited to compare common constructs of symptoms, functional status, and performance of the upper extremity. Our results showed moderate correlations with the DASH (r = −0.51) and the DASH-SM (r = −0.54) which are slightly lower than the results of the original questionnaire (Alberta et al., 2010) and its previous translations (Fredriksen, 2019; Merolla et al., 2017). While moderate correlations with the DASH and the DASH-SM indicated moderate construct validity of the KJOC-G, clear differences are apparent upon comparison of absolute scores. Assuming that 100% correspond to full elbow and shoulder function in each questionnaire, the deviation from this optimum (100% – mean value) adjusted to comparable values is 13.8% within the KJOC-G score, 10.1% with the DASH-SM and 5.5% with the DASH in all athletes. These results support our assumption that the KJOC-G is more specific for an athlete population than the DASH, which may not properly reflect complaints that appear in sport-specific conditions whereas ADLs can be performed without problems.

Known-group method analyses support the construct validity of the KJOC-G. It is able to distinguish between symptomatic and asymptomatic athletes, showing significant group differences and KJOC-G scores linked to their self-assigned injury status. Absolute KJOC-G scores of athletes playing without any arm trouble (Table 1) are in accordance with previous studies showing KJOC scores in heterogenous study groups of asymptomatic overhead athletes with mean scores of 93.6 (Turgut and Tunay, 2018) and 95.1 (Fredriksen, 2019) and symptomatic overhead athletes with mean scores of 61.7 (Turgut and Tunay, 2018) and 77.8 (Fredriksen, 2019).

Previous studies proposed cutoff values with scores below 90 points indicating deficient health status of athletes, which should be further monitored or would alert the responsible medical staff to initialize further diagnostics (Kraeutler et al., 2013; Turgut and Tunay, 2018). In our view, the stated cutoff values should be

considered with caution, since these studies did not provide concrete indications or evidence regarding the criteria for the definition or calculation of corresponding thresholds. Plausible criteria to set cutoff values might be the ability to participate symptom-free in training and competition or the necessity of therapeutic intervention and the respective scores. Nevertheless, this generally determined threshold also seems to apply to our results considering the concentrated appearance of KJOC-G scores above this threshold (Figure 2).

Our results of the principal component analysis regarding the structural validity of the KJOC-G questionnaire indicate one underlying factor of the questionnaire. This result is in accordance with the result of the confirmatory factor analysis of the original questionnaire (Alberta et al., 2010) and the principal component analysis of the Turkish KJOC-SES-Tre (Turgut and Tunay, 2018).

While the KJOC-G did not show any floor effects for symptomatic and asymptomatic athletes, ceiling effects in asymptomatic athletes occurred. These findings are consistent with Turgut and Tunay (2018) who observed a ceiling effect when using the Turkish KJOC-SES-Tr for asymptomatic overhead athletes. However, these results are acceptable and have been expected since athletes are supposed to report high scores when they are unaffected by injury.

The feasibility of the questionnaire was confirmed. Readability and comprehension were verified by the participants of the pilot study. The interpretability of the items is justified by the manner of the questions which fulfill the requirements of short and simple words without jargon and questions that do not require reading skills beyond that of a 12-year-old (Streiner, Norman, and Cairney, 20152003).

Limitations

This study is not without limitations. Firstly, this study does not provide data on the responsiveness of the KJOC-G, which could provide valuable information on the instrument's ability to assess changes over time used to assess intervention outcomes (Aaronson et al., 2002). Further limitations imply general weaknesses of patient-reported outcomes. The subjective nature of the KJOC scoring methodology may lead to inaccuracies in the data collection. The use of self-reported patient questionnaires generally involves the risk of reporting and recall bias. Also, we found inconsistencies within the statements of the athletes. While 45 athletes assigned themselves to category 2 "Playing with arm trouble," only 21 athletes ticked "yes" at the question "Is your arm currently injured?". A reason for this might be that the respondents self-define "injury" as a more severe restriction than they self-define the term "trouble" or that they don't share a common understanding of the term "injury." These ambiguities are also found in academic discourses. While Swenson, Yard, Fields, and Comstock (2009) defined injury as the loss of at least one day of athletic participation or an "event requiring medical attention," Sciascia, Haegele, Lucas, and Uhl (2015) and Clarsen and Bahr (2014) defined injury as "any event an individual could recall that he or she would personally consider to be an episode of injury but not necessarily sustained during participation in athletics." However, we intentionally did not specify and define 'injury' within the KJOC-G to avoid influencing individual perceptions of the athletes. Consequently, when analyzing the questionnaire, it is necessary to be aware that social desirability biases can occur or that personal experiences may impact the survey responses (Paulhus and Reid, 1991). Apart from different interpretation possibilities, athletes might be afraid of negative consequences regarding playing times and other matters, consequently minimizing or downplaying any injury or pain when filling in the questionnaire.

Regarding the statistical analysis of the structural validity using the principal component analysis, the confirmatory factor analysis may have been an alternative and possibly superior method to investigate this. However, this would not have allowed comparison with previous publications (Turgut and Tunay, 2018).

Implications for clinical practice and perspectives

The KJOC-G score can be applied by researchers, physiotherapists, physicians, sports therapists, coaches and athletes in German-speaking environments to identify functional impairments, to monitor treatment and rehabilitation effectiveness and to evaluate return-to-sport and return-to-competition ability after shoulder and elbow injuries in overhead athletes. It can be used supportively within clinical diagnostics but does not replace extensive physical examinations of injured athletes. Furthermore, KJOC-G scores could potentially function as predictors of potential future injuries, as previous studies showed relationships between lower preseason KJOC scores and increased in-season injury risk (Holtz and O'Connor, 2018). Furthermore, the presence of previous injuries showed to be an indicator of lower KJOC scores resulting in less physical capability before the competitive season (Franz et al., 2013; Holtz and O'Connor, 2018; Sciascia, Haegele, Lucas, and Uhl, 2015).

The questionnaire is easy to administer in a sports setting as well as in a clinical setting, where patients might fill in the questionnaire in a waiting room. The questionnaire

is self-explanatory and easy to complete. When printed true to scale, the KJOC-G can be analyzed in a reasonably short time in less than two minutes by therapists or physicians. Erickson et al. (2018) even proposed to obtain the KJOC over the phone, showing no significant differences in overall score as compared with that from in-person administration. Future studies may investigate the sensitivity of the KJOC-G to assess changes over time and the feasibility of further implementation types that will meet today's requirements such as digital applications.

Conclusion

This study shows that the KJOC-G is a reliable and valid, region and population-specific patient-reported outcome score that focuses on functional parameters related to sport-specific movement and can contribute to the assessment and detection of sports-related injuries in overhead athletes.

Acknowledgments

The authors would like to acknowledge Dr Myfanwy Evans and Dr Maike Bachmann-van Helt, who contributed to the translation and adaptation process of the study. Particular thanks go to the outpatient clinics of the Charité Berlin and the German Sport University Cologne for the assistance in recruiting participants. Furthermore, we like to thank all athletes who participated in this study. The study is part of the PhD project of Carolin Schulz, which is partially funded by a PhD scholarship of the FAZIT-Foundation of the Frankfurter Allgemeine Zeitung, Frankfurt am Main, Germany. Additionally, we acknowledge support by the Open Access Publication Fund of Humboldt-Universität zu Berlin.

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Declaration of interest

The authors declare no conflict of interest.

References

Aaronson N, Alonso J, Burnam A, Lohr KN, Patrick DL, Perrin E, Stein RE 2002 Assessing health status and quality-of-life instruments: Attributes and review criteria. Quality of Life Research 11: 193–205. doi:10.1023/A:1015291021312

Alberta FG, ElAttrache NS, Bissell S, Mohr K, Browdy J, Yocum L, Jobe F 2010 The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. American Journal of Sports Medicine 38: 903–911. doi:10.1177/0363546509355642

Asker M, Brooke HL, Walden M, Tranaeus U, Johansson F, Skillgate E, Holm LW 2018 Risk factors for, and prevention of, shoulder injuries in overhead sports: A systematic review with best-evidence synthesis. British Journal of Sports Medicine 52: 1312–1319. doi:10.1136/bjsports-2017-098254

Beaton DE, Bombardier C, Guillemin F, Ferraz MB 2000 Guidelines for the process of cross-cultural adaptation of self-report measures. Spine 25: 3186–3191. doi:10.1097/00007632-200012150-00014

Bland JM, Altman DG 1986 Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1: 307–310. doi:10.1016/S0140-6736(86)90837-8

Caine DJ 2010 Epidemiology of injury in olympic sports. Chichester: Wiley-Blackwell.

Clarsen B, Bahr R 2014 Matching the choice of injury/illness definition to study setting, purpose and design: One size does not fit all! British Journal of Sports Medicine 48: 510–512. doi:10.1136/bjsports-2013-093297

de Vet HC, Ader HJ, Terwee CB, Pouwer F 2005 Are factor analytical techniques used appropriately in the validation of health status questionnaires? A systematic review on the quality of factor analysis of the SF-36. Quality of Life Research 14: 1203–1218. doi:10.1007/s11136-004-5742-3

de Vet HC, Terwee CB, Mokkink LB, Knol DL 2011 Measurement in medicine: A practical guide. Cambridge; New York: Cambridge University Press.

Deutscher Olympischer Sportbund [German Olympic Sports Confederation] 2019 Bestandserhebung 2017 [Inventory Survey 2017]. https://cdn.dosb.de/user_upload/www.dosb.de/uber_uns/Bestandserhebung/BE-Heft_2017_aktualisierte_Version_25.01.18.pdf.

Erickson BJ, Chalmers PN, Newgren J, Malaret M, O'Brien M, Nicholson GP, Romeo AA 2018 Can the Kerlan-Jobe orthopaedic clinic shoulder and elbow score be reliably administered over the phone?: A randomized study. Orthopaedic Journal of Sports Medicine 6: 2325967118791510. doi:10.1177/2325967118791510

Franz JO, McCulloch PC, Kneip CJ, Noble PC, Lintner DM 2013 The utility of the KJOC score in professional baseball in the United States. American Journal of Sports Medicine 41: 2167–2173. doi:10.1177/0363546513495177

Fredriksen 2019 Norwegian translation, cross-cultural adaptation and validation of the Kerlan-Jobe orthopaedic clinic shoulder and elbow questionnaire. BMJ Open Sport and Exercise Medicine 5: e000611. doi:10.1136/bmjsem-2019-000611

Gallagher J, Needleman I, Ashley P, Sanchez RG, Lumsden R 2017 Self-reported outcome measures of the impact of injury and illness on athlete performance: A systematic review. Sports Medicine 47: 1335–1348. doi:10.1007/s40279-016-0651-5

Germann G, Harth A, Wind G, Demir E 2003 Standardisation and validation of the German version 2.0 of the disability of

arm, shoulder, hand (DASH) questionnaire. Unfallchirurg 106: 13–19. doi:10.1007/s00113-002-0456-x

Germann G, Wind G, Harth A 1999 The DASH(Disability of arm-shoulder-hand) questionnaire–A new instrument for evaluating upper extremity treatment outcome. Handchirurgie - Mikrochirurgie - Plastische Chirurgie 31: 149–152. doi:10.1055/s-1999-13902

Guttman L 1954 The principal components of scalable attitudes. New York: Free Press.

Harvill LM 1991 Standard error of measurement. Educational Measurement: Issues and Practice 10: 33–41. doi:10.1111/j.1745-3992.1991.tb00195.x

Holtz KA, O'Connor RJ 2018 Upper extremity functional status of female youth softball pitchers using the Kerlan-Jobe orthopaedic clinic questionnaire. Orthopaedic Journal of Sports Medicine 6: 2325967117748599. doi:10.1177/2325967117748599

Hudak PL, Amadio PC, Bombardier C 1996 Development of an upper extremity outcome measure: The DASH (disabilities of the arm, shoulder and hand). The upper extremity collaborative group (UECG). American Journal of Industrial Medicine 29: 602–608. doi:10.1002/(SICI)1097-0274(199606)29:6<602::AID-AJIM4>3.0.CO;2-L

Kaiser HF 1960 The application of electronic computers to factor analysis. Educational and Psychological Measurement 20: 141–151. doi:10.1177/001316446002000116

Kirshner B, Guyatt G 1985 A methodological framework for assessing health indices. Journal of Chronic Diseases 38: 27–36. doi:10.1016/0021-9681(85)90005-0

Kraan RB, de Nobel D, Eygendaal D, Daams JG, Kuijer PP, Maas M 2019 Incidence, prevalence, and risk factors for elbow and shoulder overuse injuries in youth athletes: A systematic review. Translational Sports Medicine 2: 186–195. doi:10.1002/tsm2.82

Kraeutler MJ, Ciccotti MG, Dodson CC, Frederick RW, Cammarota B, Cohen SB 2013 Kerlan-Jobe orthopaedic clinic overhead athlete scores in asymptomatic professional baseball pitchers. Journal of Shoulder and Elbow Surgery 22: 329–332. doi:10.1016/j.jse.2012.02.010

Mayer J, Giel KE, Malcolm D, Schneider S, Diehl K, Zipfel S, Thiel A 2018 Compete or rest? Willingness to compete hurt among adolescent elite athletes. Psychology of Sport and Exercise 35: 143–150. doi:10.1016/j.psychsport.2017.12.004

McHorney CA, Tarlov AR 1995 Individual-patient monitoring in clinical practice: Are available health status surveys adequate? Quality of Life Research 4: 293–307. doi:10.1007/BF01593882

Meister K 2000 Injuries to the shoulder in the throwing athlete. Part one: Biomechanics//pathophysiology/classification of injury. American Journal of Sports Medicine 28: 265–275. doi:10.1177/03635465000280022301

Merolla G, Corona K, Zanoli G, Cerciello S, Giannotti S, Porcellini G 2017 Cross-cultural adaptation and validation of the Italian version of the Kerlan-Jobe orthopaedic clinic shoulder and elbow score. Journal of Orthopaedics and Traumatology 18: 415–421. doi:10.1007/s10195-017-0467-6

Merolla G, Paladini P, Porcellini G 2018 Assessment of return to play in professional overhead athletes subjected to arthroscopic repair of rotator cuff tears and associated labral injuries using the Italian version of the Kerlan-Jobe orthopedic clinic shoulder and elbow score. Journal of Musculoskeletal Surgery and Research 102: 29–34. doi:10.1007/s12306-018-0547-7

Nunnally JC, Bernstein IH 1994 Psychometric Theory. New York: McGraw-Hill.

Österreichische Bundes-Sportorganisation [Austrian Federal Sports Organization] 2019 Mitgliederstatistik [Membership Statistics]. https://www.bso.or.at/fileadmin/Inhalte/Dokumente/Mitgliedsstatistik/BSO_Mitglieder_Stat_2019.pdf.

Offenbacher M, Ewert T, Sangha O, Stucki G 2003 Validation of a German version of the 'Disabilities of arm, shoulder and hand' questionnaire (DASH-G). Zeitschrift für Rheumatologie 62: 168–177. doi:10.1007/s00393-003-0461-7

Oh JH, Kim JY, Limpisvasti O, Lee TQ, Song SH, Kwon KB 2017 Cross-cultural adaptation, validity and reliability of the Korean version of the Kerlan-Jobe orthopedic clinic shoulder and elbow score. Journal of Shoulder and Elbow Surgery Open Access 1: 39–44. doi:10.1016/j.jses.2017.03.001

Parsons JT, Snyder AR 2011 Health-related quality of life as a primary clinical outcome in sport rehabilitation. Journal of Sport Rehabilitation 20: 17–36. doi:10.1123/jsr.20.1.17

Paulhus DL, Reid DB 1991 Enhancement and denial in socially desirable responding. Journal of Personality and Social Psychology 60: 334–356. doi:10.1037/0022-3514.60.2.307

Peduzzi L, Grimberg J, Chelli M, Lefebvre Y, Levigne C, Kany J, Clavert P, Bertiaux S, Garret J, Hardy A, et al. 2019 Internal impingement of the shoulder in overhead athletes: Retrospective multicentre study in 135 arthroscopically-treated patients. Orthopaedics and Traumatology: Surgery and Research 105: S201–S206.

Portney LG, Watkins MP 2015 Foundations of clinical research: Applications to practice (4th ed), Upper Saddle River, NJ: F. A. Davis Company.

Rosner B 1982 Fundamentals of biostatistics. Boston: Duxbury Press.

Saper M, Shung J, Pearce S, Bompadre V, Andrews JR 2018 Outcomes and return to sport after ulnar collateral ligament reconstruction in adolescent baseball players. Orthopaedic Journal of Sports Medicine 6: 2325967118769328.

Schober P, Boer C, Schwarte LA 2018 Correlation coefficients: Appropriate use and interpretation. Anesthesia and Analgesia 126: 1763–1768. doi:10.1213/ANE.0000000000002864

Sciascia A 2013 A basic construct for improving outcomes in rehabilitation. International Journal of Athletic Therapy and Training 18: 14–19. doi:10.1123/ijatt.18.3.14

Sciascia A, Haegele LE, Lucas J, Uhl TL 2015 Preseason perceived physical capability and previous injury. Journal of Athletic Training 50: 937–943. doi:10.4085/1062-6050-50.7.05

Shrout PE, Fleiss JL 1979 Intraclass correlations: Uses in assessing rater reliability. Psychological Bulletin 86: 420–428. doi:10.1037/0033-2909.86.2.420

Streiner DL, Norman GR, Cariney J 2003 2015 Health measurement scales. A practical guide to their development and use (5th ed.). Oxford University Press.

Swenson DM, Yard EE, Fields SK, Comstock RD 2009 Patterns of recurrent injuries among US high school athletes, 2005-2008. American Journal of Sports Medicine 37: 1586–1593. doi:10.1177/0363546509332500

Swiss Olympic 2019 Anzahl Mitglieder und Vereine - Verbände 2016 [Number of members and associations - Federation 2016]. https://www.swissolympic.ch/dam/

jcr:86eb8e84-30f2-4f2f-b2db-d7680a677def/Anzahl-Mitglieder-und-Vereine-Verbaende_2016_DE.pdf.pdf.

Terwee CB, Bot SD, de Boer MR, van der Windt DA, Knol DL, Dekker J, Bouter LM, de Vet HC 2007 Quality criteria were proposed for measurement properties of health status questionnaires. Journal of Clinical Epidemiology 60: 34–42. doi:10.1016/j.jclinepi.2006.03.012

Tsuruike M, Ellenbecker TS, Hirose N 2018 Kerlan-Jobe Orthopaedic Clinic (KJOC) score and scapular dyskinesis test in collegiate baseball players. Journal of Shoulder and Elbow Surgery 27: 1830–1836. doi:10.1016/j.jse.2018.06.033

Turgut E, Tunay VB 2018 Cross-cultural adaptation of Kerlan-Jobe Orthopaedic Clinic shoulder and elbow score: Reliability and validity in Turkish-speaking overhead athletes. Acta orthopaedica et traumatologica turcica 52: 206–210. doi:10.1016/j.aott.2018.02.007

Wong TT, Lin DJ, Ayyala RS, Kazam JK 2017 Elbow injuries in adult overhead athletes. American Journal of Roentgenology 208: W110–W120. doi:10.2214/AJR.16.16511