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The Self-Assessment Corner for Shoulder Strength: Reliability, Validity, and Correlations With Upper Extremity Physical Performance Tests

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Context: Rotator cuff weakness and rotation ratio imbalances are possible risk factors for shoulder injury among overhead athletes. In consensus statements, organizations have highlighted the importance of a screening examination to identify athletes at risk of injury. The screening should be portable and designed to be feasible in many different environments and contexts.

Objective: To evaluate the reliability and validity of the Self-Assessment Corner (SAC) for self-assessing shoulder isometric rotational strength and examining whether performance on 2 physical performance tests was correlated with isometric shoulder rotational strength using the SAC in handball players.

Design: Cross-sectional study.

Setting: Sport setting.

Patients or Other Participants: A first sample of 42 participants (18 men, 24 women) was recruited to determine the reliability and validity of the SAC. In a second sample of 34 handball players (18 men, 16 women), we examined correlations between physical performance tests and the SAC.

Main Outcome Measure(s): The SAC was used to measure isometric rotational strength with the upper extremity at 90° of abduction in the frontal plane and 90° of external rotation and the elbow flexed to 90° with neutral rotation of the forearm. The SAC findings were compared with those from manual testing. Results from the seated medicine ball throw (SMBT) and closed kinetic chain upper extremity stability test (CKCUEST) were used to establish relationships with the SAC. We calculated intraclass correlation coefficients to determine relative reliability and used standard error of measurement and minimal detectable change to quantify absolute reliability. Relationships among the different strength-testing procedures and with the physical performance tests were determined using the Pearson product moment correlation coefficient (r) or Spearman rank correlation coefficient (r_s).

Results: We observed good to excellent reliability (intraclass correlation coefficient [2,k] range = 0.89 to 0.92). The standard error of measurement varied from 3.45 to 3.48 N. The minimal detectable change with 95% confidence intervals ranged from 8.06 to 8.13 N. Strong correlations were present among strength procedures ($r = 0.824$, r_s range = 0.754–0.816). We observed moderate to strong correlations between the CKCUEST findings and rotational strength (r range = 0.570–0.767). Moderate correlations were found between rotational strength and SMBT (r range = 0.573–0.626).

Conclusions: The SAC is a clinically applicable and standardized protocol for self-assessing rotational strength in young healthy adults without pathologic conditions. Performance on the SMBT and CKCUEST may be valuable as a screening tool to further assess shoulder strength.

Key Words: rotator cuff strength, handheld dynamometer, injury prevention

Key Points

- The Self-Assessment Corner demonstrated good to excellent relative reliability and clinically acceptable absolute reliability for self-assessing rotator isometric strength.
- The seated medicine ball throw and closed kinetic chain upper extremity stability test may be valuable screening tools to further assess functional upper extremity strength during on-field testing of handball players.

According to the current literature, rotator cuff (RC) weakness, particularly external-rotation (ER):internal-rotation (IR) imbalance, is a possible risk factor for shoulder injury and might accentuate the effect of load on the shoulder-injury rate among overhead athletes, such as handball players.[1–3] Many reported shoulder injuries are muscle strains, implying a process over time, with chronic overload leading to injury.[4] Chronic shoulder pain in overhead athletes can be attributed to sport-specific adaptations or alterations in upper extremity strength, flexibility, and functional performance.[4] Consensus statements[5,6] released by health care and sports organizations have highlighted the importance of a screening examination as part of the periodic health evaluation to identify athletes at risk for injury.

Clinical examination, such as RC strength and physical performance tests (PPTs), are part of this screening and must be reliable, sensitive, specific, inexpensive, easy to perform, and widely available.[5,7] Although valid and reliable measurement techniques exist to assess shoulder rotational strength,[8–10] some limitations may interfere with season-long evaluation (eg, tester strength variability, lack of stabilization, inconsistency among testing procedures, the need for a skilled assessor, and high costs).[9–11] For example, whereas isokinetic testing is considered the criterion standard for strength evaluation, its implementation in facilities, such as courts, fitness centers, or gymnasiums, may be compromised because of the extensive equipment required. Therefore, we developed a self-assessment technique, the Self-Assessment Corner (SAC), to simplify evaluation of shoulder ER and IR isometric strength and eliminate the examiner's influence on the procedure and test results. As far as we know, no research has been conducted on the reliability and validity of a self-assessment technique for evaluating RC isometric strength. Therefore, the primary purpose of our study was to evaluate the reliability and validity of the SAC.

Physical performance tests, such as the seated medicine ball throw (SMBT) and the closed kinetic chain upper extremity stability test (CKCUEST), have been developed to assess upper body function and are routinely used on the field for injury prediction, performance assessment, or outcome measures in return-to-play decisions.[12–31] Although the reliability of these tests has been established,[23,28,32–35] comparisons of clinical examinations and PPTs are uncommon. To the best of our knowledge, no investigators have examined the relationship between these PPTs and shoulder ER and IR isometric strength using a self-assessment technique. Therefore, the secondary purpose of our study was to examine whether performance on the SMBT and CKCUEST was correlated with the isometric shoulder ER and IR strength of handball players.

METHODS

Study Design

Our research was designed to evaluate the reliability and validity of the SAC using a 2-session measurement design separated by 7 days (sample 1) and determine the relationship between 2 upper extremity field tests (SMBT and CKCUEST) and the isometric strength of the shoulder external and internal rotators using the SAC (sample 2).

Self-Assessment Corner Reliability and Validity. On day 1, we assessed 2 strength measures on the dominant side using the SAC procedure. The *dominant side* was defined as the upper limb participants used to throw a ball. On day 2, the same measurements were performed to evaluate reliability. To investigate the validity of the SAC, 2 manual strength procedures were also conducted for comparison with the SAC. To avoid fatigue due to the length of the protocol, we randomized measures by instructing participants to choose cards to determine which position would be tested first.

Physical Performance Tests and Relationship With the SAC. The testing procedure (SAC or PPTs) was randomized. For practical reasons, the order of the PPTs was always the same: SMBT and then CKCUEST.

Participants

Two samples of healthy adults were recruited. The first sample (sample 1) of 42 healthy adults (24 women: age = 21.10 ± 1.87 years, height = 1.66 ± 0.04 m, mass = 61.5 ± 9.3 kg; 18 men: age = 21.6 ± 1.9 years, height = 1.76 ± 0.04 m, mass = 73.5 ± 7.8 kg) was recruited from Parnasse-ISEI, Brussels, Belgium, and participated in the study to establish the reliability and validity of the SAC. Volunteers were included if they were between 18 and 30 years old, were in good general health, and participated in overhead sports for less than 3 h/wk.

The second sample (sample 2) of 34 healthy handball players (16 women: age = 21.10 ± 2.62 years, height = 1.66 ± 0.05 m, mass = 68.40 ± 9.89 kg; 18 men: age = 22.30 ± 3.29 years, height = 1.87 ± 0.07 m, mass = 81.70 ± 9.05 kg) was recruited from handball clubs (Don Bosco Gent, Handball Club Evergem, Belgium) to examine the relationship between PPTs and isometric shoulder ER and IR strength in an overhead athlete population. Athletes were included if they played at a competitive level in a club and practiced for a minimum of 3 h/wk.

Separate samples were chosen for each part of the study to avoid any influence of fatigue or familiarization from one testing protocol to the other. The exclusion criteria for both groups were a history of orthopaedic surgery of the upper quadrant or spine or pain in these regions within 6 months of the study. All participants provided written informed consent, and the study was approved by the Ethical Committee of Ghent University and the Université Catholique de Louvain.

Instrumentation

The SAC is composed of 2 main parts. The first part involves an aluminum tube attached with suction cups to a wall, a door, or a window at both ends to ensure the stability of the second part. This second part consists of a custom-made steel receptacle to ensure the stability of the handheld dynamometer (HHD; Figure 1). It can be adjusted to the participant's height by gliding the receptacle up and down. Measurements were performed independently by the participant in a standardized manner without any external fixation or assistance.

We used the MicroFET2 handheld dynamometer (HHD; Hoggan Health Industries Inc, West Jordan, UT) to assess isometric strength.

Self-Assessment Corner Procedure

The SAC procedure started with oral instructions from the assessor (P.D.). Participants were barefoot and instructed to stand up straight, with the nondominant hand on the back (L4–L5) and the foot opposite of the tested upper extremity placed forward (Figure 2). The forearm was positioned against the HHD 2 cm proximal to the ulnar styloid process on the dorsal (ER) or ventral (IR) forearm for the strength assessment.[36] We gave specific information about the ER and IR strength tests to be performed: "After bringing your arm in the correct starting position, we want you to gradually push against the device until you reach maximum strength. Then, you keep your maximal strength [sic] for 5 seconds without moving the rest of your body [sic]." At the end of the instructions, the assessor warned about compensatory movements, such as side bending, tilting, or rotating the trunk. Participants performed 3 submaximal familiarization trials to ensure they understood the procedure, followed by 3 test trials.

Figure 1. The Self-Assessment Corner, A, without and, B, with the handheld dynamometer placed in the receptacle.

Figure 2. The Self-Assessment Corner procedure.

Both ER and IR were assessed with the upper extremity in 90° of abduction in the frontal plane and 90° of ER and the elbow flexed to 90° with neutral rotation of the forearm (90°–90° position). Three 5-second repetitions of maximal voluntary effort were performed using a make test with 10 seconds of rest between trials. Participants built their force gradually to a maximal voluntary isometric contraction over a 2-second period and maintained the contraction for 5 seconds.[36] The nondominant side was always tested first. The absolute isometric strength data were expressed in newtons.

Manual Strength-Testing Procedures

Participants were assessed in standing (STAND) and sitting (SIT) positions (Figure 3). The ER and IR were tested in the same SAC upper extremity strength position (90°–90°) and following the SAC procedure, but the assessor (P.D.) held the HHD. In the STAND position, the assessor stood behind the participant and used his forearm to gently hold the participant's elbow and arm by placing them underneath his arm. In the SIT position, participants sat on a chair with the trunk straight, the nondominant upper extremity relaxed on the thigh, and the feet placed on the floor; the assessor was positioned as for the STAND test. For all procedures, participants and the assessor were blinded to the results. Study assistants (E.D.B., J.V.D., J.V.) recorded all data.

Seated Medicine Ball Throw

We placed a 10-m tape on the floor with the end fixed to the wall. A 2-kg medicine ball was covered in magnesium carbonate (gymnastics chalk) to leave a clear print on the floor after each throw so that the throwing distance could be easily determined.[34,37,38] Participants sat on the ground with their lower extremities extended and their back, shoulders, and head against a wall (Figure 4).[23,37] They held the medicine ball in both hands[25,37] with the upper extremities in 90° of abduction and the elbows flexed. They were instructed to throw the medicine ball straight ahead as far as possible using a basketball chest pass and without losing wall contact with the head, shoulders, and back.[23,25,29,35,37] After 3 practice trials followed by a 2-minute rest, participants performed 4 maximal-effort throws with a 1-minute rest between throws. Correct throwing technique was monitored by the study assistants (E.D.B., J.V.D., J.V.). To allow for different upper extremity lengths, participants were instructed to adopt the test position with their elbows fully extended instead of flexed and to drop the ball straight down onto the tape measure.[29] To calculate the normalized throwing distance, we subtracted the distance between the wall and the most proximal tangent of the medicine ball from the total throwing distance. For further analysis, the mean distance of the 4 test trials was calculated.

Closed Kinetic Chain Upper Extremity Stability Test

The CKCUEST was performed following the guidelines described by Tucci et al.[33] Male participants adopted a push-up position, and female participants assumed a modified (kneeling) push-up position. All adopted this position with their backs flat and parallel to the floor. On

Figure 3. Manual procedures. A, Standing position. B, Sitting position.

the floor, we marked 2 parallel aligned lines 91 cm apart[4] to determine the position of the hands. For 15 seconds, participants moved 1 hand to touch the dorsum of the opposite hand and then returned the hand to the starting position. Subsequently, they performed the same movement with the other hand. Participants were instructed to perform as many alternating touches as possible. We recorded the number of touches. After receiving instructions and a demonstration, participants performed a 5-repetition familiarization trial. Oral cues were given when necessary. Finally, 3 test trials were performed. Each trial lasted 15 seconds, with a 45-second rest between trials. The CKCUEST provides 3 scores: the number of touches the participant performed in 15 seconds; the normalized score is obtained by dividing the number of touches by body length; and the power score is calculated by multiplying the average number of touches by 68% of the participant's body weight in kilograms, which corresponds to the weight of the upper extremity, head, and trunk divided by 15.

Statistical Analysis

Means and standard deviations (SDs) were calculated across participants for all dependent variables. The SAC ER and IR strength (in newtons), ER:IR ratio, SMBT (in centimeters), and CKCUEST (mean number of touches, normalized score, and power score) were analyzed. We used the Shapiro-Wilk test to evaluate the normality of the distribution within all measurements.

Reliability Analysis (Sample 1). To assess the intraexaminer reliability of the SAC between trials on days 1 and 2 and evaluate the test-retest reliability between days 1 and 2, we calculated intraclass correlation coefficients (ICCs [2,k]). To examine the absolute reliability of the SAC, we calculated the standard error of measurement (SEM) and the minimal detectable change (MDC). The SEM was calculated as $\mathrm{SD} \times \sqrt{1 - \mathrm{ICC}}$, where SD was the SD of all scores from participants.[17,23] The SEM was used to calculate the MDC with 95% confidence intervals ($\mathrm{MDC}_{95\%}$): $\mathrm{SEM} \times 1.96 \times \sqrt{2}$. Given that the assumptions of the parametric test were not met for strength measurements, we ran a related-samples Wilcoxon signed rank test to determine any systematic strength differences between the SAC measurements on days 1 and 2.

Validity Analysis (Sample 1). We used the Pearson product moment correlation (r) or the Spearman rank test (r_s), depending on the distribution of the data (normal or not), to assess the relationships among all strength procedures (SAC, STAND, SIT). The r and r_s values were categorized as *weak* (<0.499), *moderate* (0.5–0.707), or *strong* (>0.707).[28]

Systematic differences were also of interest and tested between strength procedures. Given that the assumptions of the parametric test were not met for all strength procedures, a Kruskal-Wallis Test was performed.

Correlation Analysis (Sample 2). To analyze a possible correlation among the strength variables and performance on the SMBT and CKCUEST, we used the Pearson product

Figure 4. Seated medicine ball throw.

moment correlation. Based on the correlation coefficients, the coefficient of determination was calculated as R^2.

The α level was set at .05. All statistical analyses were performed using SPSS (version 23; IBM Corp, Armonk, NY).

RESULTS

Results are summarized in Tables 1 through 5.

Self-Assessment Corner Reliability and Validity Analysis

The ICC (2,k) reflected excellent intraexaminer reliability between trials on day 1 (range = 0.93 [ER] to 0.96 [IR]) and day 2 (0.96 for both ER and IR). The test-retest reliability between days 1 and 2 showed excellent reliability for IR (ICC [2,k] = 0.92) and good reliability for ER (ICC [2,k] = 0.89). The SEM varied from 3.45 N (IR) to 3.48 N (ER). The MDC$_{95\%}$ ranged from 8.06 N (IR) to 8.13 N (ER). A related-samples Wilcoxon signed rank test showed no differences between days for all measurements ($P > .05$).

Strong correlations were present among all procedures, ranging from $r_s = 0.754$ (SAC versus STAND for IR) to $r = 0.824$ (SAC versus SIT for ER). The Kruskal-Wallis test results showed no differences among SAC, STAND, and SIT for ER ($P = .94$) or IR ($P = .89$).

Correlation Analysis

We observed a strong correlation between the CKCUEST power score and IR strength for the nondominant side ($r = 0.767$), and the coefficient of determination was 0.588.

Table 1. Results for Trial-to-Trial Reliability and Test-Retest Repeatability (Sample 1, N = 42)[ab]

	Trial-to-Trial Reliability, ICC (2,k) (95% CI)		Test-Retest Repeatability					
Rotation	Day 1	Day 2	Day 1, N (Mean ± SD)	Day 2, N (Mean ± SD)	ICC (2,k) (95% CI)	Standard Error of Measurement, N	Minimal Detectable Change With 95% CIs, N	Wilcoxon Signed Rank Test *P* Value
External	0.93 (0.89, 0.98)	0.96 (0.93, 0.98)	39.20 ± 10.08	38.89 ± 11.04	0.89 (0.79, 0.94)	3.48	8.13	.32
Internal	0.96 (0.93, 0.98)	0.96 (0.93, 0.98)	40.36 ± 12.53	40.54 ± 11.42	0.92 (0.84, 0.95)	3.45	8.06	.86

[a] The 95% CI for intertrial values using the Self-Assessment Corner.

[b] The 95% CI, standard error of measurement, and minimal detectable change with 95% CIs for mean values using the Self-Assessment Corner between days 1 and 2.

Table 2. Descriptive Analysis (Mean ± SD) for the Self-Assessment Corner, Seated Medicine Ball Throw, and Closed Kinetic Chain Upper Extremity Stability Test (Sample 2, N = 34)

	Men		Women	
Variable	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity
Strength				
External-rotation absolute value, N	90.8 ± 17.8	79.4 ± 15.5	64.1 ± 14.7	55.3 ± 17.3
Internal-rotation absolute value, N	0.8 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	0.8 ± 0.2
External rotation : internal rotation	74.4 ± 17.5	68.2 ± 13.5	53.9 ± 14.3	45.8 ± 16.6
Seated medicine ball throw, cm	303.6 ± 42.5		233.8 ± 28.7	
Closed kinetic chain upper extremity stability test				
Normalized score	14.9 ± 1.30		15.2 ± 2.9	
Power score	103.1 ± 15.0		79.3 ± 23.1	
Mean touches	27.8 ± 2.4		25.2 ± 4.5	

Table 3. Correlation Coefficients and Comparative Analysis of Similar Measurements After Different Procedures (Sample 1, N = 42)

Self-Assessment Corner	Pairwise Correlation	Kruskal-Wallis Test Result	*P* Value
External rotation	Self-Assessment Corner × standing procedure	0.776[a]	.94
	Self-Assessment Corner × sitting procedure	0.824[b]	
	Standing procedure × sitting procedure	0.798[a]	
Internal rotation	Self-Assessment Corner × standing procedure	0.754[a]	.89
	Self-Assessment Corner × sitting procedure	0.798[a]	
	Standing procedure × sitting procedure	0.816[a]	

[a] Spearman rank test (r_s).
[b] Pearson product moment correlation coefficient (r).

Moderate correlations were found between IR strength and SMBT for the dominant ($r = 0.618$) and nondominant ($r = 0.573$) sides, ER strength and SMBT for the dominant ($r = 0.599$) and nondominant ($r = 0.626$) sides, IR strength and CKCUEST mean touches for the dominant ($r = 0.570$) and nondominant ($r = 0.647$) sides, ER strength and CKCUEST mean touches for the nondominant side ($r = 0.590$), IR strength and CKCUEST power score for the dominant side ($r = 0.700$), and ER strength and CKCUEST power score for the dominant ($r = 0.608$) and nondominant ($r = 0.664$) sides. The ER:IR ratio showed only a low correlation with the SMBT or CKCUEST (r range = –0.093 to 0.193), and none of the CKCUEST normalized scores demonstrated moderate to strong correlations (r range = 0.3 to 0.39) with shoulder-strength variables.

DISCUSSION

The primary purpose of our study was to demonstrate the reliability and validity of a novel technique, the SAC, to self-assess ER and IR isometric strength. This technique was developed to eliminate the influence of examiner strength considering the limitations of the HHD and to simplify the strength assessments with a standardized, easy-to-use procedure to facilitate implementation in a sporting area. The second objective of our study was to examine relationships between the SAC and 2 functional shoulder tests (SMBT and CKCUEST). We established good to excellent reliability for evaluating isometric strength using the SAC and its validity to assess RC isometric strength. Moderate to strong correlations were also observed between the SAC and the functional tests.

Self-Assessment Corner Strength Assessment

To the best of our knowledge, no other authors have focused on an isometric strength self-assessment in a 90°–90° shoulder position in the STAND position. Therefore, direct comparisons with related reports in the literature are difficult. In contrast, the reliability of manual isometric strength testing in various populations and shoulder positions with or without an external-stabilization device has been reported in the literature,[39] demonstrating similar relative ICC values to those in our study, ranging from 0.86 (ER 90°–90°) to 0.92 (IR 90°–90°) in a seated position. Cools et al[36] described relative ICCs between 0.93 and 0.99 while seated, supine, or prone and with the shoulder in various positions. In these studies, no external mechanical support was used. Kolber et al[9] used an external-stabilization device held by an examiner and reported excellent relative reliability for ER and IR (ICC = 0.97).

The SEM and MDC provide the extent of measurement error and are clinically useful for determining if the strength changes are real or within measurement error. Depending on the particular shoulder isometric strength assessment, SEM varied from 3.45 N (IR) to 3.48 N (ER), and the $\text{MDC}_{95\%}$ ranged from 8.06 N (IR) to 8.13 N (ER), indicating that a change from 8.06 to 8.13 N was required to be 95% certain that this change was not due to intratester variability of measurement error. In comparison, Cools et al[36] showed $\text{MDC}_{90\%}$ values ranging from 7.87 to 26.6 N, depending on shoulder or patient positions; these values were slightly larger than ours. We may conclude that our absolute reliability results were similar to the results of other recommended clinical isometric strength assessments.

We compared the SAC results with manual muscle-testing procedures (STAND, SIT) to validate our protocol. No differences were present among the SAC, STAND, and SIT for ER ($P = .94$) and IR ($P = .89$) testing. These results highlight the fact that strength assessment in a functional position with the SAC does not differ from manual testing with an examiner. The principle of external fixation of an HHD is not new and has been implemented by others.[9] Indeed, Kolber et al[9] used a stabilization device, but they maintained the trunk in fixed position with a stabilization belt and placed the upper extremity at 30° with the help of an arm apparatus. These additional procedures and the presence of a skilled assessor may complicate implemen-

Table 4. Correlation Coefficients and Coefficient of Determination Between the Seated Medicine Ball Throw and the Dominant and Nondominant Shoulder Isometric External- and Internal-Rotation Strength (Sample 2, N = 34)

	Pearson Product Moment Correlation Coefficient (r)		Coefficient of Determination (R^2)		*P* Value	
Variable	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity
External-rotation absolute strength	0.599	0.626	0.359	0.392	<.001[a]	<.001[a]
Internal-rotation absolute strength	0.618	0.573	0.382	0.328	<.001[a]	<.001[a]
External rotation:internal rotation	0.039	0.193	0.001	0.04	.83	.28

[a] Indicates correlation ($P < .05$).

Table 5. Pearson Product Moment Correlation Coefficients and Coefficient of Determination Between the Closed Kinetic Chain Upper Extremity Stability Test (Mean Touches and Power Scores) and Dominant and Nondominant Shoulder Isometric External- and Internal-Rotation Strength

Variable	Correlation Coefficient (r)				Coefficient of Determination (R^2)				P Value			
	Mean Touches		Power Score		Mean Touches		Power Score		Mean Touches		Power Score	
	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity	Dominant Extremity	Nondominant Extremity
External-rotation strength	0.499	0.590	0.608	0.664	0.348	0.297	0.370	0.441	$<.001^a$	$<.001^a$	$<.001^a$	$<.001^a$
Internal-rotation strength	0.570	0.647	0.700	0.767	0.325	0.418	0.490	0.588	$<.001^a$	$<.001^a$	$<.001^a$	$<.001^a$
ER:IR	−0.092	0.045	−0.093	−0.043	0.008	0.002	0.008	0.002	.61	.80	.60	.81

[a] Indicates correlation ($P < .05$).

tation in sporting areas compared with the functional position used for the SAC. Therefore, the SAC might be an alternative and easier way for coaches or players to evaluate isometric strength during the season in the sporting area.

Correlation Analysis

For the SMBT, we observed a moderate correlation with shoulder isometric ER and IR strength, which indicated that a greater throwing distance on the SMBT was correlated with stronger shoulder muscles. Our results are in line with those of Borms et al,[37] who examined the relationship between functional shoulder performance tests and isokinetic strength measurements in overhead athletes. In their study, the SMBT results were moderately to strongly correlated with isokinetic ER and IR shoulder strength (r range = 0.595–0.803).

For the CKCUEST, a strong correlation between the CKCUEST power score and IR strength for the nondominant side was demonstrated. Moderate correlations were found between the CKCUEST mean touches and IR and ER strength and between the CKCUEST power score and ER and IR strength. To the best of our knowledge, only Sciascia and Uhl[18] have examined the reliability of strength and performance testing measures and their relationships. However, they tested strength by elevation only in the scapular plane. To our knowledge, no other researchers have investigated the relationship between the CKCUEST results and shoulder isometric ER and IR strength in 90° of abduction and ER.

Lee and Kim[32] examined the relationship between the CKCUEST and shoulder isokinetic ER and IR strength. They noted a high correlation between the CKCUEST results and isokinetic ER and IR strength (r range = 0.87–0.94).

Clinical Implications

The SAC method was developed to simplify strength assessments with an easy-to-use procedure applicable in most settings. Strength can be reliably measured without bias in such areas as tester strength, lack of stabilization, and inconsistency between testing procedures, and no external fixation or skilled assessors are needed. This method is advantageous whenever the amount of time spent and the testing of many athletes are important concerns. Therefore, the SAC could be suitable for evaluating and monitoring player RC strength longitudinally during a season. We also demonstrated that performances on the SMBT and CKCUEST were moderately to strongly correlated with isometric tests for strength of shoulder ER and IR in a population of handball players. These results may aid athletic trainers and physical therapists in evaluating upper extremity performance in a field setting.

Limitations

Despite the SAC's being an easy-to-use, field-setting method, our study had limitations. All of the measurement techniques and procedures were performed using field-measurement tools. Although we tried to standardize the procedure and avoid compensation, we did not use additional external fixation for reasons of clinical relevance. External fixation makes the procedure more time consuming and the device less attractive for the clinician. However, the clinician's ability to consistently and accurately place participants in a 90°–90° position was a limitation. The STAND position is functional and easy to use. However, this position might have influenced our results due to compensation from the lower extremities. Testing asymptomatic participants was also a limitation. Interpretation of our results is restricted to reporting reliability and validity of the SAC in a sample of healthy participants. Our protocol was based on previous studies,[9,36,39,40] but fatigue may have strongly influenced our results. Future researchers should focus on continuing data collection to enhance the depth of the findings in view of our rather small sample and exploring the use of the SAC in different sports and patient populations.

CONCLUSIONS

The first purpose of this study was to establish the relative and absolute reliability, as well as the validity, of a novel way to self-assess rotator isometric strength. Relative reliability was good to excellent and absolute reliability was clinically acceptable. The second objective was to examine correlations between the SAC and 2 functional shoulder tests. The results suggested that the CKCUEST and SMBT may be valuable as screening tools to further assess functional upper extremity strength during on-field testing of handball players.

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