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Upper Quadrant Field Tests and Isokinetic Upper Limb Strength in Overhead Athletes

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Context: Isokinetic testing is used to determine possible deficits in upper extremity strength in overhead athletes. Given that isokinetic testing is restricted to a laboratory setting, field tests, such as the Seated Medicine Ball Throw (SMBT) and Upper Quarter Y-Balance Test (YBT-UQ), were developed to assess upper body performance. The relationships between these field tests and isokinetic strength have not been examined.

Objective: To investigate the relationship between isokinetic strength testing for shoulder external and internal rotation and elbow flexion and extension and SMBT distance and YBT-UQ performance in overhead athletes.

Design: Cross-sectional study.

Setting: Institutional laboratory.

Patients or Other Participants: A total of 29 healthy overhead athletes (14 men, 15 women; age = 21.6 ± 2.5 years, height = 177.7 ± 9.7 cm, mass = 70.3 ± 11.5 kg).

Intervention(s): A Biodex dynamometer was used to measure the isokinetic strength of the shoulder and elbow muscles. Upper extremity performance was assessed using the SMBT and YBT-UQ.

Main Outcome Measure(s): We used Pearson correlation coefficients and coefficients of determination to analyze the relationship between SMBT and YBT-UQ performance and the isokinetic strength variables.

Results: We observed moderate to strong correlations between the SMBT and isokinetic shoulder and elbow strength (r range = 0.595–0.855) but no correlations between the YBT-UQ and isokinetic strength variables. The shared variance between these strength variables and the SMBT ranged from 35.4% to 64.5% for shoulder strength and 58.5% to 73.1% for elbow strength.

Conclusions: These findings suggested that the SMBT is a reliable, low-cost, and easy- and quick-to-administer alternative to isokinetic testing for evaluating upper extremity strength in a clinical setting. Performance on the YBT-UQ did not seem to be related to upper limb strength and, therefore, cannot be used for this purpose. Using the YBT-UQ for other purposes may have value.

Key Words: shoulder, elbow, Seated Medicine Ball Throw, Y-Balance Test

Key Points

- Performance on the Seated Medicine Ball Throw was moderately to strongly correlated with isokinetic tests for shoulder external- and internal-rotation muscles and elbow flexors and extensors in a sample of overhead athletes.
- These observations may provide athletic trainers and physical therapists with a reliable, low-cost, and easy- and quick-to-administer alternative to isokinetic testing for evaluating upper extremity strength in a clinical setting.
- Performance on the Y-Balance Test-Upper Quarter did not seem to be related to upper limb strength and, therefore, cannot be used for this purpose.
- Performance on the Y-Balance Test-Upper Quarter can help determine rehabilitation goals for injured overhead athletes because no differences existed between the dominant and nondominant limbs in the study population.
- Investigators should explore the value of these field tests for preventing shoulder injuries.

Injuries to the dominant shoulder or elbow are common in throwing athletes due to the substantial stress placed on the shoulder and elbow joints during an overhead throwing motion.[1–7] These injuries have been associated with muscle weakness and strength imbalance between the agonist and antagonist muscles.[8–11] Isokinetic strength testing of the shoulder rotator muscles and the elbow flexor and extensor muscles plays a large part in the rehabilitation and prevention of throwing-related injuries and is important to determine return-to-play criteria.[9,11–17]

Whereas isokinetic testing is considered the criterion standard for strength assessment, it cannot be applied in the field. Therefore, several field tests, such as the Upper Quarter Y-Balance Test (YBT-UQ) and the Seated Medicine Ball Throw (SMBT), have been developed to assess upper body function. The YBT-UQ is a reliable test for measuring unilateral upper extremity function in a closed chain position[18,19] and could be used to identify side-to-side differences in upper limb mobility and stability for injury prevention in athletes.[18] The YBT-UQ performance in an overhead athlete population has been examined in only 2 studies.[20,21] The researchers reported no difference in test performance between the throwing and nonthrowing limbs in baseball players, softball players,[21] and swimmers,[20] suggesting that no side-to-side differences should be present during rehabilitation.[21] Furthermore, only 1 group,[19] to our knowledge, has investigated the correlation between the YBT-UQ and isometric shoulder strength but found no relationship. In contrast, the YBT-UQ was

Figure 1. Starting position for the Seated Medicine Ball Throw.

correlated with the results of tests measuring core stability and upper extremity performance.[19]

The SMBT is used widely as an assessment tool for bilateral upper body power in athletes,[22–26] older adults,[27] collegiate and university students,[28,29] soldiers,[30] healthy nonathletic individuals,[31] and children.[32–34] Nevertheless, research on the relationship between the SMBT and strength and power variables is limited, especially within an overhead athlete population. Cronin and Owen[22] found a correlation between the seated chest-pass distance and upper body strength and power in female netball players when measured using a bench press (r range = 0.709–0.803). They also emphasized that the seated chest pass is an excellent field test because it is a low-cost, portable, and easy- and quick-to-administer test that provides immediate feedback. Terzis et al[35] investigated the relationship between 1-arm shot-put performance and isokinetic elbow strength in male physical education students. The shot put was performed with the dominant limb only and for isokinetic testing; only torque production of the elbow extensors was considered. Whereas the participants were not overhead athletes, the 1-arm seated shot-put performance was highly correlated with elbow extensor strength (r range = 0.79–0.92).

Although research on the YBT-UQ and SMBT has been conducted, no investigators, to our knowledge, have examined the correlation between these upper body field tests and laboratory isokinetic tests to evaluate shoulder and elbow muscle strength in throwing athletes. Therefore, the primary purpose of our study was to examine if performance on the YBT-UQ and the SMBT was related to isokinetic shoulder external-rotation (ER) and internal-rotation (IR) strength and elbow flexion and extension strength in an overhead athlete population. The secondary objective was to examine if differences existed between the throwing and nonthrowing limbs of overhead athletes on the YBT-UQ. The tertiary objective was to assess the reliability of the SMBT and YBT-UQ. We hypothesized that shoulder and elbow isokinetic strength would be correlated with the results of upper body field tests. We also hypothesized that no difference would exist in YBT-UQ performance between the throwing and nonthrowing limbs.

METHODS

Participants

A total of 29 healthy throwing athletes (14 men, 15 women; age = 21.6 ± 2.5 years [range = 18–28 years], height = 177.7 ± 9.7 cm, mass = 70.3 ± 11.5 kg) active in various overhead sports participated. The sports consisted of volleyball (n = 16), basketball (n = 8), badminton (n = 3), handball (n = 1), and volleyball and tennis (n = 1). Volunteers were included if they were aged 18 to 50 years, were in good general health, and participated in overhead sports at least 3 hours per week. The exclusion criteria were a history of orthopaedic surgery of the upper quadrant, lower quadrant, or spine or reports of pain in these regions interfering with sport participation within the 6 months before the study. All participants provided written informed consent, and the study was approved by the Ethical Committee of Ghent University.

Procedures

Our research was designed to determine the relationship between 2 upper extremity field tests (SMBT and YBT-UQ) and criterion standard isokinetic tests of the shoulder and elbow muscles. We used the SMBT to assess bilateral upper extremity power and strength and the YBT-UQ to evaluate unilateral upper body functional performance. Isokinetic strength of the shoulder and elbow muscles was assessed using an isokinetic dynamometer (model 4; Biodex Medical Systems Inc, Shirley, NY). The test sequence was randomized to prevent order biasing.

Seated Medicine Ball Throw. For the SMBT, participants sat on the ground with their lower limbs extended and their back, shoulders, and head against the wall.[22,23,32,33] They held a 2-kg medicine ball in both hands[23,34] with their upper limbs in 90° of abduction and elbows flexed (Figure 1). In this position, they were instructed to throw the medicine ball straight ahead as far as possible using a basketball chest pass without their head, shoulders, and back losing contact with the wall.[22,23,27,29,34] 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 researcher (D.B.). A 10-m tape

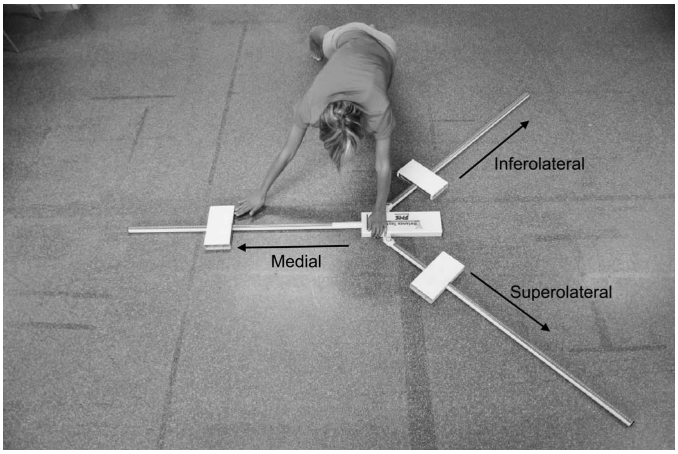

Figure 2. Y-Balance Test-Upper Quarter performance with reach directions.

Figure 3. Setup for testing isokinetic shoulder external and internal rotation using an isokinetic dynamometer (system 4; Biodex Medical Systems Inc, Shirley, NY).

measure was placed on the floor with the end fixed to the wall. The medicine ball was covered in magnesium carbonate (gymnastic chalk) to leave a clear print on the floor after each throw so that throwing distance could be easily determined.[28,33] To allow for different upper limb 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.[27] The distance between the wall and the most proximate tangent of the medicine ball was subtracted from the total throwing distance. For further analysis, we averaged the distance of the 4 test trials.[22]

Y-Balance Test-Upper Quarter. The YBT-UQ is a functional screening tool for assessing upper body mobility and stability in a closed kinetic chain.[18] We used the YBT kit (Move2Perform, Evansville, IN) according to the protocol of Gorman et al.[18] Before testing, the researcher (D.B.) instructed all participants and gave a demonstration. To account for different upper limb lengths, participants stood upright with the shoulder in 90° of abduction and the elbow fully extended. The distance between the spinous process of C7 and the most distal tip of the middle finger was measured using a tapeline.

To perform the YBT-UQ, participants adopted a push-up position with their bare feet placed shoulder-width apart (Figure 2). The test hand was placed on the stance platform with the thumb behind a red line. This hand determined the test side (left or right). With the free hand, they pushed the reach indicator as far as possible in the medial, inferolateral, and superolateral directions. At all times, participants had to return to the initial position with full body control and without losing the 3-point contact (ie, test hand and both feet). The test was conducted bilaterally, and after 2 practice trials, 3 test trials were executed for each limb and each direction. For a trial to be considered valid, (1) both feet had to maintain floor contact and the test hand had to maintain contact with the stance platform, (2) participants had to push the reach indicator using the red target area (ie, without using the reach indicator for support), (3) participants had to maintain contact with the reach indicator throughout the reach movement (ie, without pushing the reach indicator out), and (4) participants could not use the floor for support. Incorrectly performed trials were repeated. During the test period, we gave oral encouragement to stimulate maximal reach. For each reach direction, the average distance was calculated and normalized for upper limb length. A composite score, which was the mean of the averaged and normalized distances in the 3 reach directions, was also analyzed.

Isokinetic Testing. All isokinetic data were collected bilaterally using the isokinetic dynamometer (Biodex System 4). We tested the nondominant limb first and the *dominant limb*, which was defined as the throwing limb, second. During all tests, participants were encouraged orally, and visual feedback from the computer screen was not permitted. Five familiarization trials were allowed before testing.

For shoulder ER and IR, the dynamometer was rotated 20° and tilted 50°.[36] Participants were seated with the shoulder in the scapular plane (45° of abduction and 30° of forward flexion) and the elbow in 90° of flexion with neutral forearm rotation (Figure 3). The upper limb rested in the rotation cuff pad, with the olecranon approximating the axis of the dynamometer and the hand gripping the input shaft. Two straps were fixed diagonally from both shoulders to the contralateral hips to stabilize the trunk during upper limb movement. After gravitational correction, participants performed maximal ER and IR to

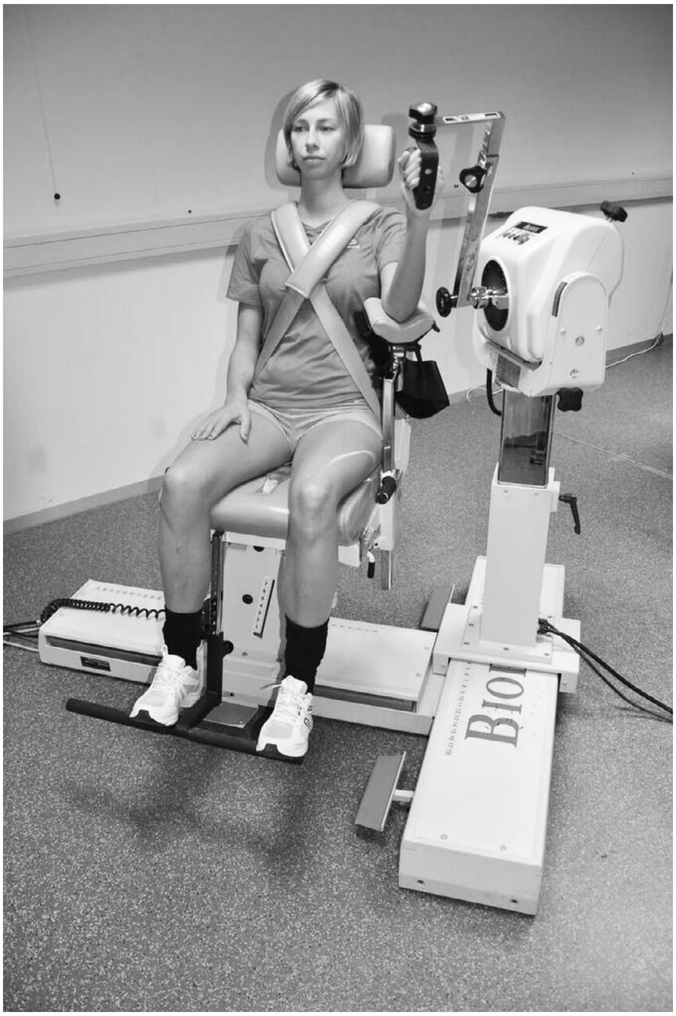

Figure 4. Setup for isokinetic elbow flexion and extension testing using an isokinetic dynamometer (system 4; Biodex Medical Systems Inc, Shirley, NY).

determine the limits of range of motion (ROM). First, they performed a concentric-concentric protocol at 60°/s (5 repetitions) and 180°/s (15 repetitions)[37] with a 60-second rest between speeds. Second, shoulder ER was tested eccentrically using a concentric-eccentric protocol at a speed of 60°/s (3 repetitions).[12] For further analysis, concentric and eccentric peak torque (PT) values were calculated.

For elbow flexion and extension, the dynamometer was rotated 30° with 0° of tilt, and the elbow attachment was aligned with the center of elbow rotation. Participants were seated with the arm resting on the limb support pad to fully support the arm without restricting elbow extension (Figure 4). We placed fixation straps diagonally over the chest and applied gravitational correction after setting elbow flexion and extension ROM limits. First, a concentric-concentric protocol was performed at 60°/s (5 repetitions) and 180°/s (10 repetitions) with a 60-second rest between speeds.[12] Second, the elbow flexors were tested eccentrically using an eccentric-concentric protocol at a speed of 60°/s (3 repetitions).[12] Concentric and eccentric PT values were used for analysis.

Statistical Analysis

Means and standard deviations were calculated across participants for all dependent variables. In addition to the isokinetic data, the dependent variables were the SMBT (cm) and YBT-UQ (cm) for the medial, inferolateral, superolateral, and composite scores on both the dominant and nondominant limbs. To assess trial-to-trial reliability of the SMBT and the YBT-UQ, we calculated intraclass correlation coefficients (ICCs [2,k]). To examine absolute reliability, we calculated the standard error of the measurement (SEM) and the minimal detectable change (MDC_{95}) using the method of Weir.[38] Given the normal data distribution, parametric tests were used. We used the Pearson correlation coefficient (r) to investigate the possible relationship between the strength variables of shoulder and elbow muscles and performance on the SMBT and YBT-UQ, respectively. We categorized r values as *weak* (<0.499), *moderate* (0.50–0.707), or *strong* (>0.707).[26] In addition, a coefficient of determination (R^2) was used to explore the amount of variability in the SMBT that is shared by shoulder and elbow strength variables. Side-to-side differences for the YBT-UQ were analyzed using paired-samples t tests. The α level was set at .05. All statistical analyses were performed using SPSS (version 22; IBM Corp, Armonk, NY).

RESULTS

The ICC (2,k) for the 4 performances of the SMBT was 0.980, showing a high trial-to-trial reliability. The throwing distance (mean ± standard deviation) was 347.77 ± 76.49 cm. The SEM was 10.82, and MDC_{95} was 29.98 cm, which means that a change of 29.98 cm is required to be 95% certain this change is not the result of a measurement error.

Pearson correlation coefficients and coefficients of determination between the SMBT and shoulder ER and IR strength are shown in Table 1. A moderate to strong correlation (r range = 0.595–0.803) was found between the SMBT and the eccentric and concentric PT variables for shoulder ER and IR of the dominant and nondominant limbs. The coefficient of determination ranged from 0.354 to 0.645. Pearson correlation coefficients and coefficients of determination between the SMBT and elbow flexion and extension strength are provided in Table 2. In both limbs, strong correlations were established for all variables (r range = 0.765–0.855), with coefficients of determination ranging from 0.585 to 0.731.

For the YBT-UQ, ICC (2,k) values ranged from 0.924 to 0.967, showing high trial-to-trial reliability. The medial reach direction produced the highest trial-to-trial reliability (ICC [2,k] range = 0.962–0.967), followed by the superolateral (ICC [2,k] range = 0.956–0.963) and inferolateral (ICC [2,k] range = 0.924–0.942) reach directions. For composite scores, ICC (2,k) values were 0.945 for both limbs, and SEMs were 1.77 and 1.41 for the dominant and nondominant limbs, respectively. The MDC_{95} values were 4.91 and 3.91 cm for the dominant and the nondominant limbs, respectively, which means that a change of 3.91 to 4.91 cm is required to be 95% certain that this change is not the result of a measurement error.

Mean normalized reach distances for the medial, inferolateral, and superolateral directions and composite score are provided in Table 3. Mean normalized test scores were

Table 1. Correlation Coefficients, Coefficient of Determination, and Difference (*P* Values) Between the Seated Medicine Ball Throw and the Variables of Dominant and Nondominant Shoulder External- and Internal-Rotation Strength

Linear Speed Motion, Action	Correlation Coefficient (*r*) DL	Correlation Coefficient (*r*) NDL	Coefficient of Determination (R^2) DL	Coefficient of Determination (R^2) NDL	*P* Value DL	*P* Value NDL
60°/s						
External rotation, concentric	0.794	0.803	0.630	0.645	<.001[a]	<.001[a]
Internal rotation, concentric	0.752	0.792	0.566	0.627	<.001[a]	<.001[a]
External rotation, eccentric	0.779	0.766	0.622	0.587	<.001[a]	<.001[a]
180°/s						
External rotation, concentric	0.672	0.595	0.452	0.354	.003[a]	.009[a]
Internal rotation, concentric	0.738	0.693	0.545	0.480	<.001[a]	<.001[a]

Abbreviations: DL, dominant limb; NDL, nondominant limb.

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

highest for the medial-reach direction, followed by the inferolateral- and superolateral-reach directions.

For the Pearson correlation coefficient between the YBT-UQ and the variables of shoulder and elbow strength of the nondominant limb, only the superolateral-reach direction was moderately correlated with concentric ER PT strength at 180°/s ($r = 0.513$, $P = .04$). None of the remaining variables of shoulder or elbow strength showed moderate or strong correlations with the YBT-UQ and, therefore, will not be discussed further.

Paired-samples *t* tests showed no differences on the YBT-UQ for any of the 3 reach directions or composite score between the dominant and nondominant limbs (*t* range = –0.336–0.882; *P* range = .39–.95).

DISCUSSION

To our knowledge, we are the first to examine the relationship between laboratory isokinetic strength testing for the shoulder and elbow muscles and 2 upper limb field tests: the bilateral open kinetic chain SMBT and the unilateral closed kinetic chain YBT-UQ. Our main findings were the moderate to strong correlation between SMBT performance and isokinetic shoulder and elbow strength but weak correlation between these strength variables and YBT-UQ performance. This observation suggests that the SMBT is a reliable alternative to isokinetic strength testing for shoulder and elbow muscle performance during on-field testing of overhead athletes. In addition, we found no difference in YBT-UQ performance between the dominant and nondominant limbs, which is in accordance with previous research on this topic.[18–21] We discuss the results in view of the 2 field-assessment tools (SMBT and YBT-UQ).

Table 2. Correlation Coefficients, Coefficient of Determination, and Difference (*P* Values) Between the Seated Medicine Ball Throw and Variables of Dominant and Nondominant Elbow Flexion and Extension Strength

Linear Speed Muscle, Action	Correlation Coefficient (*r*) DL	Correlation Coefficient (*r*) NDL	Coefficient of Determination (R^2) DL	Coefficient of Determination (R^2) NDL	*P* Value DL	*P* Value NDL
60°/s						
Biceps, concentric	0.821	0.817	0.674	0.667	<.001[a]	<.001[a]
Triceps, concentric	0.855	0.838	0.731	0.702	<.001[a]	<.001[a]
Biceps, eccentric	0.803	0.765	0.644	0.585	<.001[a]	<.001[a]
180°/s						
Biceps, concentric	0.827	0.802	0.684	0.643	<.001[a]	<.001[a]
Triceps, concentric	0.834	0.848	0.696	0.719	<.001[a]	<.001[a]

Abbreviations: DL, dominant limb; NDL, nondominant limb.

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

Seated Medicine Ball Throw

For the SMBT, we observed a moderate to strong relationship with shoulder strength and a strong relationship with elbow strength. This finding indicates that a farther distance achieved in the SMBT reflects more strength in the shoulder ER and IR muscles and the elbow flexor and extensor muscles. Several researchers have also found relationships between a seated throw and measurements of upper body power[22,27,28,32,35,39] and strength.[22,35,39] Nevertheless, comparing our results with those of other investigators is difficult because of the different types of seated throws, different weights used, and different populations tested. Cronin and Owen[22] demonstrated a moderate relationship between a seated throw using a 400-g netball and maximal strength measured by means of a bench-press throw ($r = 0.709$) in female netball players. This correlation value was lower than the values in our study, which might be due to using different weights or using a bench-press throw for overall upper body strength instead of a separate isokinetic assessment for shoulder and elbow strength. Similarly, Terzis et al,[35] who examined physical education students, found a moderate to strong correlation between a bench-press throw and a seated shot put using 6 shot weights (range, 1–6 kg; *r* range = 0.74–0.94). The highest correlation appeared with a 2-kg

Table 3. Y-Balance Test-Upper Quarter Test Scores Reported as a Percentage of Limb Length for All Reach Directions and Composite for Dominant and Nondominant Limbs

Variable	Limb, Mean ± SD: Dominant	Limb, Mean ± SD: Nondominant
Reach direction		
Medial	101.22 ± 7.32	101.07 ± 6.16
Superolateral	73.12 ± 10.24	71.54 ± 10.26
Inferolateral	96.09 ± 12.07	96.35 ± 10.17
Composite score	90.14 ± 7.56	89.65 ± 6.02

weight, and they reported a strong relationship between the 1-arm shot put and triceps muscle strength (*r* range = 0.80–0.93).[35] Unlike in our study, the seated throw was performed unilaterally on only the dominant limb. A number of investigators[22,27,28,32,35,39] have pointed out the moderate to strong relationship between upper body power and a seated throw, which is in line with our results. Whereas power and strength are different variables, power is a product of strength and velocity; therefore, greater strength results in greater power and might, in turn, lead to comparable correlations.

In our study, correlations were higher for elbow strength (*r* range = 0.765–0.855) than for shoulder strength (*r* range = 0.595–0.803). This observation can be explained by higher loads on the elbow joint during the SMBT, with participants throwing from maximally flexed elbows in the starting position to maximally extended elbows in the ending position. For shoulder ROM, maximal IR and ER are not achieved during the SMBT, possibly resulting in less stress on the shoulder muscles than during the isokinetic testing or the overhead throw. Furthermore, the coefficients of determination showed that shoulder rotation strength can account for 35.4% to 64.5% of the variance in SMBT performance compared with elbow strength, which had a shared variance ranging from 58.5% to 73.1%.

For elbow strength, strong correlation coefficients were present for concentric strength of the triceps (*r* range = 0.834–0.855) and the biceps muscles (*r* range = 0.802–0.827). As in the acceleration phase of an overhead throw, the SMBT was characterized by explosive elbow extension. The elbow extension during this phase is caused by a concentric contraction of the triceps along with the stabilizing function of the bi-articular biceps muscle in relation to the shoulder and elbow joints. The strong correlation for eccentric biceps strength (*r* range = 0.765–0.803) could be explained by the need for a large eccentric elbow-flexion torque to slow the elbow extension during acceleration. The strong correlation between the SMBT and biceps muscle strength is important in a population with pathologic conditions of the biceps, such as superior labrum anterior-posterior lesions, tendinosis, or ruptures. More research is needed to determine the biceps load during the SMBT before this test is used during rehabilitation of pathologic conditions of the biceps. In addition, the contribution of triceps muscle strength to SMBT performance was approximately 70% or higher (*r* range = 0.696–0.731), whereas biceps muscle strength can account for 58.5% to 68.4% of the variation in SMBT performance.

Y-Balance Test-Upper Quarter

Generally, the YBT-UQ did not appear to be related to either shoulder or elbow strength. This observation could be explained by test characteristics because the YBT-UQ is performed in the closed kinetic chain, and isokinetic strength assessment is performed in the open kinetic chain. It may also suggest that other variables within the kinetic chain are related to YBT-UQ performance because researchers[18–20] have postulated that core and shoulder stability play a crucial part in YBT-UQ performance. Gorman et al[18] described the YBT-UQ as challenging for thoracic and reach-limb mobility while maintaining stability in the stance limb and core. More specifically, Westrick et al[19] examined the relationship between the YBT-UQ and shoulder isometric strength, measured by means of a handheld dynamometer, in a population of healthy non-overhead athletes. They found no relationship between the YBT-UQ and shoulder strength, which is in line with our results. In addition, they reported a relationship between the YBT-UQ and measurements for core stability, evaluated by the lateral trunk endurance test, and upper extremity stability, measured by the closed kinetic chain upper extremity stability test. Unlike in our study, the relationship was expressed only as significant or not significant, without considering the extent of the correlation coefficient (weak, moderate, or strong). The *r* values expressing the relationship between YBT-UQ performance using the dominant and nondominant limbs, lateral trunk endurance test, and closed kinetic chain upper extremity stability test were 0.38, 0.45, and 0.49, respectively. According to the classification that we used, these correlations were weak. Furthermore, only the total excursion score on the YBT-UQ, which is the sum of 3 non-normalized reach directions, was considered for the correlation measurements. Future investigation is required to determine the possible relationship between the normalized scores of the YBT-UQ and other core- and shoulder-stability tests. No other researchers, to our knowledge, have examined the correlation between YBT-UQ performance and shoulder or elbow strength. Therefore, it is not possible to compare our results with other studies. Our results showed 1 unexpected correlation: between superolateral reach and concentric ER PT strength at high speed for the nondominant limb. This correlation was probably due to coincidence and might not reflect clinically relevant associations.

Scores on the YBT-UQ in the 3 reach directions and the composite score were similar to but slightly higher than those reported in previous studies.[18–21] The overhead athletes in our study performed equally using the dominant and nondominant limbs. Researchers have also reported symmetric performance between limbs within a healthy nonathletic population[18,19]; overhead athletes involved in baseball and softball, which require a dominant unilateral component[21]; and swimmers, who pursue upper quarter symmetry in sport.[20] Our results confirm the assumption of previous researchers[19,21] that performance by the uninjured limb can serve as a reference value for the injured limb during rehabilitation.

LIMITATIONS

Some limitations of our study need to be considered. First, we included athletes from different overhead sports, which could have influenced our results. Second, whereas SMBT performance was correlated with upper extremity strength, this test did not directly measure strength as an outcome variable. Therefore, the SMBT cannot identify specific muscle-strength deficits. Manual muscle testing could be an additional tool to measure shoulder and elbow muscle strength. Third, given that the SMBT is performed bilaterally, it cannot be used to assess side-to-side differences. Fourth, the SMBT and YBT-UQ mean test scores had limited clinical value. Future researchers should focus on providing normative data for athletes in different overhead sports. Fifth, the YBT-UQ was not correlated with other possible characteristics, such as functional joint stability or core stability measures.

CONCLUSIONS

Whereas isokinetic testing is considered the criterion standard in strength assessment, these laboratory or clinical tests are expensive, time consuming, and require an experienced assessor. In addition, field tests that assess upper body strength are limited. We showed that performance on the SMBT was moderately to strongly correlated with isokinetic tests for strength of the shoulder ER and IR muscles and the elbow flexors and extensors within a population of overhead athletes. These observations may provide athletic trainers and physical therapists with a reliable, low-cost, and easy- and quick-to-administer alternative to isokinetic testing to evaluate upper extremity strength in a clinical setting. Performance on the YBT-UQ did not seem to be related to upper limb strength and, therefore, cannot be used for this purpose. It can help determine rehabilitation goals for injured overhead athletes because no differences were found in the dominant and nondominant limbs in our population of healthy overhead athletes. In future prospective studies, investigators should explore the value of these field tests in the prevention of shoulder injuries.

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