The “upper limb rotation test”: Reliability and validity study of a new upper extremity physical performance test

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Abstract
Objectives: The primary purpose was to evaluate the reliability of the Upper Limb Rotation Test (ULRT). The secondary objective was to evaluate the relationship between the ULRT and two PPTs (SMBT and CKCUEST), trunk rotation range of motion (SRT) and shoulder rotational isometric strength.

Design: Reliability study and correlation study.

Setting: Laboratory.

Participants: 91 healthy adults participated to establish the reliability and validity of the ULRT.

Main outcome measures: We used a two-session measurement design to evaluate the reliability of the ULRT. The SMBT, CKCUEST, SAC and the SRT were performed to determine relationships with the ULRT.

Results: Results showed good reliability. The SEM95 and the MDC95 showed clinically acceptable absolute reliability values for the ULRT. A moderate correlation was found between the ULRT and CKCUEST scores. A moderate correlation was found between ULRT and SMBT scores.

Conclusions: Results demonstrated good relative reliability and clinically acceptable absolute reliability values for the ULRT. Performances on the ULRT were moderately correlated with the PPTs.

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1. Introduction

Several risk factors for throwing-related shoulder injuries such as Glenohumeral Internal Rotation Deficit (GIRD), loss of total range of motion, scapular dyskinesia or external/internal rotation strength ratio imbalances are described in the literature (Borms & Cools, 2018; Clarsen et al., 2014; Hjelm, Werner, & Renstrom, 2012; McClure et al., 2009; Moller et al., 2017; Reeser et al., 2006; Seminati & Minetti, 2013). Techniques and protocols to evaluate these deficits are already available (Cools et al, 2014, 2015, 2016). However, the rate of shoulder injuries in overhead throwing athletes still remains particularly high (Clarsen et al., 2014; Myklebust et al., 2013) in spite of the use of these screening procedures suggesting that improvement strategies to screen athletes at risk are required. From this perspective, physical performance tests (PPTs) have been developed to provide a more complete picture of the functional status of the athlete’s upper extremity. These PPTs are routinely used for injury prediction (Pontillo, Spinelli, & Sennett, 2014), performance enhancement or post-rehabilitation outcome measures (Borms & Cools, 2018; Creighton et al., 2010; Negrete et al., 2011; Tucci et al., 2014). Furthermore, PPTs are, most of the time, easily performed in many different environments and contexts with minimal material (Hegedus & Cook, 2015) and are thus, very attractive. However, in comparison to PPTs for the lower extremity, upper extremity PPTs are not profuse (Tarara et al., 2016). Some PPTs have been developed to evaluate upper extremity function in a closed kinetic chain (CKC) such as the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST). The functionality of this test lays in the involvement of the entire kinetic chain in test performance. For open kinetic chain (OKC) evaluation, the seated medicine ball throw (SMBT) is often used to assess bilateral upper body strength or power in overhead athletes (Borms, Maenhout, & Cools, 2016; Cronin & Owen, 2004). However, this test is performed with the arms at shoulder height. One common limitation of many upper extremity PPTs currently available is that they do not fully take into account the specific requirements of overhead throwing.
including a combination of OKC, CKC and a trunk rotation as well as 90°/90° shoulder position (Seminati & Minetti, 2013). In order to comply with this need, we have elaborated a new test, the Upper Limb Rotation Test (ULRT), which promotes weight bearing, requires shoulder motor control and stability, involves the entire kinetic chain and places the shoulder in a more complex position of 90° abduction and 90° external rotation.

Therefore, the primary purpose of our study was to determine the relative and absolute reliability of the ULRT in a population of healthy adults, and report preliminary reference data for that population. The secondary objective was to examine the correlations of this test with two widely used PPTs, the CKCUEST and SMBT, and two clinical measurements, shoulder isometric rotational strength using the Self-Assessment Corner (SAC) (Decleve et al., in press) and trunk rotational range of motion (SRT).

2. Methods

2.1. Participants

A sample of 91 healthy adults (45 females; age = 21.5 ± 2.27 years old, height = 1.67 ± 0.06 m, weight = 60.1 ± 9.41 kg and 46 males; age = 21.07 ± 2.29 years old, height = 1.78 ± 0.06 m, weight = 72.4 ± 12.61 kg) participated in the study to establish the reliability and validity of the Upper Limb Rotation Test. Volunteers were included if they were aged between 18 and 30 years old, were in good general health, and participated in overhead sports for less than 3 h per week. The exclusion criteria were a history of orthopaedic surgery of the upper quadrant or spine or reports of pain in these regions within a 6-month period before the study and overhead sports participation more than 3 h per week. All participants provided written informed consent, and the study was approved by the Ethical Committee of the Université Catholique de Louvain 2018/12SEP/341- B403201837497.

2.2. Study design

This research was designed (1) to evaluate the reliability of the ULRT using a two-session measurement design separated by seven days and (2) to determine the relationship between the ULRT and two previously published upper extremity PPTs: the Seated Medicine Ball Throw and the Closed Kinetic Chain Upper Extremity Stability Test, and commonly used clinical measurements: shoulder external and internal rotators isometric strength using the Self-Assessment Corner, and the trunk rotation range of motion -Seated Trunk Rotation Test.

2.2.1. Procedure

The participants attended two assessment sessions conducted by the same investigators (two fourth-year physical therapy students were the primary investigators under the direct supervision of a physical therapist with over 10 years of clinical experience). In order to evaluate test-retest reliability, the ULRT was performed on two sessions (day 1 and day 2), separated by seven days. In addition to the ULRT, we performed the SRT and CKCUEST on day 1 and the SMBT and the shoulder isometric rotational strength using the SAC on day 2. We decided to space out the tests between day 1 and day 2 to avoid fatigue as a result of the length of the protocol. For all procedures, participants were blinded to the results.

2.3. ULRT procedure

Participants started in a modified (on elbows) push-up position, back flat parallel to the floor, elbows flexed at 90° and feet apart at shoulder width and arms positioned perpendicular to the floor (Fig. 1) (Video.1). Forearms and fists rested on the floor. Participants were positioned next to a wall in order to allow the shoulder, the elbow epicondyle, the greater trochanter and the lateral malleolus of the ankle to touch the wall. Participants were asked to perform a trunk rotation, coupled with an external rotation of the shoulder in a 90°-90° position (90° abduction, 90° external rotation) touching the tape placed vertically on the wall as quickly as possible for 15 s. They had to touch the marker fixed on the wall with the elbow before returning to the starting position. We placed the tape to ensure that participants would touch the wall in a 90°-90° shoulder position when rotating with the non-weight-bearing arm. After getting the instructions and a demonstration, participants performed a familiarization trial consisting in 3 repetitions for each side. Verbal cues were given when necessary. Finally, three 15-s test trials were performed, with 45 s rest between each trial. We opted for a 1:3 work-rest ratio because it is optimal recovery time following a short-duration and high-intensity test (Goldbeck & Davies, 2000).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.ptsp.2020.01.009

For practical reasons, participants started with their right shoulder against the wall. The number of repetitions was recorded. We consider the tested arm is the one that maintains the CKC position. The test was considered fully completed if the subject kept his or her back flat, the arm in a 90°—90° position, knees did not touch the floor and his or her feet remained in the initial position. The Borg Scale was used to assess participant exertion. In order to
minimize the effect of fatigue on the results, we decided to use a Borg rating of perceived exertion scale to assess participants’ subjective experiences of fatigue after 45 s (Borg, 1998). This scale is a valid measure of local upper extremity exertion (Kang et al., 1998).

We considered the participants to be fatigued when they reported an exertion level exceeding 14 of 20 (Tripp, Yochem, & Uhl, 2007). A rating of 15 on the rating of perceived exertion scale corresponds with “hard/heavy work or strain and fatigue on muscles” (Borg, 1998). An extra 45-second rest was allowed if the score was 14 or higher.

2.4. SAC procedure

The procedure was performed following the guidelines as described by Decleve et al. (in press). We started with verbal instructions from the investigators. Participants were instructed to stand up straight, barefoot, with the non-tested hand on the back of the head. The forearm was placed against the hand-Held Dynamometer (HHD) (MicroFET2 HHD, Hoggan Health industries Inc, West Jordan, UT, USA) 2 cm proximal of the ulna styloid process on the dorsal (ER) or ventral forearm (IR) for strength assessment. We gave specific information about the external and internal rotation strength tests to perform: “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 for 5 s without moving the rest of your body”. To end the instructions, the assessor warned the participants against compensatory movements such as side bending, tilt or rotation of the trunk. After the instructions, three familiarization trials were performed sub-maximally in order to control the participant’s understanding of the procedure, followed by three testing trials. Both ER and IR were assessed in a 90°-90° position (90° of abduction in the frontal plane, 90° of ER and 90° of elbow flexion with neutral rotation of the forearm). Three repetitions of 5 s of maximal voluntary effort were performed using a “make” test with 10 s of rest between trials. Participants had to build their force gradually to a maximum voluntary contraction over a 2-s period and had to keep the maximal voluntary contraction for 5 s (Cools et al., 2014). The non-dominant side was always tested first. The absolute isometric strength data were expressed in Newton (N). The SAC procedure was found to be reliable and validated compared to manual HHD testing procedure (Decleve et al., in press).

2.5. Seated medicine ball throw (SMBT)

The participants were sitting on the ground with their lower limbs extended and their backs, shoulders, and heads against the wall (Borms et al., 2016; Cronin & Owen, 2004). A 2-kg medicine ball was held in both hands (Borms et al., 2016) with the upper limbs at 90° of abduction and elbows flexed. In this position, they were instructed to throw the medicine ball straight ahead as far as possible using a basketball chest pass and without losing contact with the wall with their heads, shoulders and backs (Borms et al., 2016; Cronin & Owen, 2004). After 3 practice trials followed by a 2-min rest, the participants performed 4 maximal effort throws with a 1-min rest between throws. Correct throwing technique was monitored by the researcher. A 10-m tape was placed on the floor with the end fixed to the wall. The 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 (Borms et al., 2016). 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. To calculate the normalized throwing distance, the distance between the wall and the most proximal tangent of the medicine ball was subtracted from the total throwing distance. For further analysis the mean distance of the four test trials was calculated.

2.6. Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST)

The test was performed following the guidelines as described by Tucci et al. (Tucci et al., 2014). Participants adopted a push-up position with a flat back parallel to the floor. However, in order to avoid the influence of the anthropometric characteristics of individuals (Tucci et al., 2017), we used the inter acromial distance of each participant instead of the standardized between hands distance of 91.4 cm. Two parallel and aligned lines with the inter acromial distance of individuals in between were marked on the floor to determine the position of the hands. For 15 s, participants were instructed to move one hand to touch the dorsum of the opposite hand and then return the hand to the starting position. Subsequently, the same movement was performed by the other hand. Participants were instructed to perform as many alternating touches as possible. The number of touches was recorded. After instructions and demonstration, a familiarization trial was performed, consisting of 5 repetitions. Verbal cues were given during familiarization when necessary. Finally, three test trials were performed. Every trial lasted 15 s with 45 s rest in between. The CKCUEST provided three scores. The number of touches represents the number of touches that the participant was able to perform in 15 s. The normalized score is obtained by dividing the number of touches by the body length. Finally, 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 arms, head and trunk, divided by 15.

<p>| Table 1 |
|---|---|---|---|---|---|---|
| | | | | | |
| Table 1 | | | | | |
| Descriptive analysis (mean and SD) for SAC results, SMBT, CKCUEST and SRT scores for global, male and female participants (N = 91). | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th>DA</th>
<th>NDA</th>
<th>DA</th>
<th>NDA</th>
<th>DA</th>
<th>NDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength IR (N)</td>
<td>35.36 ± 11.51</td>
<td>34.89 ± 11.96</td>
<td>41.26 ± 11.50</td>
<td>40.13 ± 13.10</td>
<td>29.33 ± 7.87</td>
<td>29.54 ± 7.73</td>
</tr>
<tr>
<td>Strength ER (N)</td>
<td>34.63 ± 11.49</td>
<td>33.04 ± 12.16</td>
<td>39.82 ± 12.55</td>
<td>38.93 ± 13.16</td>
<td>28.91 ± 6.91</td>
<td>27.91 ± 7.19</td>
</tr>
<tr>
<td>SMBT(cm) (normalized)</td>
<td>232.77 ± 48.58</td>
<td>269.82 ± 36.92</td>
<td>198.89 ± 23.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CKCUEST normalized score</td>
<td>17.60 ± 3.78</td>
<td>18.46 ± 4.47</td>
<td>16.72 ± 2.71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CKCUEST power score</td>
<td>1379.02 ± 428.75</td>
<td>1602.02 ± 404.40</td>
<td>1151.0 ± 321.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CKCUEST mean touches</td>
<td>30.44 ± 6.86</td>
<td>32.8 ± 7.72</td>
<td>27.9 ± 4.78</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SRT(°) (left)</td>
<td>59.81 ± 8.85</td>
<td>59.32 ± 7.95</td>
<td>60.31 ± 9.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRT(°) (right)</td>
<td>62.08 ± 9.78</td>
<td>61 ± 9.56</td>
<td>63.20 ± 9.98</td>
<td></td>
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</tbody>
</table>

DA, dominant arm; NDA, non-dominant arm; IR, internal rotation; ER, external rotation; N, newton; cm, centimeter; SD, standard deviation; °, degree.
Table 2
Results for Trial to Trial Reliability And Test Retest Repeatability (ICC2k) with their 95% CI, SEM, MDC95% for mean values (number of touches) using the ULRT between day 1 and day 2 (N = 91).

<table>
<thead>
<tr>
<th>Trial to Trial Reliability within Day 1 and Day 2</th>
<th>Test Retest Repeatability Between Day and Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULRT DA Mean D1±SD</td>
<td>Mean D2±SD</td>
</tr>
<tr>
<td>0.93 (0.86–0.96)</td>
<td>0.97 (0.95–0.98)</td>
</tr>
<tr>
<td>ULRT NDA Mean D1±SD</td>
<td>Mean D2±SD</td>
</tr>
<tr>
<td>0.96 (0.94–0.98)</td>
<td>0.97 (0.95–0.98)</td>
</tr>
</tbody>
</table>

ICC: Intraclass correlation coefficient; CI: Confidence interval; SD: Standard Deviation; SEM: Standard error measurement; MDC: Minimal detectable change; ULRT: Upper Limb Rotation Test; DA: Dominant arm; NDA: Nondominant arm.

2.7. The Seated Trunk Rotation Test (SRT)

Participants sat upright on a chair with knees and feet together and arms across the chest (Aragon et al., 2012). Participants held a stick horizontally at the sternum just below the clavicles. We used the EasyAngle© (Gymna; reference: Meloq AB, Sweden), a digital goniometer with a display attached in the middle of a hard plastic ruler and provided with a position sensor, always aware of its position in space. The EasyAngle© was attached to the stick and provided data expressed in degrees (°). The procedure started with 3 trunk rotations to the right followed by 3 trunk rotations to the left. Participants had to rotate as far as possible to the end of their range of motion and to keep the position until the examiner recorded the measurement, before returning to the starting position. Trunk rotation was accepted if knees and feet remained together, ischium did not take off from the chair and the head followed the movement. For further analysis, the mean results of the 3 test trials were calculated.

2.8. Statistical analysis

Means and standard deviations were calculated across participants for all dependent variables. The ULRT (mean number of touches), SAC ER and IR strength (N), ratio ER/IR, SMBT (cm), and CKCUEST (mean number of touches, normalized score and power score), SRT (mean degrees) were analyzed. The Kolmogorov-Smirnov test was first used to evaluate the normality of the distribution within all measurements.

2.8.1. Reliability analysis

To assess the intra-session reliability of the ULRT between trials on day 1 and day 2 and to evaluate the test-retest reliability between day 1 and day 2, intraclass correlation coefficients (ICC2k) were calculated. The ICC values ranges from 0 to 1: 1 = perfect reliability: 0.90–0.99 = very high reliability: 0.70–0.89 = high reliability: 0.50–0.69 = moderate reliability: 0.26–0.49 = low reliability and 0.00–0.25 little, if any, reliability (Portney & Watkins, 2000). In order to examine the absolute reliability of the ULRT, the standard error of measurement (SEM) and the minimal detectable change (MDC) were calculated. The SEM was calculated as SD x √1-ICC, where SD is the SD of all scores of participants (Weir, 2005). The SEM was used for calculating the MDC95, which was calculated as SEM x 1.96 x √2 (Weir, 2005). To check for systematic differences between day 1 and day 2, a paired-t-test was performed.

2.8.2. Correlation analysis between PPTs, SAC and SRT

The Pearson correlation coefficient (r) parametric test was used to assess the possible relationship between ULRT and performances on PPTs (CKCUEST, SMBT), strength (SAC) and range of motion (SRT) procedures. The r values were categorized as weak (<0.499), moderate (0.5–0.707), or strong (>0.707) (Stockbrugger & Haennel, 2003). Based on the correlation coefficients, the determination coefficient was calculated as R². The alpha level was set at 0.05. All statistical analyses were performed using IBM SPSS 23 software (IBM Corp, Armonk, NY, USA).

3. Results

Descriptive analysis for ULRT, SMBT, CKCUEST, SAC and SRT results are summarized in Table 1. Reliability and correlation analysis results are summarized in Tables 2–3.

3.1. ULRT reliability

The ICC (2,k) reflected very high reliability for intra-session reliability between trials with values within day 1 and day 2, ranging for day 1 from 0.93 on the dominant arm (DA) to 0.96 on the non-dominant arm (NDA). For day 2, the ICCs (2,k) were 0.97. The Test Retest reliability between day 1 and day 2 showed high reliability ranging from 0.76 (DA) to 0.78 (NDA). The SEM95 varied from 1.14 touches (DA) to 1.18 touches (NDA). The MDC95 ranged from 3.15 touches (NDA) to 3.27 touches (DA) (Table 1).

3.2. Correlation analysis between ULRT and CKCUEST, SMBT, SAC and SRT

A moderate correlation was found between the ULRT and CKCUEST mean touches (r = 0.553 for DA; r = 0.615 for NDA) and the determination coefficient was 0.306 and 0.378 respectively. Moderate correlations were found between ULRT and CKCUEST normalized score (r = 0.505 for DA; r = 0.566 for NDA) and
CKCUEST power score ($r = 0.512$ for DA; $r = 0.589$ for NDA). A moderate correlation was found between ULRT (NDA) and SMBT mean score ($r = 0.556$) and SMBT normalized score ($r = 0.544$). The ULRT showed only low correlation with SAC ($r = 0.303–0.455$) and SRT ($r = 0.017–0.178$) (Table 2).

4. Discussion

The primary purpose of this study was to demonstrate the reliability of a new physical performance test, the ULRT. This test was developed to propose to clinicians a new closed chain upper extremity functional test. The second objective of this study was to examine correlations between the ULRT and two widely used closed and open-chain upper extremity PPTs, the CKCUEST and SMBT, and two clinical measurements, the shoulder rotational isometric strength using the SAC and the SRT. This study established very high reliability for intra-session reliability between trials within day 1 and day 2 and high reliability for test-retest reliability. Moderate correlations were found between the ULRT and the CKCUEST and the SMBT (NDA).

4.1. Relative and absolute reliability

Our study provided appropriate levels of intra-session and test-retest reliability with intra-session ICC values varying from 0.93 to 0.97 and test-retest ICC values ranging from 0.76 to 0.78. Our results regarding intra-session and test-retest reliabilities are in accordance with reliability studies (de Oliveira et al., 2017; Tucci et al., 2014) on another widely used closed-chain PPT, the CKCUEST.

In comparison, studies which have evaluated the intra-session and test-retest reliability of the CKCUEST have shown values varying from moderate to very high reliability (de Oliveira et al., 2017; Goldbeck & Davies, 2000; Tucci et al., 2014). Intra-session ICC values ranged between 0.86 and 0.97 depending on the population (Tucci et al., 2014) whilst test-retest ICC values varied between 0.68 and 0.96 (de Oliveira et al., 2017; Goldbeck & Davies, 2000; Tucci et al., 2014). The SEM indicates the limit for the smallest change that explains a real modification. In our study, the SEM was calculated using the NDA (de Oliveira et al., 2017) and the DA (Goldbeck & Davies, 2000) and was found to be 2.17 and 6.01 respectively. However, considering the poor correlation between the ULRT and both shoulder isometric strength and trunk rotational range of motion, it could be explained by the test characteristics because the ULRT is performed in a closed kinetic chain and isometric strength assessment is performed in the open kinetic chain.

4.2. Correlations between ULRT and CKCUEST, SMBT, SAC and SRT

The second purpose of our study was to determine relationships between the ULRT and two widely used closed and open-chain upper extremity PPTs, the CKCUEST and SMBT, and with two clinical measurements, the shoulder rotational isometric strength using the SAC and the SRT. We observed a moderate correlation between the ULRT and CKCUEST scores ($r = 0.505–0.589$) and SMBT scores ($r = 0.544–0.556$ on NDA) and coefficients of determination showed that CKCUEST can account for 30.6% to 37.8% of the variance in the ULRT performance. We found low correlation with SAC ($r = 0.303–0.455$) and SRT ($r = 0.017–0.178$).

The results of the correlation analysis between PPTs can be discussed in relation to the characteristics of test performance and more specifically, the kinetic chain involvement and shoulder position at which the test is performed. The CKCUEST is performed in a closed chain and the SMBT is executed in an open chain. Like the CKCUEST, the ULRT is performed in a closed chain. But the ULRT starts with shoulders placed in a 90° shoulder forward flexion and ends in a 90° shoulder abduction while the CKCUEST is performed with both shoulders perpendicular to the hands apart from the inter acromial distance. The differences in task characteristics may explain the moderate correlation between the ULRT and the CKCUEST and SMBT. Since the ULRT is not strongly related to the CKCUEST and SMBT, we suggest implementing all three tests when screening for shoulder function.

Clinical measurements such as shoulder isometric rotational strength and trunk rotational range of motion are widely used on the field and provide important data for shoulder rehabilitation and prevention. We found low correlation between the ULRT and both shoulder isometric rotational strength and SRT. These observations could be explained by the test characteristics because the ULRT is performed in a closed kinetic chain and isometric strength assessment is performed in the open kinetic chain. Regarding the trunk mobility, it could also be explained by not challenging enough the trunk range of motion. In a previous study (Decleve et al., in press), we found moderate to strong correlation ($r = 0.570–0.767$) between the isometric rotational strength and CKCUEST. The results of this present study highlight the fact that performance on the ULRT does not depend solely on isometric rotational strength and trunk rotational range of motion.

5. Limitations and future direction

Some limitations of our study need to be considered. All measurement techniques and procedures performed in this study used field measurement tools for reasons of clinical relevance. The clinician’s ability to consistently and accurately place the subject in a 90/90 position needs to be acknowledged as a limitation. In addition, participation of a narrow age range asymptomatic individuals also needs to be acknowledged as a limitation. The increase in the ULRT mean score between days might be attributed to the learning effect. The interpretation of our results is limited to reporting the reliability and relationships of the ULRT in a sample of healthy subjects. Like in many other studies, our study is limited to one test and does not evaluate all the different characteristics of a performance task. Future research should evaluate the effect of test duration on the ULRT results. Moreover, considering the poor correlation to shoulder isometric strength, a weight relative to the participant’s body mass might be added to the wall reach arm to increase muscle demand during the test. The future lies in the development of a shoulder test battery. A first attempt was proposed by Olds et al. (Olds et al., 2019), but they only reported the reliability of the tests that were part of the test battery and not the relationships between the tests or the shoulder strength.

6. Conclusions

The first purpose of this study was to establish the relative and absolute reliability of a new physical performance test, the ULRT. Results demonstrate very high reliability for intra-session reliability and high reliability for test-retest reliability as well as clinically acceptable absolute reliability values.

The second objective was to examine correlations between the
ULRT and two widely used PPTs, the CKCUEST and SMBT and two clinical measurements, shoulder isometric rotational strength and trunk rotational range of motion. Results suggest that the ULRT is moderately correlated with the CKCUEST and SMBT and poorly correlated with shoulder isometric rotational strength and SRT. Future research should focus on continued data collection to enhance the depth of the findings and assess the validity and clinical importance of the test of the ULRT in different sports and patient populations.

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None.

Ethical approval

Approval opinion of the Research Ethics Committee of the University of Louvain-La-Neuve – Saint-Luc. Protocol 2018/12sept/341 B403201837497.

Ethical statement

The study was approved by Research Ethics Committee of the University of Louvain-La-Neuve-Saint-Luc protocol 2018/12sept/341 B403201837497 and all participants signed a free and informed consent form.

Declaration of competing interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2020.01.009.

References