

Original Article

Reliability and validity of the closed kinetic chain upper extremity stability test

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Abstract. [Purpose] The purpose of this study was to examine the reliability and validity of the Closed Kinetic Chain Upper Extremity Stability (CKCUES) test. [Subjects and Methods] A sample of 40 subjects (20 males, 20 females) with and without pain in the upper limbs was recruited. The subjects were tested twice, three days apart to assess the reliability of the CKCUES test. The CKCUES test was performed four times, and the average was calculated using the data of the last 3 tests. In order to test the validity of the CKCUES test, peak torque of internal/external shoulder rotation was measured using an isokinetic dynamometer, and maximum grip strength was measured using a hand dynamometer, and their Pearson correlation coefficients with the average values of the CKCUES test were calculated. [Results] The reliability of the CKCUES test was very high (ICC=0.97). The correlations between the CKCUES test and maximum grip strength ($r=0.78-0.79$), and the peak torque of internal/external shoulder rotation ($r=0.87-0.94$) were high indicating its validity. [Conclusion] The reliability and validity of the CKCUES test were high. The CKCUES test is expected to be used for clinical tests on upper limb stability at low price.

Key words: Closed kinetic chain upper extremity stability, Peak torque of internal/external shoulder rotation, Maximum grip strength

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INTRODUCTION

The shoulder is one of the joints that we use everyday in our physical activities, and people can develop various complex problems in the shoulder joint. The shoulder joint has the biggest range of motion because of its delicate and smooth movement^{1, 2)}. The glenohumeral joint consists of a ball and socket joint. The glenohumeral has a large range of movement, but its excessive mobility causes chronic stress in the tissues around the joint. The rotator cuff muscle, the long head of the biceps, the negative intra-articular pressure, and ligament around the shoulder joint support its stability³⁾.

Shoulder disease causes pain in specific actions⁴⁾. Recent research has focused not only on shoulder pain, but also on the stability of the shoulder, and associated functional and social conditions⁵⁾.

Many radiography examinations are performed for diagnosis of shoulder joint problems. Ultrasonography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), X-ray, etc. are examinations that are widely used^{6, 7)}. However, the cost of these physical examinations is high, and they do not examine the functional stability of the gle-

nohumeral joint.

The CKCUES test scores closed kinetic chain exercise of the upper limbs in an examination of the stability of shoulder. It doesn't require high level technique or clinical preparation, and it is cheap to conduct. In this test, the subject counts the number of times he touches his other hand for 15 seconds while doing a push up. This test is clinically simple to conduct and it is also easy for the subject to understand his physical condition^{8, 9)}. However, the validity of the CKCUES test has not yet been established. Therefore, in this research, the reliability of the CKCUES test was examined with healthy adults as subjects, and its validity was examined by comparison with peak torque of internal/external shoulder rotation and maximum grip strength.

SUBJECTS AND METHODS

The subjects of this study were 40 healthy Korean adults, 20 males and 20 females, who volunteered to participate in the experiment after being given an explanation of its purpose and method. The subjects had an average age 28.96 ± 3.15 , of an average height of 169.47 ± 8.33 cm, and an average weight of 67 ± 14.24 kg. They had no pain or disability in hand grip. They also had no pain, instability or limited range of motion in shoulder function. This study obtained the approval of the Bioethics Committee of Catholic University of Pusan (CUPIRB-2014-016).

The CKCUES test requires two examiners. One examiner counts the number of times the subject touches hands. The other uses a stop watch to begin and end the test. The test

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was conducted twice over three days in order to verify the test-retest reliability. In the first round, the testers explained the CKCUES test method to the subjects by demonstrating it to them. They also gave them a clear explanation about the tests.

The CKCUES test is performed in the same way by males and females. Two strips of athletic tape with a width of 1.5 inches were placed parallel to each other 36 inches apart, as measured by a standard tape measure on a tiled floor. The starting position of the test is one hand on each piece of tape in the pushup position. The subjects were instructed from the starting position they were to use one hand to reach across their body and touch the piece of tape lying under the opposing hand. After touching the tape line, the hand was returned to the original starting position. Then the subject performed the same movement with the other hand. Touches were counted as every time the hand reached across the subject's body and touched the tape. The total time of the trial was 15 seconds. Each subject performed a warm up trial followed by three trials of the test with a rest period of 45 seconds between trials. The average of the three trials was used in the data analysis¹⁰.

During the test, subjects had to keep a straight flat back, keep their hands and shoulders in a perpendicular position so that body weight was sufficiently distributed over the upper limbs, and the knees must never touch the ground. If a subject complain about pain, he or she was excluded from the study.

A Jamar hydraulic hand dynamometer (PC 5030JI, Preston Inc, USA) was used for measurement of the maximum grip strength of the subjects. According to the recommendation of the American Limb Therapist Association, the subjects were seated comfortably with the shoulder abducted and neutrally rotated, the elbow joint at 90 degree flexion, and the wrist in the neutral position. Three measurements were taken and the data were averaged. After each measurement, 30 seconds of rest was given in order to offset fatigue.

In order to measure isokinetic muscle strength, Biodex System 3 Pro (BBS, Biodex Medical System, Inc., USA), an isokinetic measurement equipment, was used to measure the maximum value of shoulder joint internal/external rotation. The subjects are seated in the Biodex measurement chair with elbow joint flexed out at 90 degrees and the shoulder abducted at 45 degrees. The abdomen and chest areas were fixed with a belt to prevent movement during the shoulder muscle test. A safety key was used to set up a range of motion around the rotating axis of the motor system in order to prevent hyperflexion and hyperextension. Also, the length of the forearm and the adjustment axis were adjusted to facilitate exertion of full muscle strength. The isokinetic angular velocities of the shoulder were set at 60°/sec (5 times), 180°/sec (15 times) for concentric exercise. A rest period of 30 seconds was given after each session.

Statistical analyses were performed using SPSS for Windows ver. 20.0 software. The CKCUES test was conducted four times and the data of the last three measurements were used to calculate the intraclass correlation coefficient (ICC) for the reliability of test-retest and the 95% confidence interval. In order to test validity of the CKCUES test Pearson correlation coefficients were calculated for the average values

Table 1. Test and retest mean (and standard deviation) of CKCUES test scores and reference values

CKCUES	Mean±SD for test	Mean±SD for retest	ICC	CI
	13.31±4.78	13.10±4.72	0.97	0.93–0.99

CKCUES: Closed Kinetic Chain Upper Extremity Stability; SD: standard deviation; ICC: Intraclass Correlation Coefficient; CI: Confidence Interval

Table 2. Correlation between CKCUES test, IR/ER peak torque and the hand grip test

		Mean	r
Hand Grip	RT	82.9223.13	0.79*
	LT	77.9423.40	0.78*
	RSIR	29.7613.32	0.90*
60°/sec	RSER	21.308.18	0.90*
	LSIR	29.6112.30	0.93*
	LSER	20.708.24	0.91*
180°/sec	RSIR	27.8110.57	0.94*
	RSER	20.685.32	0.82*
	LSIR	28.349.97	0.90*
	LSER	20.304.72	0.87*

CKCUES: Closed Kinetic Chain Upper Extremity Stability; RT: Right; LT: Left; RSIR: Right Shoulder Internal Rotation; RSER: Right Shoulder External Rotation; LSIR: Left Shoulder Internal Rotation; LSER: Left Shoulder External Rotation; SD: standard deviation; *significant correlation, $p < 0.01$

of the CKCUES test and the peak torque of internal/external shoulder rotation, and the maximum grip strength values.

RESULTS

The intraclass correlation coefficient of the test-retest reliability was 0.97 (Table 1).

Pearson's correlation coefficient showed there was a high positive correlation between the CKCUES test values and maximum grip strength and between the CKCUES test values and peak torque of internal/external rotation (Table 2).

DISCUSSION

Closed kinetic chain exercises are being widely used in rehabilitation treatments in clinics¹¹. Research has indicated that the development of closed kinetic chain exercise for the low limb would be beneficial for the upper limb⁹. Closed kinetic chain exercises have positive effects on muscle activity, stability of the joint, proprioceptive sense, etc¹². Hirashima et al. suggested that closed kinetic chain exercise with weight bearing is a good test method for isometric weight bearing and movement¹³.

Goldbeck and Davies conducted a test-retest reliability test of the CKCUES test using only male athletes and reported that the ICC showed very high reliability (0.92)¹⁴. In the present study, the test-retest result showed high reliability

(0.97). Roush et al. conducted the CKCUES test with baseball players without injury, and examined the differences was among the plating positions. They found no significant differences, and concluded the CKCUES test could be used for determining the return of a player to competition and changes in shoulder condition after shoulder damage¹⁵. After examining patients who had shoulder damage and healthy persons with the CKCUES test, Helga concluded that it has sufficient reliability for checking the shoulder function of athletes and ordinary patients with subacromial impingement syndrome. Even though the reliability of the CKCUES test has been established, its validity has not previously been demonstrated¹⁰.

Hand grip is closely related to upper extremity function and is an action that facilitates rotator cuff movements. Hand grip strength is important data for rehabilitation treatment and shoulder pain¹⁶. Thus, the validity of the CKCUES test was tested against hand grip in this study and the result showed high positive correlations for both the right hand (0.79) and the left hand (0.78). Thus, a high CKCUES test score indicates the hand grip value will also be high.

The isokinetic test for internal/external shoulder rotation is a very objective and accurate way of measuring shoulder muscle strength. Many researchers have used isokinetic muscle examination to measure shoulder stability¹⁷⁻¹⁹. Accordingly, this study compared shoulder internal/external peak torque data at angular speeds of 60°/sec and 180°/sec with CKCUES data, and found high correlations for all the results. The results showed the CKCUES test had high reliability, and had high correlations with the results of the hand grip test and isokinetic test, so it is considered a very useful examination method for clinical use.

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