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Limb Symmetry Index (LSI) values for Closed Kinematic Upper Extremity Multi Directional Reach Test (CKUEMDRT)

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Abstract

Background: There is sparse evidence for return to sport criteria after upper extremity injury. Functional performance deficits, particularly in fatigued muscular condition, should be verified prior to the attempt to return to high-risk pivoting sports. The purpose of this study was to generate reference values of Closed Kinematic Upper Extremity Multi Directional Reach Test (CKUEMDRT) for the limb symmetry index (LSI) of healthy subjects of both dominant and non-dominant hand in a newly designed test. **Objective:** To find the normative score of Closed Kinematic Upper Extremity Multi Directional Reach Test (CKUEMDRT) for Limb Symmetry Index. **Materials and Methodology:** 220 healthy subjects were screened out of which 200 were selected, Screening was done on the basis of participants performing 60% pushups (males-27 and females-20) according to ACSM guidelines. The ratio of gender distribution was 1:1 i.e. 100 males and 100 females. Those subjects who completed the pushup test, aged between 19 years to 30 years and having Shoulder Pain And Disability Index (SPADI) score "0" were included. **Results:** The LSI of boys for dominant and non-dominant extremity should be minimum within the range of 103%-107.1% and 98.2%-103.5% and for girls it should be minimum within the range of 106.1%-111% and 95.4%-101.3% respectively. **Conclusion:** The current study established gender specific reference values for Closed Kinematic Upper Extremity Multi Directional Reach Test in healthy young adults, In this study males performed better than females. These values can be generalized to adult population from age 19 to 29 years for CKUEMDRT.

Keywords :- CKUEMDRT- Closed Kinematic Upper Extremity Multi Directional Reach Test, LSI- Limb Symmetry Index, Pushups.



Introduction

Movements of the human shoulder represent a complex dynamic relationship of many muscle forces, ligament constraints, & bony articulations. Static and dynamic stabilizers allow the shoulder the greatest range of motion of any joint in the body & position the hand and elbow in space. This extensive range of motion affords the athlete the ability to engage in a many of sports activities; however this range of motion is not without risk. The bony architecture of the gleno-humeral joint with its large humeral head & relatively small glenoid fossa relies heavily on ligamentous & muscular stabilizers throughout its motion arc. If any of the static or dynamic stabilizers are injured by trauma or overuse, the shoulder is at increased risk of injury. The shoulder injury account for 8% to 20% of athletic injuries.¹

Both static and dynamic mechanisms have been cited as important contributing aspects to stability of the shoulder. An important static mechanism is the labrum. The labrum is a wedge-shaped, fibrous structure that is attached to the Periphery of the glenoid. The labrum is typically firmly attached in the inferior half of the glenoid and sometimes more loosely attached in the superior half, particularly anteriorly. The labrum serves as a site of attachment for the capsule, the glenohumeral ligaments, and the biceps. Also, the labrum assists in stability by increasing the contact area of the glenoid and the humeral head, and by increasing the depth of the glenoid by as much as doubling it.²

Static stability is enhanced via stimulation of joint mechanoreceptors resulting from compression of the capsule. There is also some information that suggests that weight bearing through the upper extremities increases overall stability because of the anatomical structures of the glenohumeral Joint.³

Dynamic movement testing during the preparticipation examination is gaining popularity as a component of musculoskeletal screening with the goal of identifying increased injury risk.⁴ Known injury risk factors include anthropometric measures, player position, skill level, amount of training time, flexibility, asymmetry, prior injury, playing surface, and shoe type . Although these risk factors have been identified individually, injury risk is likely multifactorial. Recently, researchers have used tests involving comprehensive movement patterns to predict injury .Although this has been reported in the literature for the lower extremity, only few studies have addressed this testing for the upper extremity.^{5,6}

The components of dynamic stability are; flexibility, muscular strength, coordination, synchronicity and neuromuscular control.⁷

Dynamic stability of the glenohumeral joint is afforded by the musculature around the shoulder, including the rotator cuff, the deltoid, and the long head of the biceps. The coordinated muscular contraction provides joint compression that aids in stability by increasing the required force necessary to translate the humeral head. These are particularly helpful in alleviating potential force applied to the capsule-ligamentous structures. Proprioceptive feedback during contraction likely also assists in providing some stability. The scapulo-thoracic musculature assists in glenohumeral joint stability by providing appropriate movement of the scapula and positioning of the glenoid under the



humerus. The overhead throwing motion is highly skilled movement performed at extremely high velocity. The throwing motions generates extraordinary demands on the glenohumeral joint. The shoulder plays a vital role in many athletic activities.⁸

Till date as per our knowledge only 3 closed-kinetic chain upper extremity tests have been described in the literature: the one-arm hop test ,upper quarter y balance test and the closed-kinetic chain upper extremity stability test (CKCUEST) .^{9,15}

To perform the one-arm hop test, an athlete assumes a 1-arm push-up position on the floor and then uses the arm to hop onto a 10.2-cm step and back onto the floor. The time required to perform 5 repetitions as quickly as possible is recorded.

The CKCUEST begins in a traditional push-up position with the hands placed 36 inches apart on strips of athletic tape. The athlete then reaches with alternating hands across the body to touch the piece of tape under the opposing hand; the number of cross-body touches performed in 15 seconds is recorded. Although these tests do place an athlete in a closed-kinetic chain position, they require power, speed, and stability and do not take into account mobility.¹⁰

The Y Balance Test Kit (Move2Perform, Evansville, IN, USA; Figure 1), on which the YBT-UQ is performed, consists of a stance platform to which 3 pieces of polyvinyl chloride pipe are attached in the medial, inferolateral, and superolateral reach directions. The posterior pipes are positioned 135 from the anterior pipe, and there is 90 between the posterior pipes. Each pipe is marked in 0.5-cm increments for measurement. The subject pushes a target (reach indicator) along the pipe, which standardizes the reach height (i.e., how far off the ground the reach hand is), and the target remains over the tape measure during performance of the test, which improves the precision in determining reach distance.^{11,12}

Upper Quarter Y balance test measures stability of upper extremity of an athlete in 3 planes but cannot measure stability more than 3 planes hence CKUEMDRT was introduced which evaluated the stability in multi directions(8directions) for upper extremity moreover the reliability and validity of this test has proved to be significant but there is a need to establish a normative data in healthy individuals.^{13,14}

Materials and Methodology

The study to establish scoring pattern and normative value for Closed Kinematic Upper Extremity Multi Directional Reach Test (CKUEMDRT) was conducted in Dr. D.Y Patil College of Physiotherapy after institutional Ethical clearance. 220 healthy subjects were screened out of which 200 were selected, Screening was done on the basis of participants(both males and females) performing 60% pushups (males-27 and females-20) according to ACSM guidelines. The ratio of gender distribution was 1:1 i.e. 100 males and 100 females. Those subjects who completed the pushup test, aged between 19years to 30years and having Shoulder Pain And Disability Index (SPADI) score “0” were included. The subjects with medical illness, neurological conditions, all shoulder injuries and disabled individuals were excluded.



The procedure was explained to the participants and a written consent was taken. Demographic data was obtained and base line descriptive data like age, weight, height, bilateral upper limb length, hand length and torso length was documented.

- Upper limb length was measured from acromion tip to tip of middle phalanx, with the shoulder abducted to 90 degrees with elbow extended and wrist and hand in neutral.
- Torso length was measured from the spinous process of C7 to a horizontal line corresponding to the iliac crest height.
- Hand length was measured from the distal wrist crease to the tip of the longest digit.
- The Close kinematic upper extremity multi directional reach test was assessed

test description:-

The Closed Kinematic Upper Extremity Multi Directional Reach Test (CKUEMDRT) was used in the study to establish the normal values of the tool for both males and females of dominant and non-dominant hand and projecting the dynamic stability of the shoulder complex in eight directions. The direction of reach were as follows-

1. Upper (U)
2. Upper Oblique (UO)
3. Lateral (L)
4. Lateral Oblique (LO)
5. Inferior (I)
6. Inferior Oblique (IO)
7. Contra-Lateral Lateral (CLL)
8. Contra-Lateral Lateral Upper Oblique (CLLUO)

The CKUEMDRT Tool was used to measure reach distance of each direction. This tool consist of octagonal wooden base and 8 PVC pipes on which 0-150 cms laser markings has been done by precise engraving machine. Size of each side of octagonal wooden base is 15cms. Along with those eight small wooden blocks markers will be placed on eight PVC pipes so that an individual can slide those markers up to maximum capacity of reach and reach distance was measured. The sum of the eight reach directions was calculated for a total excursion score.

To establish the normative score for CKUEMDRT the average value of three trials of reach distance was put in the following formulae.



- Limb symmetry index=mean score of dominant limb/mean score of non-dominant limb *100

Starting position:-

- Individual was in push-up position.
- Inter shoulder and inter feet distance was marked.
- The hand was placed on the center.

Familiarization procedure:-

- Client was having simulated environment for trail.
- Learning procedure was completed in one trail.
- During the trails the client was advised on permissible and non-permissible errors.
- Now the actual was performed.
- The client performed the test with dominant side first followed by non-dominant.
- The test was performed thrice.
- The average values of the right and the left Upper extremity was taken in consideration.

Permissible Errors:-

- Elbow flexion
- Trunk rotation
- Movement of the upper quadrant

Non permissible Errors:-

- Jerky movements
- moving of stable hand off the support block.
- Shifting of foot position
- Touching of any body parts to the floor apart from the permitted points of contact.
- Bending of knee.
- Moving hand touching the floor before coming back to starting position.
- Deliberately pushing the scoring block with force than gently sliding.



Figure no.1



Closed Kinematic Upper Extremity Multi Directional Reach Test (CKUEMDRT) Starting Position

Data Analysis and Interpretation

The data collected were analysed using MedCalc (version 18.11.3). Total 200 participants were recruited in the study (100 males and 100 females) and statistical analysis was done to establish normative scoring for the CKUEMDRT tool. Values of the all the 8 component performed by the participant was considered on the basis of average value of three trials. These values were inserted in the software so as to obtain the percentile for each component. At 95% confidence interval 20, 40, 60 and 80 percentiles were considered. The grading for each component was done as follows -

PERCENTILE	GRADING
< 20	POOR
20 to 40	AVERAGE
40 to 60	GOOD
60 to 80	VERY GOOD
>80	EXCELLENT



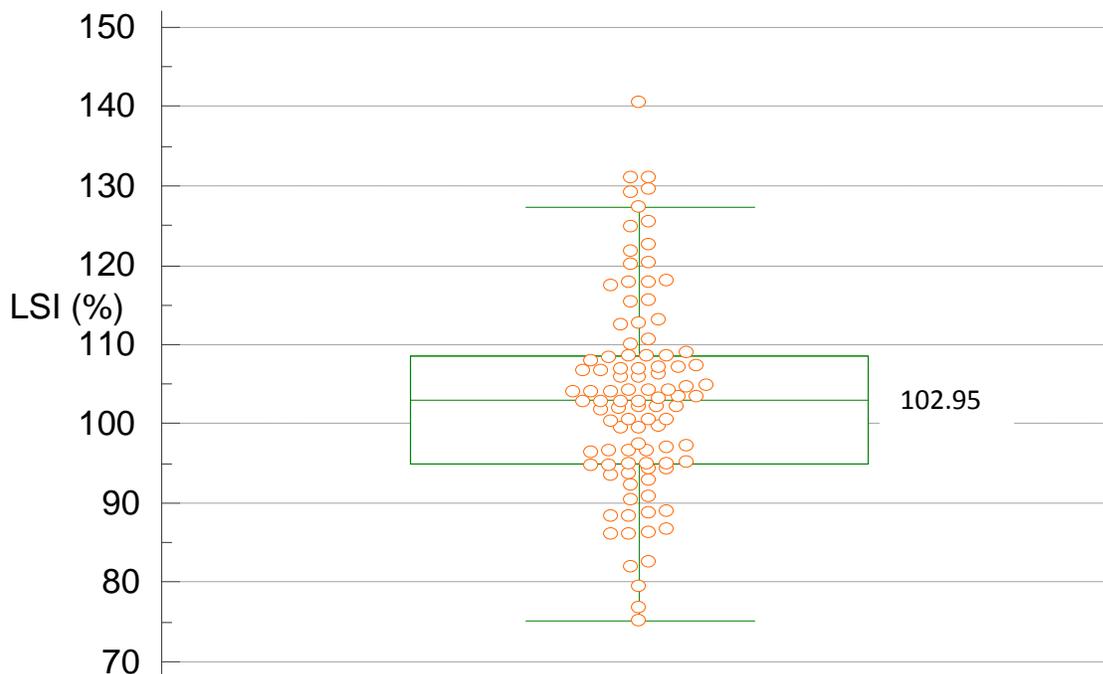
Table no.1

Limb Symmetry Index (LSI) for dominant hand reach-boys

[Limb symmetry index=mean score of dominant limb/mean score of non-dominant limb *100]

Variable	LSI
Sample size	100
Lowest value	<u>75.20</u>
Highest value	<u>140.50</u>
Arithmetic mean	103.54
95% CI for the Arithmetic mean	101.05 to 106.02
Median	102.95
95% CI for the median	100.60 to 104.75
Variance	156.99
Standard deviation	12.52

Percentiles	Mean reach distance	95% Confidence interval
5	84.25	76.45 to 88.40
20	94.40	88.99 to 96.41
40	100.60	96.60 to 102.85
60	104.80	103.04 to 107.19
80	112.50	108.16 to 119.04
95	128.25	120.60 to 133.48



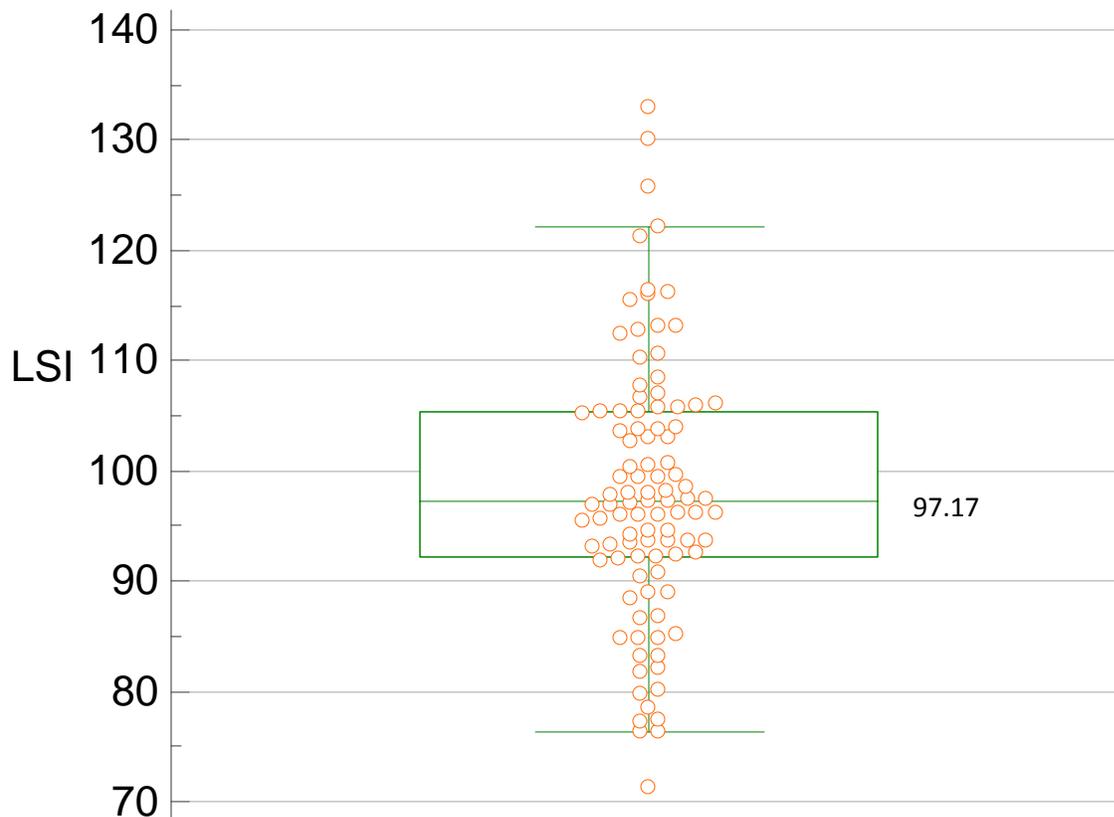
Interpretation – The median at 50 percentile for LSI is 102.95

Table no.2
Limb Symmetry Index (LSI) for non-dominant hand reach- boys

Variable	LSI	
Sample size	100	
Lowest value	<u>71.21</u>	
Highest value	<u>132.99</u>	
Arithmetic mean	98.02	
95% CI for the Arithmetic mean	95.67 to 100.37	
Median	97.17	
95% CI for the median	95.52 to 99.41	
Variance	140.50	
Standard deviation	11.85	
Percentiles	Mean reach distance	95% Confidence interval
5	77.99	75.00 to 82.26
20	88.94	83.78 to 92.48



40	95.47	93.28 to 97.11
60	99.42	98.24 to 103.54
80	105.97	104.80 to 112.39
95	118.81	113.18 to 130.82



Interpretation – The median at 50 percentile for LSI is 97.17

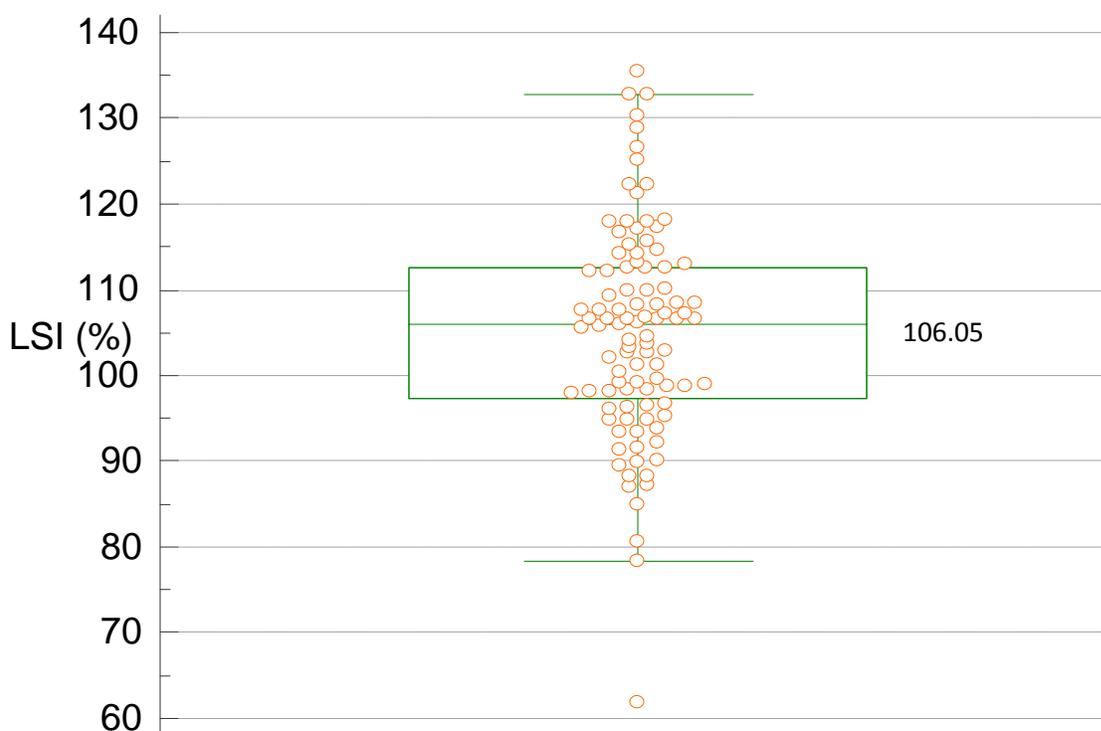
Table no.3
Limb Symmetry Index (LSI) for dominant hand reach- girls

Variable	LSI
Sample size	100
Lowest value	61.90
Highest value	135.50
Arithmetic mean	105.04



95% CI for the Arithmetic mean	102.58 to 107.49
Median	106.05
95% CI for the median	102.46 to 107.38
Variance	153.30
Standard deviation	12.38

Percentiles	Mean reach distance	95% Confidence interval
5	87.15	74.08 to 89.94
20	95.05	91.59 to 98.31
40	102.35	98.70 to 105.95
60	107.45	106.14 to 111.09
80	114.45	112.10 to 119.90
95	127.70	120.7 to 133.43



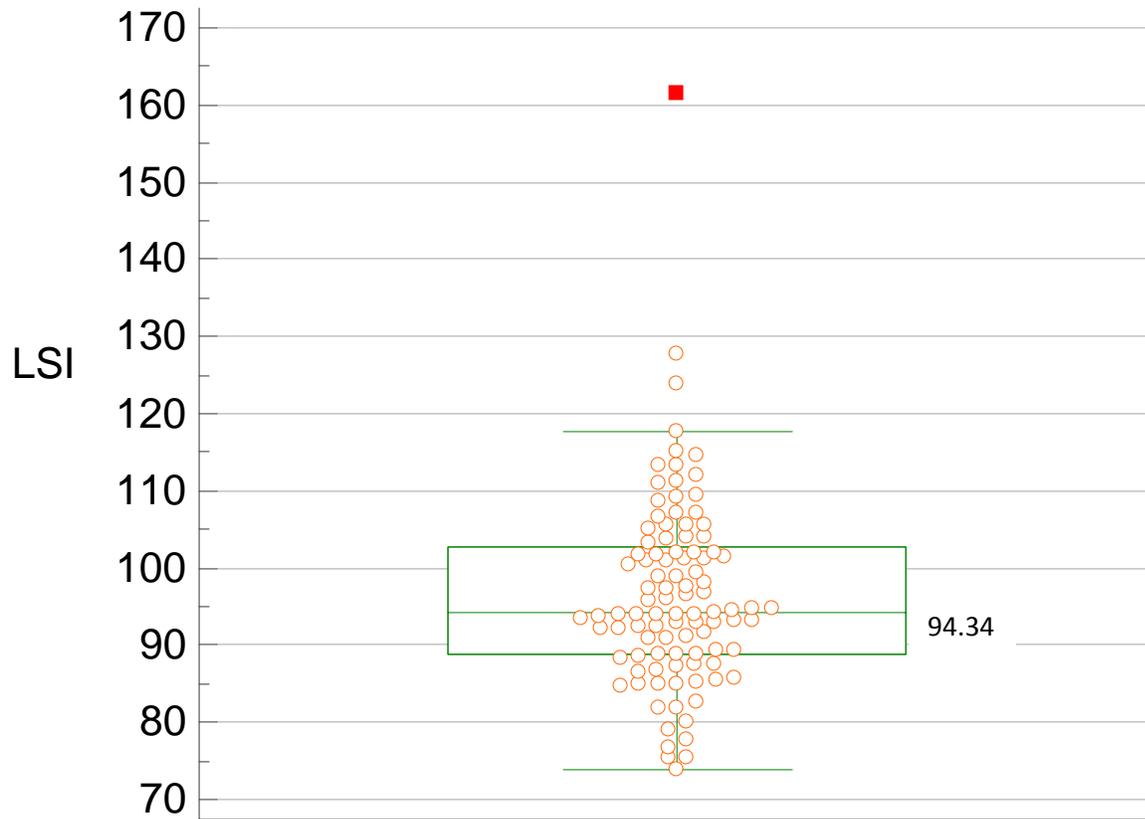
Interpretation – The median at 50 percentile for LSI is 106.05



Table no.4

Limb Symmetry Index (LSI) for non-dominant hand reach- girls

Variable	LSI	
Sample size	100	
Lowest value	<u>73.82</u>	
Highest value	<u>161.61</u>	
Arithmetic mean	96.65	
95% CI for the Arithmetic mean	94.18 to 99.12	
Median	94.34	
95% CI for the median	93.14 to 97.64	
Variance	155.16	
Standard deviation	12.45	
Percentiles	Mean reach distance	95% Confidence interval
5	78.35	74.96 to 82.86
20	87.40	83.86 to 89.21
40	93.09	90.93 to 94.27
60	97.75	95.41 to 101.39
80	105.30	102.76 to 109.20
95	114.77	110.21 to 136.51



Interpretation – The median at 50 percentile for LSI is 94.34

Results

Table no.1

the graphs indicate normative score for LSI for males (dominant hand). At the percentiles 5, 20, 40, 60, 80, 95 the grading for the percentiles of each component are as given below

	<20 (POOR)	20-40 (AVERAGE)	40-60 (GOOD)	60-80 (VERY GOOD)	>80 (EXCELLENT)
LSI	76.4- 95.4	96.6- 102.8	103.0- 107.1	108.1- 119.0	120.6- 133.4



Table no. 2

and the graphs indicate normative score for LSI for males (non-dominant hand). At the percentiles 5, 20, 40, 60, 80, 95 the grading for the percentiles of each component are as given below

	<20 (POOR)	20-40 (AVERAGE)	40-60 (GOOD)	60-80 (VERY GOOD)	>80 (EXCELLENT)
LSI	75.0- 92.4	93.2- 97.1	98.2- 103.5	104.8- 112.3	113.1- 130.8

Table no. 3

and the graphs indicate normative score for LSI for Females (dominant hand). At the percentiles 5, 20, 40, 60, 80, 95 the grading for the percentiles of each component are as given below

	<20 (POOR)	20-40 (AVERAGE)	40-60 (GOOD)	60-80 (VERY GOOD)	>80 (EXCELLENT)
LSI	74.0- 98.3	98.7- 105.9	106.1- 111.0	112.1- 119.9	120.7- 133.4

Table no. 4

and the graphs indicate normative score for LSI for Females (non-dominant hand). At the percentiles 5, 20, 40, 60, 80, 95 the grading for the percentiles of each component are as given below

	<20 (POOR)	20-40 (AVERAGE)	40-60 (GOOD)	60-80 (VERY GOOD)	>80 (EXCELLENT)
LSI	74.9- 89.2	90.9- 94.2	95.4- 101.3	102.7- 109.2	110.2-136.5

Discussion

This study was conducted to establish the normative scoring of Closed Kinematic Upper Extremity Multi Directional Reach Test for assessing upper extremity stability and mobility at a stretch. This test is a step further in the direction of Upper Quarter Y Balance Test for assessing the dynamic stability of glenohumeral joint in eight direction (UQY-BT measures dynamic stability of glenohumeral joint in



three directions). The CKUEMDRT was found to be a valid assessment of upper extremity closed kinetic chain excursion in individuals with shoulder pain.

The normative data of CKUEMDRT with respect to LSI is categorized within 5 grades depending on percentile values namely; <20 as poor, 20- 40 as average, 40- 60 as good, 60-80 as very good and >80 as excellent. The reference values for Limb Symmetry Index (LSI) of dominant hand in boys was categorized as 'Poor' in boys within the range of 76.4% to 95.4% and that of girls was 74.0% to 98.3% whereas it was considered as 'Excellent' within the range of 120.6% to 133.4% in boys and 120.7% to 133.4% in girls.

The normative data considering the non-dominant upper extremity in boys with respect to LSI was considered to be 'Poor' within the range of 75.0% to 92.4% respectively which was greater on comparison with girls as LSI values were 74.9% to 89.2% respectively. However in boys LSI was considered to be 'Excellent' within the range of 113.1% to 130.8% respectively which was greater than girls such as LSI was within the range of 110.2% to 136.5% respectively.

The score of LSI shows difference in dominant and non-dominant upper extremity of boys and girls. The dominant and non-dominant upper extremity of boys and girls shows difference of 5% and 11% respectively. The LSI score of dominant and non-dominant upper extremity should be at least 103% and 98.2% in boys and 106.1% and 95.4% in girls, score below the values mentioned is an indication of any shoulder pathology, instability or loss of power of upper extremity. Here the dominant hand shows better performance than the non-dominant hand.

As for calculating the reach distance of dominant hand the non-dominant hand is playing a role of maintaining stability. Hence increase in stability gives better performance of reach in dominant hand.

The Reach distance of an individual depends upon the factors such as muscular strength, flexibility, co-ordination, synchronicity and neuromuscular control. A study did by Todd S. Ellenbecker, et. al. stated that there arises difficulty in trying to describe any closed-kinetic chain test that assesses the independent function of the shoulder complex or the elbow complex, as the function of these complexes are not independent from one another and requires coordination between scapular, glenohumeral, elbow, and forearm muscles. Similar to their study, this study provides a strong basis for evaluating flexibility, strength, while considering the upper extremity in close kinematic position. A study was conducted by Ellenbecker TS, et.al. on 'Closed kinetic chain testing techniques of the upper extremities'. In their study the authors reported reference values for the CKCUEST of 18.5 touches for males and 20.5 touches for females (females used a modified starting position). Similar to their study, this study also provides reference values for closed kinematic upper extremity multi directional reach test described under the components of (i) absolute reach distance (ii) relative reach distance (iii) composite reach distance and (iv) limb symmetry index for young healthy males and females.

Ali H Alnahdi, et, al did a study to find out the "Reference values for the Y Balance Test and the lower extremity functional scale in young healthy adults". Reference values for gender specific were obtained for the right, left, dominant, and right and left non-dominant leg as well as for the average performance of both the legs. Greater YBT normalized reach distances was found in males and females showed lesser YBT normalized reach distance did in the anterior, posteromedial, and



posterolateral directions; furthermore, males showed higher YBT composite scores than females did. However, the LEFS-Ar values was similar between males and females. According to their study, we have found out the gender specific reference values for right, left dominant, and non-dominant upper extremity.

Another study was conducted by Paul P. Gorman, et.al. on 'Differences in dynamic balance scores in one sport versus multiple sport high school athletes'. They found that males showed greater normalized reach distances in the posteromedial and postero lateral directions and higher composite reach scores than the females did. Our study paralleled their findings where we found the males showed higher normalized reach scores in all 8 directions of the CKUEMDRT and also showed higher composite reach scores than the females did.

conclusion

The current study established gender specific reference values for Closed Kinematic Upper Extremity Multi Directional Reach Test in healthy young adults, In this study males performed better than females. These values can be generalized to adult population from age 19 to 29 years for CKUEMDRT.

The limb symmetry index of boys for dominant and non-dominant extremity should be minimum within the range of 103%-107.1% and 98.2%-103.5% respectively. However the Limb Symmetry Index of girls for dominant and non-dominant upper extremity should be minimum within the range of 106.1%-111% and 95.4%-101.3% respectively.

The LSI score below the above mentioned range is indicative of instability or loss of power of upper extremities. There was a difference of 5% in dominant and non-dominant upper extremity of boys whereas it was 11% in girls.

Limitations & Recommendations

➤ **limitations:**

- Sample population was considered of 19 to 29 age group only
- Sample population of sedentary lifestyle only was considered
- Body Mass Index of the participants was not taken into consideration

➤ **recommendations:**

- The study could be performed on individuals with various professions like body builders, athletes, etc.
- A study finding the correlation between core stability and upper extremity stability could be done.
- To use CKUEMDRT as an outcome measure in shoulder pathology and upper extremity pathology.

Source of funding-Self



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