Reliability of Scapular Downward Rotation Measurement in Subjects With Scapular Downward Rotation Syndrome

Woo-jeong Choi[1], BPT, PT, Ji-hyun Lee[1], MSc, PT, Hyo-jung Jeong[1], BPT, PT,
Tae-lim Yoon[1,2], MA, PT, Heon-seock Cynn[3,4], PhD, PT

[1]Dept. of Physical Therapy, The Graduate School, Yonsei University
[2]Dept. of Physical Therapy, College of Health and Welfare, Woosong University
[3]Dept. of Physical Therapy, College of Health Science, Yonsei University
[4]Dept. of Ergonomic Therapy, The Graduate School of Health and Environment, Yonsei University

Abstract

The purposes of the current study were to (1) estimate the inter-rater agreement for visual assessment of scapular downward rotation (SDR), (2) develop the scapular downward rotation index (SDRI) as a method to measure SDR objectively and quantitatively, and (3) analyze the intra- and inter-rater reliability of the SDRI. Twenty subjects with scapular downward rotation syndrome (SDRS) were recruited for this study. The visual assessment and the measurement for the SDRI were conducted by two examiners in two sessions each. The SDRI [(a-b)÷a×100] is calculated with the measurement of two linear distances: One is a perpendicular distance from the root of the scapular spine to the thoracic mid-line (a), and the other is a perpendicular distance from the inferior angle of the scapula to the thoracic mid-line (b). Cohen's kappa coefficient was calculated to estimate the inter-rater agreement for visual assessment. Intra-class correlation coefficients (ICCs) with a 95% confidence interval (CI), the standard error of measurement, and minimal detectable differences were calculated to assess intra- and inter-rater reliability of SDR measurement using the SDRI. The results indicated that the kappa coefficient of inter-rater agreement for visual assessment was fair (κ=.21). The intra-rater reliability of SDR measurement using the SDRI was excellent for examiner 1 (ICC=.92, 95% CI=.78~.97) and good for examiner 2 (ICC=.82, 95% CI=.55~.93). The inter-rater reliability was moderate (ICC=.73, 95% CI=.32~.89). These findings showed that SDR measurement using the SDRI for subjects with SDRS may be considered reliable and better than the visual assessment.

Key Words: Reliability; Scapular downward rotation index; Visual assessment.

Introduction

Normal scapular alignment is when the vertebral border of the scapula is parallel to the spine and is positioned approximately 3 inches from the mid-line of the thorax (Sobush et al, 1996). The scapula should be positioned between the spinous process of the thoracic vertebrae 2nd to 7th (Hoppenfeld et al, 1976; Kendall et al, 2005; Magee, 2013; Sahrmann, 2002). Because of a change in muscle length and joint alignment, the scapular alignment can be altered, resulting in interference with performing optimal movement (Sahrmann, 2002). Scapular alignment impairment may also contribute to unwarranted stress and compression on joints, muscles, and ligaments, leading to pain (Magee, 2013; Tüzün et al, 1999). Some research studies have established the relationship between alignment and pathology (Azevedo et al, 2008). Especially, the influences of scapular alignment-related syndromes on shoulder pain and impairment of movement pattern have been emphasized (Sahrmann, 2002; Swift and Nicols, 1984).

Scapular downward rotation syndrome (SDRS) is one of the most common scapular alignment impair-

Corresponding author: Ji-hyun Lee jihyun.lee@yonsei.ac.kr

ments and is responsible for shoulder pain (Sahrmann, 2002). SDRS is described as the inferior angle of the scapula being more medial than the root of the scapular spine rather than the vertebral border being parallel to the spine (Sahrmann, 2002). Various causes are involved with SDRS, such as thoracic kyphosis and imbalance of muscles between the scapular downward rotators and upward rotators (Sahrmann, 2002). Before correction of the problems, an accurate assessment of scapular alignment is considered as a critical component of the physical examination to make a diagnosis (Akalin et al, 2001; Clein, 1976; Host, 1995; Kendall et al, 2005; Kibler, 1998). Also, a precise measurement during assess-ment is important to track the progression during rehabilitation (Sahrmann, 2002; van der Helm, 1994).

Visual inspection of the scapula to assess the scapular alignment has been used and suggested (Kibler et al, 2002; McClure et al, 2009; Plafcan et al, 1997; Sahrmann, 2002). Many previous studies have investigated the visual inspection assessment of scapular alignment with instruments such as a goni-ometer or an electrical inclinometer (Burkhart et al, 2003; Odom et al, 2001). In fact, Tucker and Ingram (2012) researched measuring scapular upward rotation by using an electrical inclinometer, and Odom et al (2001) used a tape measure to achieve the value of a lateral scapular slide test. McClure et al (2009) re-ported that visual assessment offers an alternative to linear measurement for evaluating 3-dimensional scapular motion. Visually based assessment could be used practically in a clinical setting. Different meth-ods to assess the scapular alignment by using in-struments have been introduced; however, no studies have suggested a method that is clinically accessible as well as quantitative and objective for measuring scapular downward rotation (SDR). In that respect, we designed a scapular downward rotation index (SDRI) as a measurement.

Therefore, the purposes of this study were to (1) estimate the inter-rater agreement for visual assess-ment of SDR, (2) develop the SDRI as a method to measure SDR objectively and quantitatively, and (3) analyze the intra- and inter-rater reliability of the SDRI. We hypothesized the inter-rater agreement for visual assessment of SDR would be poor to fair. Also, using the SDRI to measure SDR would dem-onstrate good to excellent intra- and inter-rater reliability.

Methods

Subjects

Twenty subjects (12 men and 8 women) with SDRS participated in this study. Demographic data are shown in Table 1. The principal investigator re-cruited subjects by screening the appearance around shoulder. The screening test included the presence of shoulder slope, lower clavicle angle, and shoulder ab-duction relative to scapular external rotation (Sahrmann, 2002). Subjects' shoulders were sloped and clavicle angles were even. When subjects were all recruited by screening, SDR was measured by using the SDRI. We operationally defined SDRS when the SDRI score was higher than "0". (The SDRI is explained in the procedure section.) Subjects who had an SDRI score less than "0" were excluded. Both sides were measured to determine SDRS. The more downwardly rotated scapula (higher SDRI) was chosen to be examined. The more downwardly ro-tated scapula was on the right side in two subjects and on the left side in 18 subjects. Subjects were excluded from participating if they had a history of shoulder injury or surgery in the past 3 years. Also, subjects who had scapular alignment impairment

Table 1. Demographic data of subjects   (N=20)

	Mean±SD[a]
Age (year)	19.8±1.6
Height (㎝)	68.2±6.5
Weight (㎏)	57.2±6.3
BMI[b] (㎏/㎡)	20.2±1.4

[a]mean±standard deviation, [b]body mass index.

other than SDR in the sagittal or transverse plane, such as scapular winging or tipping, were excluded so that SDRI measurement would not be affected during the experiment. Before participation, the detailed experimental process was explained to all subjects, and consent was given before the experiment.

Procedures

The two examiners were physical therapists with 1-year clinical practice experience. Before the experiment, the principal investigator conducted a 1-hour training session for the examiners to ensure familiarization and standardization of determining the precise location of the landmarks and measurement to reduce measurement error. To minimize bias, the measurement order of the two examiners was randomized by creating a randomization scheme on the website Randomization.com (available from: http://www.randomization.com; accessed 10 June 2014). Visual assessment was followed by two sessions of SDRI measurement. Also, two examiners were not informed that subjects has scapular downward rotation syndrome during the visual assessment. The visual assessment and SDRI measurement results were blinded to each examiner. Men did not wear tops and women wore backless tops so that both scapula were in full view of the examiners.

Visual assessment

First, a straight line was drawn on the floor parallel to the frontal plane. The subject was asked to stand on the line and look directly ahead. To aid in remaining still while holding the same posture during the assessment session, the subject was instructed to fix both arms at his or her sides with the glenohumeral joints in a neutral position. Second, a straight line was drawn on the floor parallel to and 50 ㎝ behind the first line. The examiner stood on the second line and faced the subject's back. After observing the subject's scapula for 30 seconds, the examiner recorded if a scapula was or was not downwardly rotated. The two examiners assessed

every subject one time each.

Scapular downward rotation index

For SDRI measurement, the instructions for the subjects were the same as the instructions during the visual assessment. The principal investigator attached 5-㎜ diameter paper tape along the spinous process from thoracic vertebrae 1st to 12th. Next, the examiner palpated the subject's scapula and marked a dot with a black-ink pen at two landmarks: the root of the scapular spine and the inferior angle. Then, the examiner used a universal caliper to measure the lengths of two perpendiculars from the two landmarks to the paper-tape line. The marked dots on the landmarks were completely removed after one measurement. The two examiners made measurements twice each in the separate time sessions that were one day apart for every subject.

The SDRI was calculated using the equation $[(a-b) \div a \times 100]$. This equation includes two lineal distances: one is a perpendicular distance from the root of the scapular spine to the thoracic mid-line (a), and the other is a perpendicular distance from the inferior angle of the scapula to the thoracic mid-line (b). Subtraction of (b) from (a) is divided by (a) and multiplied by 100 (Figure 1).
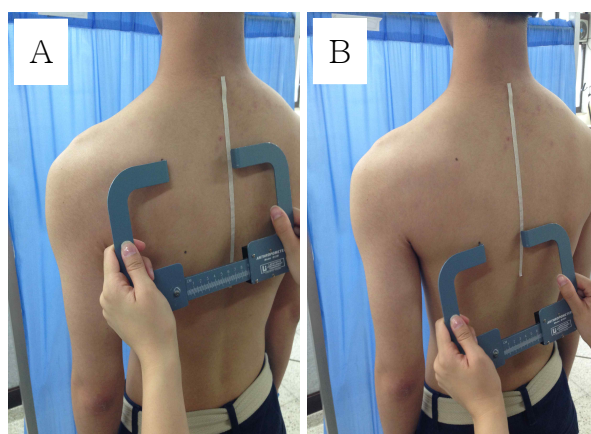

Figure 1. Scapular downward rotation index [A: measuring (a) a perpendicular distance from the root of the scapular spine to the thoracic mid-line, B: measuring (b) a perpendicular distance from the inferior angle of the scapula to the thoracic mid-line].

Statistical analysis

Cohen's kappa coefficient was used to estimate inter-rater agreement for the visual assessment of SDR. For the purpose of interpretation, kappa values were defined as the following: .20 or less=poor, .21~.40=fair, .41~.60=moderate, .61~.80=substantial, and greater than .80=good (Landis and Koch, 1977).

The mean differences between the SDRI results from the two examiners and between each examiner's SDRI results from two sessions were calculated, and a paired t-test was used for comparison. p<.05 was deemed statistically significant. Intra-class correlation coefficients [ICCs (3,1)] were used to determine the intra- and inter-rater reliability of SDR measurement using the SDRI. Intra-rater reliability was calculated across results from the test sessions. Inter-rater reliability was calculated across examiners in session 2. Degree of reliability bases on ICCs was defined using the following criteria: .69 or less=poor, .70~.79=moderate, .80~.89=good, and .90~.99=excellent (T'Jonck and Lysens, 1996). The standard error of mean (SEM) was calculated for each measurement to assess absolute consistency [SEM=SD$\sqrt{(1-ICC)}$]. Minimal detectable difference (95% confidence interval) (MDD$_{95}$) scores were calculated [MDD$_{95}$=1.96×SEM×$\sqrt{2}$]

(Beaton et al, 2001). All statistical analyses were performed using SPSS ver. 21.0 (SPSS, Inc., Chicago, IL, USA).

Results

Cohen's kappa coefficient of inter-rater agreement for visual assessment of SDR was fair (κ=.21). The means and standard deviations of each measurement of the SDRI are shown in Table 2. There were no significant differences between measurements of session 1 and session 2 or between measurements of the examiners (p=.91, .83, .06, respectively). The intra-rater reliability of SDR measurement using the SDRI was excellent for examiner 1 (ICC=.92, 95% CI=.78~.97) and good for examiner 2 (ICC=.82, 95% CI=.55~.93). The inter-rater reliability was moderate (ICC=.73, 95% CI=.32~.89). The ICCs with 95% CIs, SEM, and MDD$_{95}$ results are shown in Table 3.

Discussion

The purposes of this study were to (1) estimate

Table 2. Mean±standard deviation of scapular downward rotation index

Examiner	Test session	Mean±SD[a]
1	1	13.34±5.62
	2	13.43±6.60
2	1	10.90±7.19
	2	10.63±7.05

[a]mean±standard deviation.

Table 3. Intra- and inter-rater reliability, standard error of measurement, and minimal detectable differences of scapular downward rotation measurement using the scapular downward rotation index

	Intra-rater reliability		Inter-rater reliability
	Examiner 1	Examiner 2	
ICC[a] (95% CI[b])	.92 (.78~.97)	.82 (.55~.93)	.73 (.32~.89)
SEM[c]	1.71	2.98	3.56
MDD$_{95}$[d]	4.74	8.26	9.88

[a]intra-class correlation coefficient, [b]confidence interval, [c]standard error of mean, [d]minimal detectable differences.

the inter-rater agreement for visual assessment of SDR, (2) develop the SDRI as a method to measure SDR objectively and quantitatively, and (3) analyze the intra- and inter-rater reliability of the SDRI. In the results, the inter-rater agreement was fair for visual assessment of SDR. Also, the intra-rater reliability for the SDRI was excellent for examiner 1 and good for examiner 2, and the inter-rater reliability was moderate.

In the current study, we used Cohen's kappa coefficient to estimate inter-rater agreement for visual assessment of SDR. The value was .21, which was interpreted as fair agreement. A visual-based classification system for scapular dysfunction has been researched by Kibler et al (2002). Abnormal dynamic scapular movement patterns were defined, and inter-rater reliability of the visual-based classification system between two physical therapists and between two physicians was analyzed (κ=.42 and .31, respectively, which failed to support the application of their system). McClure et al (2009) also researched the inter-rater reliability of the visual identifying method for scapular dyskinesis. They reported the average value of the kappa weighted coefficient was .57, which was higher than the result from the research study by Kibler et al (2002). Even though it is difficult to compare directly, the result of inter-rater agreement for visual assessment in the current study is considered poorer than the results from some previous studies. We suggest the reason why our result was poorer is that the visual assessment of SDR in the current study was performed with subjects' arms in a static position; by contrast, in the previous research studies by Kibler et al (2002) and McClure et al (2009), the tests were conducted with dynamic upper extremity movement. Warner et al (1992) found that scapular abnormalities were more evident during dynamic assessment than during static testing in participants with impingement and instability. Visual assessment may be refined if the rating involves a lack of SDR during subjects' shoulder abduction.

The intra-rater reliabilities of SDRI measurement were good to excellent. For the intra-rater reliability of examiner 2, the ICC was .82, which was lower than the ICC of .92 for the intra-rater reliability of examiner 1. This relatively lower intra-rater reliability likely occurred because measurements were made in different time sessions. Measurements on different days may influence both the subjects and the examiners. Even though the subjects were instructed to hold the same anatomical position during every session and not make any motion if at all possible during the measurement, small body movements between the first and second sessions may have influenced the results of measurement. Examiner differences in measurement technique or skill between sessions could also have affected the results. Even though intra-rater reliability of SDRI measurement showed a difference between examiner 1 and examiner 2, inter-rater reliability of SDRI measurement had moderate reliability. As a result, SDRI measurement is a more reliable method than visual assessment, whose inter-rater reliability was poor.

In a neutral position, the vertebral border of the scapula is 6.35~7.62 ㎝ from the spinous process of thoracic vertebrae (Sahrmann, 2002). Moghaddam and Salimee (2012) reported that the distance between the vertebral border of the scapula and the spinous process of thoracic vertebrae was 6.64 ㎝ by palpation measurement in healthy adults. In the current study, the mean value and standard deviation of the distance was 7.89±1.52 ㎝ between the root of the scapular spine and the spinous process of thoracic vertebrae (a) and 6.95±1.49 ㎝ between the inferior angle and the spinous process of thoracic vertebrae (b).

The current study has several limitations. First, we did not perform the power analysis to calculate the sample size in this study. Second, we used only a universal caliper to measure the distance between landmarks. Further studies are needed to compare the reliability of the SDRI using other methods, such as tape measurement and photographic measurement.

Third, the validity of the SDRI was not investigated. Fourth, the examiners who measured SDRI did not have wide experience. Further studies should be performed on the validity of measuring SDR with a gold standard, such as computed tomography and magnetic resonance imaging. Also, examiners with wide experience and the sample size with the result of power analysis are recommended to generalize the findings of this study.

Conclusion

This current study developed the SDRI as a method to measure SDR and analyzed the reliability. The findings showed that having the same and different examiners use the SDRI to measure SDR in subjects with SDRS may be considered reliable and better than visual assessment. On the basis of the findings of the current study, we recommend the SDRI as quantitative method to measure SDR.

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