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Measurement of passive range of internal rotation of shoulder in supine versus side-lying position: A reliability study

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Abstract
Study Design: Cross-sectional study.
Objective: To compare reliability of shoulder internal rotation (IR) passive range of motion measurements in supine and side-lying position.
Background: Intrarater reliability for measuring shoulder IR has been found to be excellent. Interrater reliability for measuring shoulder external rotation has always been good but interrater reliability for measuring shoulder IR has been poor or fair. Side-lying position which is similar to sleeper stretch position has been reported to give better reliability for measuring IR. However, there is need of more evidence to support this hypothesis. Also there is need for more objective data for normative values in this position on both dominant and non-dominant side.
Methods: 200 asymptomatic subjects, 108 females and 92 males with mean age 22.24years were included in the study. Shoulder IR passive range of motion (PROM) of dominant and non-dominant side was measured by two physical therapists in both supine and side-lying position. For interrater reliability, each rater obtained 2 PROM measurements on the same day. For intrarater reliability, two PROM measurements were measured after 48 hours again by primary investigator (rater 1) in both positions.
Results: Intrarater reliability in supine and side-lying positions was excellent for dominant and non-dominant shoulder IR with ICC ranging from 0.950 to 0.970. Interrater reliability in supine position for dominant shoulder IR was good (ICC= 0.853) and for non-dominant was fair (ICC= 0.775). Interrater reliability in side-lying position for dominant and non-dominant shoulder IR was excellent, ICC= 0.946 and 0.924 respectively. The mean side-lying IR ROM value for dominant shoulder was 61.06˚ ± 9.64˚ and non-dominant shoulder was 69.56˚ ± 9.50˚ and average supine IR ROM value for dominant shoulder was 91.63˚ ± 10.28˚ and non-dominant shoulder was 99.44˚ ± 10.06˚.
Conclusion: Intrarater and interrater reliability of shoulder IR measurements in side-lying position was superior compared to that in standard supine position.

Keywords: goniometry, joint motion, glenohumeral joint, scapular stability, dominant, non-dominant

Introduction

RANGE OF MOTION (ROM) assessment is an essential part of the musculoskeletal examination. Outcome analysis, treatment effect monitoring, diagnosis and evaluation of impairment is supported by range of motion measurement. To establish the clinical usefulness of any proposed ROM measure, it is vital to standardise valid and reliable methods of measurement [1]. Goniometry is an important part of a comprehensive examination of joints and surrounding soft tissue[2]. In goniometry, reliability indicates the constancy or the reproducibility of the ROM measurements, i.e. when the same instrument and procedures are used, under similar conditions, it produces the same measurements repeatedly. On the same subject and under the same conditions, if repeated measurements of joint range of motion produces the same outcome, the goniometric measurement is considered highly reliable [2, 3].

Testing passive range of motion (PROM) provides information regarding integrity of joint surfaces, capsule extensibility, ligaments, muscles, fascia and skin but it is more challenging to measure reliably then active ROM. According to study conducted by Pandya *et al* [4], inter tester reliability values of goniometric PROM measurements were lower as compared to intra tester values, which he attributed to the variable force exerted by different therapists [4] Following a study conducted by Hellebrandt *et al* [5] on reliability of active movements of the upper extremity, many investigations in healthy subjects have demonstrated better intra tester than inter tester reliability [5].

Shoulder examination is very common in clinical settings as shoulder pain is one of the most prevalent musculoskeletal complaint [6, 7]. Measuring glenohumeral rotation is very important part of complete shoulder examination. In overhead athletes, increased risk of injury and impaired athletic performance may result from reduced shoulder internal rotation (IR) due to a tight capsule or rotator cuff. Therefore, identifying and treating glenohumeral internal rotation deficits is important part of shoulder rehabilitation. Range of motion at the shoulder is a sum of the movements occurring at the joints included in the shoulder complex and motion at the glenohumeral joint is frequently described as a percentage of this range. Abduction and flexion at the glenohumeral joint is

reported to be 100-120 degrees. Shoulder rotation, however, occurs only at the glenohumeral joint [8]. There is no widely accepted and reliable method for measuring isolated glenohumeral IR. Interrater reliability for measuring shoulder IR in standard supine position has been found to be poor. According to Riddle *et al*, poor interrater reliability could be due to difference in scapular stabilization by testers [9].

Also several methods used for measuring IR require two examiners to be present. Recently, side-lying position similar to that used in sleeper stretch position is been used for measuring glenohumeral IR. There is initial evidence for better reliability of IR PROM measurement in the side-lying position as it allows more consistent scapular stabilization than supine position.[6] However, there is need of more proof of the same as well as normative data of shoulder IR PROM in the side-lying position. Given the poor interrater reliability and the need of two examiners in the supine position, the aim of this research was to use the alternative side-lying position for measuring shoulder IR and comparing its reliability with the standard supine position. The secondary objective was to provide descriptive data of shoulder IR PROM measurement on dominant and non-dominant sides, in the side-lying position.

Methods

Subjects

200 asymptomatic (without shoulder pathology) 108 females and 92 males with mean age 22.24±4.29 years from age group 18-35 were included in the study. Exclusion criteria for this study comprised history of trauma/injury, tumour, fracture, infection, surgery, degenerative conditions of cervical/shoulder joint. Individuals with any prior history of connective tissue disorder, systemic disease or neurological deficit, overhead athletes and pregnant women. Approval for conducting the study was accorded by ethics committee of the institute and university. All subjects read and signed an information sheet and consent form in the language best understood by them, before participating in the study.

Procedure

Shoulder IR PROM of both shoulders was measured by two physical therapists. Rater 1 was a PG student specializing in musculoskeletal sciences and rater 2 was a senior physical therapist. For interrater reliability, each rater obtained two PROM measurements of dominant and non-dominant shoulder internal rotation in supine and side-lying positions, on the same day (mean of the two readings was taken for final analysis). For intrarater reliability, two IR PROM measurements of dominant and non-dominant shoulder were measured after 48 hours again by the primary investigator (rater 1) in both the positions [7] (mean of two readings was taken for final analysis). The order of the raters was randomized using chit method for each subject prior to data collection, to control for order effect.

Measurement of shoulder IR in supine position

In supine lying, the starting position was: 0˚ shoulder rotation, 90˚ shoulder abduction, 90˚ elbow flexion and neutral pronation/supination of forearm. To ensure that the humerus was level with the acromion, a towel roll was placed under the distal humerus with the olecranon process at the edge of the plinth. The rater stabilized the scapula with one hand positioned over the acromion and coracoid processes and supported the subject's hand, proximal to the wrist, with her other hand. Maintaining shoulder abduction and elbow flexion at 90˚, the humerus was then passively internally rotated. When the humerus was maximally internally rotated with a firm end feel, the IR PROM was measured using a goniometer, without any change in scapular stabilization provided by the rater.

Measurement of shoulder IR in side-lying position

To measure IR PROM, the subject was asked to lie on the side to be tested, so that on visual inspection, the acromion processes appeared to be aligned perpendicular to the plinth. The position of the shoulder was 90˚ of flexion, 0˚ rotation with 90˚ flexion of elbow and olecranon process positioned at the edge of the plinth. Manual stabilization of scapula was not required, but rater visually ensured that subject maintained the acromion process perpendicular to the table. Maintaining 90˚ of shoulder and elbow flexion, the rater then passively internally rotated the humerus. IR PROM was again determined based on the point of maximum range and when the rater noted a distinct firm end feel.

The universal full circle goniometer used in this study, had a 25 cm mobile arm and it's scale was marked in 1˚ increments. In the side-lying position, IR ROM can be measured by a single examiner, however in our study a research assistant was also included so as to blind the examiner and prevent bias.

The research assistant, a PG student specializing in musculoskeletal sciences, independent of the two raters, placed the goniometer such that the fulcrum was located on the olecranon process of the ulna. The stationary and mobile arms were aligned perpendicular to the ground and towards the subject's ulnar styloid process respectively. The assistant then read the goniometer scale and noted the measurement on the subject's data sheet after reconfirming the alignment with the rater, making sure that the rater could not see the readings.

Data Analysis

Statistical package for social sciences (SPSS) version20 was used to analyse the data. Descriptive data for glenohumeral IR PROM, in supine and side-lying positions, of dominant and non-dominant shoulder, was established by computing average of collective data of both raters. As the data followed normal distribution (Kolmogorov-Smirnov test), parametric tests of significance were used for statistical analysis. Paired t test was used to analyse difference between IR ROM measured in supine versus side-lying position, in both shoulders, using mean of combined data of first measurements of both raters. Difference in IR PROM between dominant and non-dominant shoulder was analysed using paired t test in both positions. For determining interrater and intrarater reliability, Intraclass Correlation Coefficient (ICC) was used. ICC values were classified for reliability, using the following criteria: excellent (0.90-0.99), good (0.80-0.89), fair (0.70-0.79), and poor (≤0.69). Minimal detectable change (MDC) at 95% was calculated using the equation $MDC_{95} = 1.96 \times \sqrt{2} \times SEM$.[6] Level of significance for this study was set to $P<.05$.

Results

In this study, the mean shoulder IR PROM measure, in side-lying was 61.06˚ ± 9.64˚ for dominant side and 69.56˚ ± 9.50˚ for non-dominant side, while mean IR PROM measure, in supine was 91.63˚ ± 10.28˚ for dominant and 99.44˚ ± 10.06˚ for non-dominant side. Significantly lower measurements were observed for shoulder IR PROM in the side-lying position, on both sides (p= 0.000). Significant difference in IR PROM was observed between the shoulders (p=0.000), with lesser measurement on dominant side, in both positions. Interrater reliability for dominant shoulder IR PROM measured in supine position was good; ICC=0.853 and for non-dominant was fair; ICC=0.775. In side-lying position, interrater reliability was excellent for dominant and non-dominant shoulder IR PROM, ICC= 0.946 and 0.924 respectively. The intrarater reliability for dominant and non-dominant shoulder IR PROM measurements in supine position was excellent; ICC= 0.964 and 0.950 respectively and in side-lying position was also excellent; ICC= 0.970 and 0.964 respectively. For interrater reliability, the MDC in supine position was 10.77˚ (dominant) and 13.04˚ (non-dominant) and in side-lying position was 6.38˚ (dominant) and 7.35˚ (non-dominant). For interpreter reliability, the MDC in supine position was 5.63˚ (dominant) and 6.27˚ (non-dominant) and in side-lying position was 4.39˚ (dominant) and 4.94˚ (non-dominant).

Discussion

In this study, the mean IR PROM measure in the side-lying position was 61.06˚ ± 9.64˚ for dominant side and 69.56˚ ± 9.50˚ for non-dominant side and mean supine IR PROM value was 91.63˚ ± 10.28˚ for dominant and 99.44˚ ± 10.06˚ for non-dominant side. In this study, significantly lower values were found for IR ROM measured in side-lying position on both sides (p= 0.000). In the side-lying position, the shoulder being tested is already in a position of flexion and horizontal adduction. When it is internally rotated, more tension develops in the posterior glenohumeral tissues as compared to in the supine position [6, 10]. This may therefore lead to a firm end feel and an isolated range of glenohumeral internal rotation. Jason Lunden *et al* suggested that, in the side-lying position, weight bearing over the scapula on the side being tested, facilitates improved scapular control which reduces the anterior tipping accessory motion of the scapula.[6] Isolation of glenohumeral internal rotation along with better scapular control may be the reason for lower IR PROM measurements. In this study, significant difference was observed in IR PROM of both shoulders; p=0.000, with reduced internal rotation on dominant side in supine and side-lying positions. Boon and Smith observed significant difference in rotation ROM between both shoulders, with diminished internal rotation and better external rotation in the dominant extremity in both overhead and non-overhead athletes [11]. Research conducted by Brown [12], Chandler [13], Chinn [14], Ellenbecker [7] and Kibler [15] have all documented significant differences in shoulder internal rotation between dominant and non-dominant arms in overhead athletes. Gunal *et al* recorded a minor but significant difference in shoulder rotation ROM between dominant and non-dominant extremities of healthy Turkish men aged 19 and 21 years [16] Therefore, according to Boon and Smith, decreased dominant shoulder internal rotation may be a normal finding in all people, which is only heightened in overhead athletes [11].

In the present study, inter rater reliability for dominant shoulder IR PROM, measured in supine position was good and for non-dominant shoulder was fair. In the side-lying position, inter rater reliability for measuring dominant and non-dominant shoulder IR PROM, was excellent. On comparing the two positions, inter rater reliability value for side-lying position was higher (table 2).The intrarater reliability for dominant and non-dominant shoulder IR ROM measurements in supine and side-lying position was excellent with higher values for side-lying position (table 3). According to study conducted by Boon, inter rater reliability for measuring IR PROM in the supine position was poor, when using non-stabilised and stabilised method (ICC= 0.13 and 0.38 respectively). Intrarater reliability was poor for non-stabilised method; ICC= 0.23 and good for stabilised method; ICC= 0.60 in athletes. He therefore suggested that manual scapular stabilisation be used when measuring IR PROM in traditional supine position [11]. In a study by Awan *et al*, intrarater reliability was good for scapular stabilised (SS) and non-stabilised techniques (NSS) of IR PROM measurement (ICC= 0.63-0.71) while inter rater reliability was fair to good (ICC=0.41-0.66), in supine position [1]. Riddle *et al* suggested that poor inter rater reliability of internal rotation measurement in supine position was due to lack of uniform scapular stabilization by testers [9]. In 1985, Pandya *et al* reported high intratester and lower intertester values following reliability study of PROM measurements of various movements in children with Duchenne's muscular dystrophy. He hypothesised that the gonometric discrepancy may be caused due to the variable therapist force exerted during the passive movement, as otherwise a standardised procedure and position had been used [4].

True shoulder rotation range comes solely from glenohumeral joint[8], but additional anterior tipping motion of the scapula makes it difficult to measure pure glenohumeral internal rotation motion in supine position. If this additional movement were to be curtailed by improving stabilization methods, then IR would be more isolated to GH joint. The side-lying position used in this study is comparable to the sleeper stretch position used to increase the extensibility of dorsal soft tissues of the glenohumeral joint. Immediate increase in shoulder IR ROM has been observed following use of the sleeper stretch [17] The side-lying position on tested side facilitates improved scapular control by weight bearing on the scapula.[6] It therefore minimises the additional anterior tipping motion of scapula and provides regular amount of scapular weight bearing, free of any stabilization by the tester. Therefore, in side-lying position, there is unvarying scapular stabilization between the testers in the same subject, unlike the supine position in which stabilisation depends on the manual force applied by the tester. Side-lying position also produces a distinctive and firm end feel. All these factors contribute to improved interrater reliability in side-lying position.

Also interrater reliability for measuring glenohumeral IR ROM in supine position was fair to good in this study compared to previous studies [1, 9, 11]. Standardised technique and unvarying scapular stabilization by both the examiners

might have contributed to better reliability. However the ICC's for side-lying position was higher than that found in supine position (table 2, 3). This points to some limitations in the supine position due to varying stabilization while side-lying position proves to be better for measuring IR PROM. Also as supine position requires two examiners, the use of side-lying position which requires only one examiner for measuring shoulder IR ROM, is recommended.

Intrarater standard errors of measurement (SEM) were 2.04º and 2.27º in supine position and 1.59º and 1.79º in side-lying position for dominant and non-dominant side respectively. Interrater SEMs were 10.77º and 13.04º in supine position and 6.38º and 7.35º in side-lying position for dominant and non-dominant side respectively. The SEMs (table 2 and 3) indicate that differences of about 2º in both supine position and side-lying position may be ascribed to measurement error when the same examiner repeats a measurement and about 10º to 13º in supine position and 6º to 7º in side-lying position may be ascribed to measurement error when different examiners take a measurement. Therefore, it appears that measurement error in side-lying is lesser compared to supine and hence can be considered a better position for measurement of IR ROM.

The range of MDC values for this study was between 6.38˚ and 13.04˚ (by position and side) for interrater reliability and 4.39˚ and 6.27˚ for intrarater reliability which is similar to values in earlier studies [6, 18]. The MDC values in side-lying position were lesser than those compared to supine position, for both dominant and non-dominant extremities, indicating that a smaller change that corresponds to a noticeable change in ability can be detected in the side-lying position.

Limitations of this study include a relatively younger age group of subjects and use of only two raters. Multicentric studies can be conducted to establish normative data by age group, gender and side (dominant vs non-dominant) for IR PROM. Further study should be conducted to test use of side-lying position to measure IR PROM in patients with shoulder pathology.

Table 1: Shoulder ir range of motion measurements for dominant and non-dominant shoulder in supine and side-lying position

Position	Side	Mean±SD	Range
Rater 1			
Supine	Dominant	92.03º±10.82º	81.21º -102.85º
Side-lying	Dominant	61.07º±10.05º	51.02º -71.12º
Supine	Non dominant	97.97º±10.87º	87.1º-108.84º
Side-lying	Non dominant	69.42º±9.65º	59.77º-79.07º
Rater 2			
Supine	Dominant	91.22º±11.20º	80.02º-102.42º
Side-lying	Dominant	61.04º±9.75º	51.29º-70.79º
SUPINE	Non dominant	100.92º±11.39º	89.53º-112.31º
Side-lying	Non dominant	69.69º±10.05º	59.64º-79.74º

Table 2: Interrater reliability for shoulder ir prom measurements

Position	Side	Rater 1 Mean ± SD	Rater 2 Mean ± SD	ICC (95% CI)	SEM
Supine	Dominant	92.03º±10.82º	91.22º±11.20º	0.853(0.806-0.889)	3.90º
Side-lying	Dominant	61.07º±10.05º	61.04º±9.75º	0.946(0.928-0.959)	2.31º
Supine	Non dominant	97.97º±10.87º	100.92º±11.39º	0.775(0.703-0.830)	4.72º
Side-lying	Non dominant	69.42º±9.65º	69.69º±10.05º	0.924(0.899-0.942)	2.66º

Table 3: Intrarater reliability for shoulder ir prom measurements by rater 1

Position	Side	M1 mean ±SD	M2 mean ±SD	ICC (95%CI)	SEM
Supine	Dominant	92.03º±10.82º	91.58º±10.01º	0.964(0.952-0.973)	2.04º
Side-lying	Dominant	61.07º±10.05º	61.76º±8.93º	0.970(0.960-0.977)	1.59º
Supine	Non dominant	97.97º±10.87º	98.15º±10.33º	0.950(0.934-0.962)	2.27º
Side-lying	Non dominant	69.42º±9.65º	69.34º±8.55º	0.964(0.952-0.972)	1.79º

Abbreviations: SD = standard deviation; IR = internal rotation; ICC = intraclass correlation coefficient; SEM = standard error of measurement, M1= measurement 1, M2= measurement 2

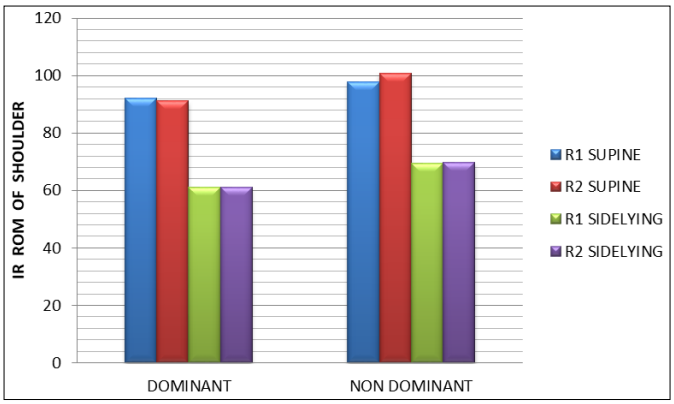
Fig 1: Start position of supine IR passive ROM measurement

Fig 2: End position of supine IR passive ROM measurement

Fig 3: Goniometer alignment at end IR ROM in supine position

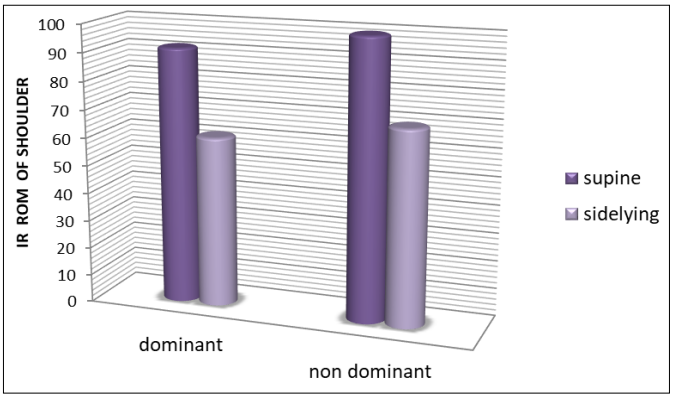
Fig 4: Acromion processes perpendicularly aligned in the side-lying position

Fig 5: End position with alignment of goniometer in side-lying position



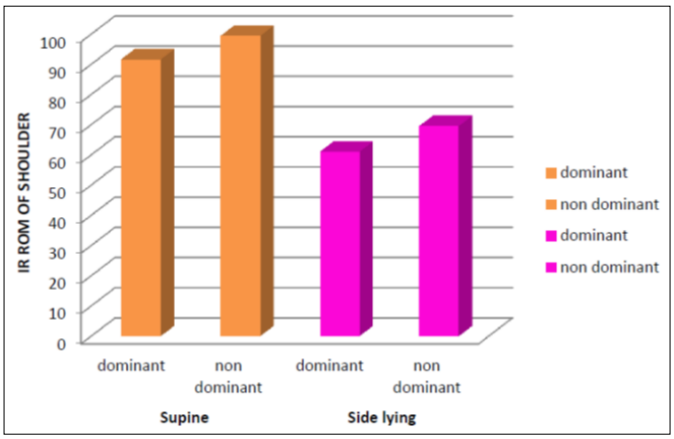
R1= rater 1, R2= rater 2

Fig 6: Average shoulder IR ROM measured by raters 1 & 2 for dominant and non-dominant side in supine and side-lying positions



IR PROM was significantly less (P<.05) in side lying position compared to supine, on both dominant and non-dominant sides.

Fig 7: Difference between IR PROM measurements of shoulder in supine versus side-lying position using mean of collective data of Rater 1 and 2 on dominant and non-dominant sides



IR PROM was significantly less (P<.05) on dominant side in supine and side-lying positions.

Fig 3: Difference between IR ROM measurements of dominant shoulder and non-dominant shoulder using average of collective data of Rater 1 and 2, in supine and side-lying position.

Conclusion

Average IR PROM measurement in side-lying position was 61.06˚ for dominant and 69.56˚ for non-dominant shoulder which was significantly lower compared to supine position.

There was significant difference in shoulder IR PROM between both sides, with significantly lower values on dominant side in both supine and side-lying position. Side-lying position had better intrarater and interrater reliability than traditional supine measurements.

Key Points

Findings: Shoulder IR PROM measured in side-lying position is more reliable when compared to traditional supine position.
Implication: Side-lying position should be used for measuring shoulder IR PROM in clinical setting.
Caution: Study was done on normal healthy subjects only.

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