J. Phys. Ther. Sci. 34: 732–736, 2022

The Journal of Physical Therapy Science

Original Article

Relationship between hand-behind-back motion and internal rotation with the shoulder in extension

Takanao Shirai, RPT, MS[1)*], Tomohito Ijiri, RPT, PhD[1)], Toshiaki Suzuki, RPT, DMSc[2)]

[1)] *Department of Rehabilitation, Medical Corporation Juzankai: 4-2-8 Iwatacho, Higashiosaka-shi, Osaka 578-0941, Japan*
[2)] *Graduate School of Health Sciences, Kansai University of Health Sciences, Japan*

Abstract. [Purpose] The purpose of the present study was to investigate whether the extent of shoulder internal rotation measured in the extended position of the shoulder could be a good indicator of hand-behind-back motion ability. [Participants and Methods] We measured internal rotation with the shoulder in extension in 26 healthy adults (average age, 25.2 ± 2.5 years). Internal rotation was measured passively in the supine position at 30° of shoulder extension. Additionally, a hand-behind-back motion was performed, and the hand-behind-back distance was measured. The relationship between the angle of internal rotation with the shoulder in extension and hand-behind-back distance was evaluated using Pearson's product-moment correlation. The level of significance was set at 5%. [Results] The angle of internal rotation with the shoulder in extension and the hand-behind-back distance correlate significantly. [Conclusion] Internal rotation with the shoulder in extension is a good indicator of hand-behind-back motion.

Key words: Hand-behind-back motion, Shoulder internal rotation in extended position, Pearson's product-moment correlation

(This article was submitted Jul. 5, 2022, and was accepted Aug. 5, 2022)

INTRODUCTION

Hand-behind-back (HBB) motion is a necessary action during daily activities, such as removing something from a back pocket, dressing, undoing a bra clasp, and scratching one's back[1)]. We often focus on internal rotation of the shoulder joint during HBB motion. Recently, it has been reported that there are two movement patterns for HBB motion[2–4)]. Abduction of the shoulder joint (abduction method) occurs when touching the ipsilateral scapula, and adduction pattern of the shoulder joint (adduction method) occurs when touching the contralateral scapula[3)]. During activities of daily living, both the adduction and abduction methods are used frequently, depending on the intended action. For example, the abduction method involves removing something from a back pocket on the same side. In the adduction method, you can pull your jacket from the opposite side at the back. The adduction and abduction methods not only differ in the abduction angle of the shoulder joint, but the scapula movement as well. Therefore, it is important to analyze each method group[3)].

When assessing HBB, the Apley scratch test is often performed[5)]. In this test, the hand is placed behind the back, and the vertebral level reached by the tip of the extended thumb is recorded[6–10)]. This allows indirect evaluation of the range of motion of internal rotation of the shoulder joint. Ginn et al.[6)] reported a low to moderate correlation between internal rotation with the shoulder joint abducted and HBB, and that measuring internal rotation with the shoulder joint abducted is not an accurate measure of HBB. There are other methods used to measure the internal rotation's range of motion of the shoulder joint. It is a method of internal rotation of the shoulder joint with the upper limb in a drooping position. However, in our experience, this measurement is limited by contact between the abdomen and forearm or hand. Therefore, it is not an accurate

*Corresponding author. Takanao Shirai (E-mail: hrk08sn05@yahoo.co.jp)

way to look at the relationship between HBB. The third is a method of measuring the range of shoulder internal rotation in the flexion position. This position differs from HBB motion, which requires shoulder extension. Therefore, it is not an indicator of HBB. In contrast, we believe that it is necessary to reexamine HBB motion index.

In this study, we focused on shoulder joint extension and internal rotation movements, which are required during HBB motion. If a high correlation is found between internal rotation with the shoulder in extension (IRwEx) and HBB motion, it may be used as an index of HBB motion. We aimed to apply the obtained results to the evaluation of HBB motion during rehabilitation.

PARTICIPANTS AND METHODS

Twenty-six healthy adults (14 males and 12 females) without upper limb/trunk disease, with a mean height of 165.4 ± 9.3 cm, mean weight of 55.7 ± 9.0 kg, and mean age of 25.2 ± 2.5 years were recruited for this study. The study was approved by the Medical Corporation Juzankai Ethics Committee (approval number: 2020001). The purpose of the study and methods were fully explained to the participants according to the documents, and consent was obtained.

Hand-behind-back motion was measured by placing the thumb above the spinal column with the upper limb in a relaxed position and the participants in a sitting position. The distance between the seventh cervical spinous process and thumb was measured. There are many reports on the range of motion of the shoulder joint on the dominant and non-dominant sides. In this study, the non-dominant side was measured based on reports that the range of motion of shoulder internal rotation on the dominant side was smaller than that on the non-dominant side[11, 12)]. The distance between the seventh cervical spinous process and thumb was calculated in relation to the distance between the seventh cervical spinous process and fifth lumbar spinous process; this result was considered the HBB distance. The upper limb on the dominant side was kept in a relaxed position next to the participant's trunk. Additionally, the participant faced forward, such that no significant cervical lateral bending and extension, trunk flexion and lateral bending, and rotation occurred.

Figure 1 shows the method for measuring the range of internal rotation with the shoulder joint in extension. The participant was placed in the supine position. The examined limb was located outside the bed with the forearm in supination. The shoulder joint was extended by 30°. The elbow joint was flexed, and the forearm was placed in an intermediate pronation/supination position. The forearm was supported on a table placed under the bed so that the angle of shoulder joint extension and elbow joint flexion did not change during measurement. The measurer touched the anterior surface of the humeral head so that excessive shoulder girdle flexion did not occur. The angles were analyzed using data obtained with a digital camera. It was placed at 1.73 m from the participant's shoulder, 1.0 m above, and tilted 30° down. The basic axis used when measuring IRwEx was a line parallel to the trunk passing through the shoulder, and the movement axis was a pad attached to the posterior part of the upper arm. The pad was attached to be parallel to the line connecting the lateral epicondyle and medial epicondyle of the upper arm. The pad was a urethane taping pad (Nitoms Co., Ltd., Tokyo, Japan) cut to 1 × 1 ×10 cm (Fig. 2).

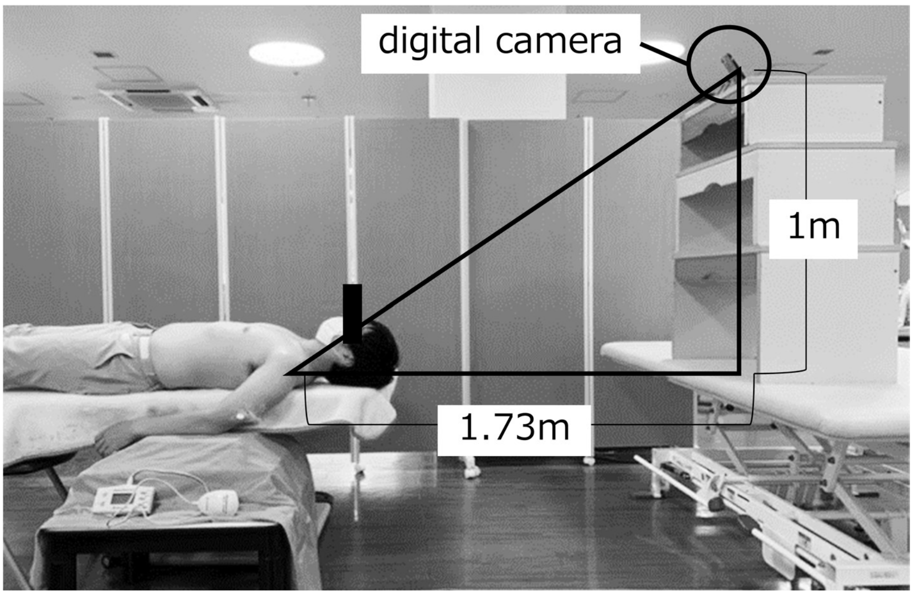

Fig. 1. The method for measuring the range of IRwEx.
The angles were analyzed using data obtained with a digital camera. It was placed at 1.73 m from the participant's shoulder, 1.0 m above, and tilted 30° down.

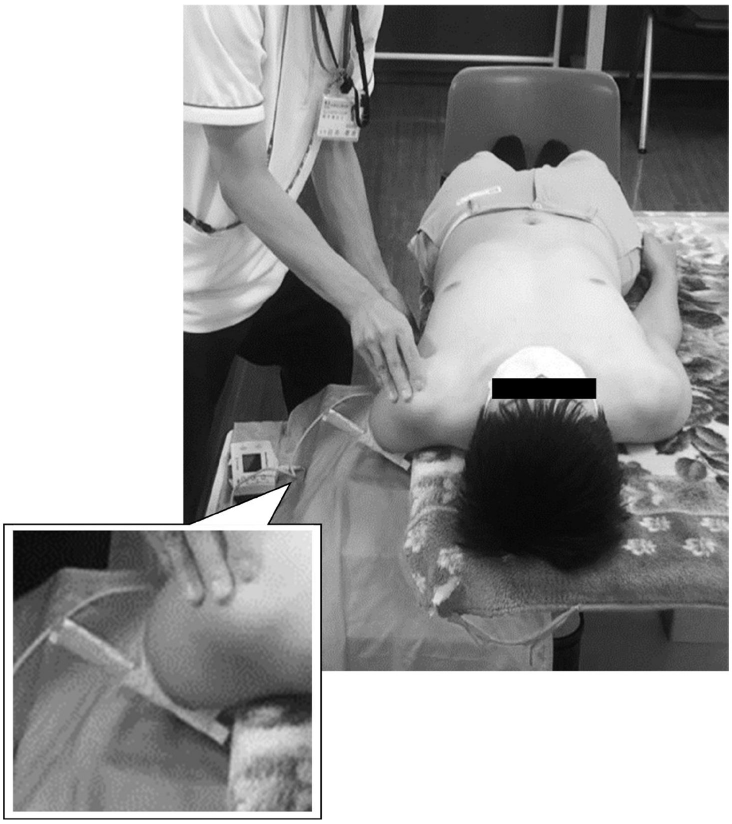

Fig. 2. The pad used when measuring.
The basic axis used when measuring IRwEx was a line parallel to the trunk passing through the shoulder, and the movement axis was a pad attached to the posterior part of the upper arm. The pad was attached to be parallel to the line connecting the lateral epicondyle and medial epicondyle of the upper arm.

The accuracy of the measured range of motion is easily influenced by the measurement site, method, and skill level[13–16]. Furthermore, measurer reliability is improved if the measurer uses a well-defined measurement method[14]. Therefore, in this study, we used a manual muscular strength meter (Isoforce GT-300, manufactured by OG Giken Co., Ltd., Tokyo, Japan) to unify the range of joint angles. The Isoforce GT-300 detects the measured values when a force of 10 N or more is applied. The measurer measured internal rotation of the shoulder joint passively with the manual muscular strength meter in contact with the distal lateral forearm. The internal rotation with the shoulder extended was defined as the angle at which the measured value of the manual muscular strength meter was 10 N. The difference between the angle at the start and at the end was defined as the angle of IRwEx.

As mentioned earlier, there are abductive and adductive methods for HBB motion[2–4]. The abductive and adductive method groups were divided according to a previous report by Wada et al[4]. In a previous study, the shoulder abduction angle (mean ± standard deviation) at the end limb position in the abduction method was 27 ± 6°. The abduction method was defined as cases in which the shoulder abduction angle was larger than 21°, obtained by subtracting the standard deviation from the mean value. The shoulder abduction angle at the end limb position in the adduction method was 9 ± 6°. The adduction method was defined as cases in which the shoulder abduction angle was smaller than 15°, obtained by summing the standard deviation and the mean value. Participants with shoulder joint angle between 15 and 21 were excluded. The angle of the shoulder joint was analyzed using data obtained with a digital camera installed behind the participants. The angle between the vertical line from the acromion on the examination side to the floor and the line connecting the acromion on the examination side and the olecranon on the examination side was analyzed.

The Shapiro–Wilk test was used to test the normality of the data distribution. A correlation test was performed to investigate whether there was a relationship between the HBB distance and IRwEx. When the data were normally distributed, Pearson's product-moment correlation was used. When the data were not normally distributed, Spearman's rank correlation test was used. Additionally, when the data were normally distributed, an unpaired t-test was performed to examine whether there was a difference in the angle of IRwEx and HBB distance between the abduction and adduction method groups. If the data were not normally distributed, the Wilcoxon rank-sum test was performed. The significance level was set at 5%. Statistical analysis was performed using R2.8.1 (CRAN, free software).

RESULTS

The dominant side in all the participants in this study was the right side. Therefore, the upper left limb was measured in all the participants. The abduction method group had 13 participants (10 males and 3 females), and the adduction method group included 12 participants (4 males and 8 females). One female who had a shoulder joint angle of 20° and so excluded from the analysis. The HBB distance and angle of IRwEx were normally distributed. There was a negative correlation (r=−0.84) between IRwEx and HBB distance in all the participants (p<0.05). A negative correlation was also observed in the abduction and adduction method groups individually (abduction method group, r=−0.73, p<0.01; adduction method group, r=−0.74, p<0.01) (Fig. 3). The angle of IRwEx (mean ± standard deviation) was 14.8 ± 4.2° for all the participants, 12.4 ± 3.0° for the abduction method group, and 17.5 ± 3.5° for the adduction method group. The angle of IRwEx was significantly larger in the adduction method group than in the abduction method group (p<0.01). The HBB distance was 36.0 ± 9.5% for all the participants, 42.5 ± 7.1% for the abduction method group, and 28.8 ± 5.2% for the adduction method group. The HBB distance in the adduction method group was significantly smaller than that in the abduction method group (p<0.01).

DISCUSSION

In this study, a significant negative correlation was found between HBB distance and IRwEx. Thus, it was found that if the range of IRwEx position was small, HBB motion may become difficult. The infraspinatus and teres minor muscles that antagonized the internal rotation of the shoulder joint. The infraspinatus muscle is stretched the most by IRwEx[17, 18]. The range of IRwEx in this study was measured while controlling the flexion of the shoulder girdle. Therefore, the range of IRwEx in this study was greatly affected by the internal rotation of the scapulohumeral joint, and the infraspinatus was sufficiently stretched. In this study, a high correlation (r=−0.84) was observed between range of internal rotation and HBB distance. Ginn et al.[6] reported that the internal rotation with the shoulder abducted and HBB distance showed a low-to-moderate correlation. In contrast, a high correlation was found between IRwEx and HBB distance in this study. This may be because the infraspinatus is stretched more with the internally rotated shoulder in extension than in the internally rotated shoulder in abduction position. The results of this study are better than those reported so far and maybe recommended for evaluating HBB motion.

The internal shoulder rotation with the arm relaxed and next to the trunk, which is generally measured, was 80°. However, the average range of IRwEx in this study was 14.8 ± 4.2°. Thus, the range of internal rotation of the shoulder in this study was considerably lower than that obtained in general range of motion measurements. Koishi et al.[19] reported that the mobility of the shoulder girdle greatly affects the final range of internal rotation of the shoulder joint. In this study, by controlling the flexion of the shoulder girdle, the internal rotation of the scapulohumeral joint could be mainly evaluated. As a result, the range of internal shoulder rotation is likely to be reduced. Additionally, it is considered that the method of sufficiently stretching the infraspinatus, which antagonizes the internal shoulder rotation, reduces the range of internal shoulder rotation. Patients with shoulder joint disease, such as frozen shoulder and humeral fractures, often have limited internal rotation of the shoulder joint. It is predicted that the value for such patients will be smaller than the value obtained in this study, and it is unclear whether this measurement method can be applied to patients with shoulder joint disease. Therefore, in the future, we would like to investigate whether similar results can be obtained for IRwEx, including movement of the shoulder girdle.

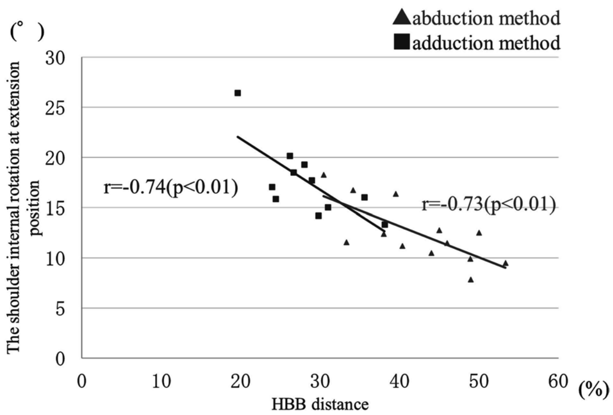

Fig. 3. Correlation between IRwEx and HBB.
There was a negative correlation (r=−0.84) between IRwEx and HBB distance in all the participants (p<0.05). A negative correlation was also observed in the abduction and adduction method groups individually (abduction method group, r=−0.73, p<0.01; adduction method group, r=−0.74, p<0.01).

The participants of this study were divided into abduction and adduction method groups. The HBB distance in the adduction method group was significantly smaller than that in the abduction method group. The range of IRwEx was significantly larger in the adduction method group than in the abduction method group. A greater flexion of the elbow joint is needed as a factor to bring the hand closer to the upper back. In addition to this, as per the results of this study, it is recommended to use the adduction method when it is necessary to position the hand near the upper back. Examples include the action of a woman putting on and taking off underwear, and the action of scratching your back. Furthermore, it was shown that it is necessary to expand the range of IRwEx in order to use the adduction method. We believe the infraspinatus is the factor that leads to the difference between the adduction and abduction method groups. Traditionally, the infraspinatus is considered a muscle responsible for external rotation. Recent reports have shown that the infraspinatus stops at a position similar to that of the supraspinatus and has an abductive action[20]. In other words, the adduction method, which requires a small abduction angle and internal rotation of the shoulder requires more extensibility of the infraspinatus.

Therefore, IRwEx is a useful index of HBB motion. Internal rotation with the shoulder in extension is considered important for HBB motion.

The limitation of this study is that measurements were only performed in healthy participants, which do not reflect measurement results in patients with shoulder joint disease.

Conflict of interest

The author, their immediate family, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article. We have not received any funding related to the subject matter of this article.

REFERENCES

1) Satpute KH, Bhandari P, Hall TM: Efficacy of Hand Behind Back mobilisation with movement for shoulder pain and movement impairment: a double blind randomised controlled trial. J Manipulative Physiol Ther, 2015, 38: 324–334. [Medline] [CrossRef]
2) Matsumoto M, Wada M, Komaki R, et al.: The range of motion of the glenohumeral joint which is important for the hand lifting along the spine on the back: a study for the hand lifting along the spine on the back of people in good health (The second report). Soc Rehabil Orthop, 2014, 16: 51–54 (in Japanese).
3) Shirai T, Ijiri T, Suzuki T: The scapular movement and the muscle activity of the peri-scapular muscle due to the difference in the belt-tying Movement. Jpn J Rehabil Med, 2020, 57: 1197–1203 (in Japanese). [CrossRef]
4) Wada M, Matsumoto M, Komaki R, et al.: A study for the hand lifting along the spine on the back of healthy people. Soc Rehabil Orthop, 2012, 15: 34–37 (in Japanese).
5) Woodward TW, Best TM, Clinical Evaluation: The painful shoulder: part I. Clinical evaluation. Am Fam Physician, 2000, 61: 3079–3088. [Medline]
6) Ginn KA, Cohen ML, Herbert RD: Does hand-behind-back range of motion accurately reflect shoulder internal rotation? J Shoulder Elbow Surg, 2006, 15: 311–314. [Medline] [CrossRef]
7) Wilk KE, Obma P, Simpson CD, et al.: Shoulder injuries in the overhead athlete. J Orthop Sports Phys Ther, 2009, 39: 38–54. [Medline] [CrossRef]
8) Edwards TB, Bostick RD, Greene CC, et al.: Interobserver and intraobserver reliability of the measurement of shoulder internal rotation by vertebral level. J Shoulder Elbow Surg, 2002, 11: 40–42. [Medline] [CrossRef]
9) Kumar VP, Satku SK: Documenting rotation at the glenohumeral joint. A technical note. Acta Orthop Scand, 1994, 65: 483–484. [Medline] [CrossRef]
10) Mallon WJ, Herring CL, Sallay PI, et al.: Use of vertebral levels to measure presumed internal rotation at the shoulder: a radiographic analysis. J Shoulder Elbow Surg, 1996, 5: 299–306. [Medline] [CrossRef]
11) Fleisig GS, Andrews JR, Dillman CJ, et al.: Kinetics of baseball pitching with implications about injury mechanisms. Am J Sports Med, 1995, 23: 233–239. [Medline] [CrossRef]
12) Bigliani LU, Codd TP, Connor PM, et al.: Shoulder motion and laxity in the professional baseball player. Am J Sports Med, 1997, 25: 609–613. [Medline] [CrossRef]
13) Low JL: The reliability of joint measurement. Physiotherapy, 1976, 62: 227–229. [Medline]
14) Miyamae T, Ogawa K: The reliability of joint measurement. Jpn J Phys Ther Occup Ther, 1978, 12: 139–144 (in Japanese).
15) Moore ML: The measurement of joint motion; introductory review of the literature. Phys Ther Rev, 1949, 29: 195–205. [Medline] [CrossRef]
16) Wilmer HA, Elkins EC: An optical goniometer for observing range of motion of joints a preliminary report of a new instrument. Arch Phys Med Rehabil, 1947, 28: 695–704. [Medline]
17) Dashottar A, Costantini O, Borstad J: A comparison of range of motion change across four posterior shoulder tightness measurements after external rotator fatigue. Int J Sports Phys Ther, 2014, 9: 498–508. [Medline]
18) Muraki T, Aoki M, Uchiyama E, et al.: The effect of arm position on stretching of the supraspinatus, infraspinatus, and posterior portion of deltoid muscles: a cadaveric study. Clin Biomech (Bristol, Avon), 2006, 21: 474–480. [Medline] [CrossRef]
19) Koishi H, Goto A, Tanaka M, et al.: In vivo three-dimensional motion analysis of the shoulder joint during internal and external rotation. Int Orthop, 2011, 35: 1503–1509. [Medline] [CrossRef]
20) Mochizuki T, Sugaya H, Akita K: Humeral insertion of the supraspinatus and infraspinatus reply. J Bone Jt Surg, 2009, 91: 962–969.