ORIGINAL ARTICLE

Effect of positioning and bracing on passive position sense of shoulder joint

B Ulkar, B Kunduracioglu, C Çetin, R S Güner

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See end of article for authors' affiliations

Correspondence to: Assistant Professor Ulkar, Ankara University Medical School, Sports Medicine, Ankara 06590, Turkey; ulkar@medicine.ankara.edu.tr

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Objective: To examine the effects of positioning and sleeve type bracing on passive position sense of shoulder joints of healthy untrained subjects.

Method: A cross over study was carried out on 26 subjects (13 male, 13 female) with a proprioception measurement device. The selected method of testing was passive reproduction of a target angle. Both shoulder joints of all the subjects were evaluated with and without a compressive neoprene sleeve type of brace at two different start positions (45° internal rotation, 75° external rotation) with an angular rotational movement at a constant speed of 0.5°/s. The angular displacements from the target angles at the end of the reproduction tests were recorded as position sense deficit scores.

Results: The overall mean (SD) deficit score (0.99 (0.06)) was significantly ($p<0.001$) lower with the brace than without, and the overall mean deficit score was significantly ($p<0.001$) higher at the 45° internal rotation start position than at the 75° external rotation start position. However, there was no significant ($p>0.05$) interaction between brace application and start position.

Conclusion: Terminal limits of range of motion facilitate the position sense of shoulder joints. Compressive brace application improves the passive positioning sense possibly by stimulating cutaneous mechanoreceptors.

Proprioception has been defined as a specialised variation of the sensory modality of touch that encompasses the sensation of joint movement and joint position sense.[1–3] The sensory receptors for proprioception, which are found in the skin, muscles, joints, ligaments, and tendons, provide information to the central nervous system on tissue deformation.[1–5] Proprioception contributes to motor programming for the neuromuscular control required for precision movements and also contributes muscle reflex, providing dynamic joint stability.[1]

For the evaluation of joint proprioception, joint position sense and the threshold for detection of passive motion have been used.[1 6 7]

Joint position sense is mediated by joint and muscle receptors as well as visual, vestibular, and cutaneous input.[8] It is measured by active or passive positioning of the limbs. To eliminate the muscle-tendon proprioceptor contribution, the passive repositioning technique is preferred.

Positioning of the hand is a necessary task during activities of daily living as well as in sport specific patterns. Joint position sensibility does not only play a part in the maintenance of dynamic shoulder stability, but has also been shown to alter after injury.[1] Position and movement senses of the shoulder are important because they have a major role in sports that involve the upper extremities, activities of daily living, and occupational tasks. Motor control for executing complex activities depends on afferent inputs. Data suggest that the risks of injury to a joint increase as the load shifts from the fatigued muscles to the joint capsule and ligaments.[9]

The efficacy of bracing for ankle and knee joints has been investigated by several researchers. Some pointed out the positive effects of these applications on the neuromuscular function of these joints. However, to date, no studies have examined the effect of a brace on proprioceptive ability of the shoulder joint.

The objectives of this study were to examine the effects of two different start positions and neoprene brace applications on shoulder joint positioning sense. Reproduction of the target angle by passive positioning was preferred to determine the contribution of the capsular and ligamentous structures to position sense. A neoprene brace was used to investigate the contribution of afferent feedback of cutaneous receptors to passive position sense.

MATERIALS AND METHODS

Twenty six healthy sedentary volunteers (13 men, 13 women) who had never experienced shoulder trauma and had no neurological deficits were tested. The mean (SD) age was 21.3 (3.1) years. Before the testing procedure, goniometric measurements on the shoulder joints were performed by the same examiner, and no range of motion limitations were found. Subjects received verbal and written descriptions of all procedures, and the testing was performed after written informed consent had been given.

A Prosport 1000 PMS (Tümer Engineering Co Ltd, Ankara, Turkey) was used for the measuring. Three different sizes of neoprene sleeve (Rehband Anatomiska AB, Sollentuna, Sweden) were used to obtain exact fits to the shoulders of the subjects.

Testing instrument

The Prosport 1000 PMS (fig 1) was designed to measure the threshold of detection of passive motion and passive repositioning of the shoulder and knee joints. Shoulder joints are tested with the subject supine, and knee joint tests are tested with the subject sitting. The device has a moving arm on which the forearm holder and pneumatic cuff has been firmly adapted. The motor of the instrument produces a rotational movement with a preadjusted angular velocity of 0.2–20°/s. The time, angular displacement, and velocity are displayed digitally. Subjects are told to stop the moving arm using the hand held disengage switch when they detect the threshold of passive motion or the prepositioned angle. For safety, there is an emergency stop button under the control of the tester.

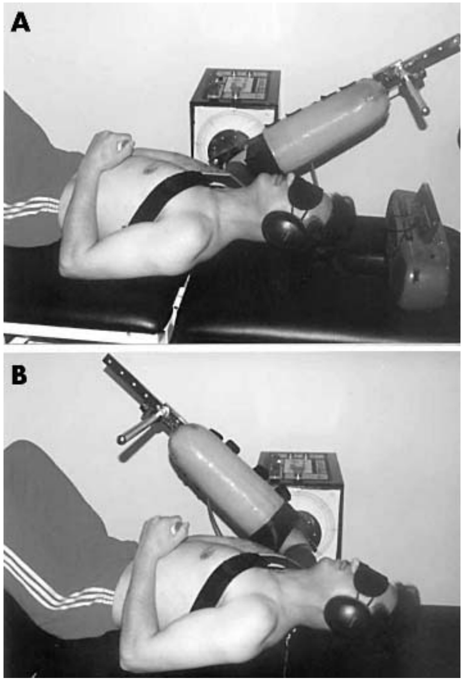

Figure 1 Proprioception measurement device. Passive position matching tests were performed with and without neoprene sleeve type braces at two different start positions: 45° internal rotation and 75° external rotation. The subjects were asked to stop the motion with the hand held disengage switch when they thought the arm had reached the target angle. The deficit scores were recorded from the display present at the top of the machine.

The validity and reliability of the instrument were determined by repeated measurements on the shoulder joints of 15 subjects 10 days after the first tests. Intraclass correlation coefficients were calculated (0.84 at 45° internal rotation, 0.88 at 75° external rotation).

Testing procedure

The shoulder joints were tested at two start positions: 45° internal rotation and 75° external rotation. Tests were performed with a low speed, passive angular movement of 0.5°/s. Subjects were tested lying supine with 90° shoulder abduction and 90° elbow flexion. Selection of the shoulder, application of the neoprene sleeve, and start positions were randomly determined. The function of the hand held disengage switch to stop the angular motion was explained to each subject before the tests. To eliminate the effect of the audiovisual senses, the subjects were blindfolded and metallic sounds were played through head phones. To eliminate cutaneous sensations in distal parts of the upper extremity, a pneumatic compression cuff connected by a tube to a pneumatic compression device located in the testing device was applied. It was inflated to 40 mm Hg during the test procedure.

The subjects were informed of the initiation of the test by a gentle touch on the leg. The test device started the passive motion into internal rotation after 1–10 seconds. The target angles were randomly selected 10−15° from the start position angle. The rotational arm of the instrument moved until the predetermined angles were reached. This posture was maintained for 10 seconds before returning to the start position. After 1–10 seconds, the rotational arm started to move at the same speed. The subjects were asked to stop its motion with the hand held disengage switch when they thought the arm had reached the target angle. Overshooting and undershooting were recorded as deficit scores. Three measurements were performed with the brace and three without, at two different start positions with an interval of one week between to eliminate the effect of learning. The mean values of three measurements were used for statistical analysis.

Data analysis

Position deficit scores were calculated as the mean absolute difference between the target and reproduced angles.

The brace and without brace conditions and two different test start positions (45° internal rotation, 75° external rotation) were compared using a two way repeated measures analysis of variance test. All statistical analyses were performed using the Statistical Package for the Social Sciences, Personal Computer version 9 (SPSS Inc, Chicago, Illinois, USA). The 0.05 level was used to denote significance.

RESULTS

Analysis of variance revealed a significant main effect for the brace application ($F_{1,25}$ = 160.40, $p<0.001$). There was a significant difference between the with brace and without brace conditions on the overall mean deficit scores. Measurements with the brace showed a lower overall mean (SD) deficit score (0.99 (0.06)) than those without (1.52 (0.05)). There was also a significant main effect for the start position ($F_{1,25}$ = 193.90, $p<0.001$). The overall mean deficit score at the 45° internal rotation start position was higher (1.41 (0.06)) than at the 75° external rotation start position (1.10 (0.05)). Finally, the test of the "brace application" by "start position" interaction gave a non-significant result ($F_{1,25}$ = 1.07, $p>0.05$). In other words, brace application and start position did not combine to influence the overall mean deficit scores. Table 1 and fig 2 present the mean position deficit scores observed during the 45° internal rotation, 75° external rotation start positions, and with/without brace conditions.

DISCUSSION

Proprioception is a specialised sensory modality giving information about extremity position and direction of motion.[1 4 7] It has been stated that proprioception has great importance in avoiding unphysiological joint movements such as extreme extension and flexion; therefore it provides injury prophylaxis and coordinates complex movement systems.[7] The shoulder joint has a very wide range of motion. For maintenance of stability, a coordinated control mechanism is crucial.[10] Proprioceptive inputs coming from the peripheral tissues are processed by the central nervous system and used to control joint movements.[11 12]

Position sense has been assessed in several clinical studies. The tests usually involve some type of position matching procedure, in which a target joint position is presented and the subject must match that position. The absolute difference between the target and the matching joint positions is often used as a measure of position sense accuracy.[9 13 14] The assessment of proprioception using "reproduction of passive positioning" is a valid and established method described by Barrett.[15] Very slow, passive change of position has been shown to maximally stimulate slowly adapting ligamentous and capsular receptors.[16] Birmingham *et al*[17] stated that the sense of knee joint position and movement arises through activity in mechanoreceptors located in the muscle, skin, and joint structures. As a result, the relative contribution of these different sensory channels may vary depending on the specific contexts of limb movement. We performed the measurements at 0.5°/s to primarily stimulate the mechanoreceptors located at the joint.

It is well known that visual, vestibular, and tactile sensations also contribute to this control.[8] Jerosch *et al.*[18]

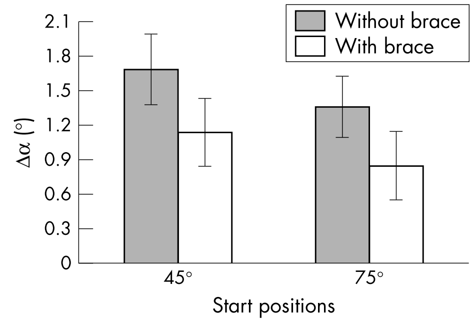

Figure 2 Mean absolute deficit scores (Δα; in degrees) of the passive repositioning tests, performed with and without a brace, at 45° internal rotation and 75° external rotation starting positions. The overall Δα scores obtained with the brace and at 75° external rotation start position were significantly lower than without the brace and 45° internal rotation start position ($p<0.001$). Error bars show ±1SD.

reported that repositioning tests performed for upper extremities gave better results when the eyes of the subjects were open than when they were closed. If visual senses are not eliminated, acuity of the joint movements increases because of domination of the other senses.[19] In our study, the subjects were blindfolded and metallic sounds were played through head phones to eliminate audiovisual input from the environment.

There is less contribution of cutaneous proprioceptive information in the proximal parts of the extremities such as the shoulder joints than in the distal parts.[2] In this study, the hands and forearms of the subjects were covered by pneumatic cuffs inflated to a pressure of 40 mm Hg to eliminate distal cutaneous contribution.

Allegrucci *et al*[8] reported lower thresholds to detect passive motion at 75° external rotation, suggesting enhanced proprioceptive feedback, which was attributed to the relative tautness of the glenohumeral joint capsule. This is consistent with proprioceptive findings on anterior cruciate ligament reconstructed and deficient knees, where deficits have been identified in terminal extension when the anterior cruciate ligament is taut.[20]

Lephart *et al*[21] examined the threshold for detection of passive motion and reproduction of passive positioning in normal shoulders and found no significant differences between the dominant and non-dominant shoulders. In our study, careful attention was paid to the starting position and brace application.

There is a certain amount of compression on the bony structures in the direction of joint rotation, and the resulting mechanical deformation is thought to stimulate the joint proprioceptors.[2 22] In our study, tests were performed in two different shoulder positions. At the 45° internal rotation position, the capsular and surrounding structures were looser than at 75° external rotation. The significantly better perception of passive motion at 75° external rotation can be attributed to the increased tension facilitating the stimulation of capsular mechanoreceptors.

Table 1 Mean absolute position deficit scores obtained by passive repositioning tests of shoulder joints

	Position sense deficit scores (°)		
Start position	Without brace	With brace	p Value
45° IR	1.69 (0.31)	1.14 (0.30)	<0.001
75° ER	1.36 (0.36)	0.85 (0.30)	<0.001

IR, Internal rotation; ER, external rotation.

Take home message

Brace application is quite common in sports medicine practice, but the benefits are not clearly identified. Although compressive braces do not provide much mechanical support, they may help patients by enhancing neuromuscular performance—that is, proprioceptive ability.

Studies performed to show the prophylactic effects of ankle taping and bracing on sports injuries found considerable benefits.[23–25] The poor mechanical performance of braces in resisting impact forces, together with altered kinematics when wearing a brace during sporting activities, has led some researchers to suggest that proprioception may be responsible for the findings of decreased injury when wearing a brace. Those studies put forward the positive effects of bracing on the proprioceptive ability of ankle and knee joints.[26–30]

Many clinicians like to apply compressive neoprene shoulder sleeves, which provide very little or no mechanical support, for painful chronic overuse injuries such as rotator cuff and biceps muscle tendinopathies. Although several studies have investigated the effects of external supports such as orthotic devices, elastic bandages, and braces on the proprioceptive ability of the ankle and knee joints,[27–31] there is lack of information on the shoulder joint.

Mechanoreceptors located in the skin have been shown to transmit information about the joint position and motion to the central nervous system via neurones sensitive to tension.[32] Athletes with chronic knee ligament injuries often report the beneficial effect of an elasticated stocking or strapping, although these provide little or no biomechanical support.[26 31] Therefore the beneficial effects of external supports may be attributable to increased proprioceptive input obtained by stimulation of cutaneous pressure receptors.

The application of external support appears to promote the sensation of stability.[27 29–31] In this study, the proprioceptive ability of the shoulder joints of healthy volunteers measured by the passive repositioning method is shown to be significantly enhanced by application of neoprene sleeve type braces.

CONCLUSION

Although the shoulder joint has the greatest capacity for moving in a multidirectional fashion, 75° external rotation is about the limit in this direction for healthy subjects. The terminals of range of motion create more tension over the joint structures that contain mechanoreceptors. This load, resulting in stretched soft tissues, appears to stimulate these receptors producing a positive effect on passive position sense.

Compressive brace application directly interferes with the cutaneous mechanoreceptors, enhancing the positioning sense of the shoulder joint. Although the results of this study are promising, more functional neuromuscular studies are needed to clarify whether shoulder braces can be recommended for proprioceptive purposes.

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Authors' affiliations

B Ulkar, B Kunduracioglu, R S Güner, Department of Sports Medicine, Ankara University School of Medicine, Ankara, Turkey
C Çetin, Department of Sports Medicine, Suleyman Demirel University Medical School, Isparta, Turkey

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