Do obstetrical brachial plexus injuries affect proprioceptive sense?

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ABSTRACT

الأهداف: دراسة تأثير إصابات الضفيرة العضدية بعد الولادة والتي تتعرض لها مستقبلات الحس العميق في مفصل الكتف.

الطريقة: أُجريت هذه الدراسة في قسم الفسيولوجيا والتأهيل الحركي بكلية العلوم الصحية في جامعة هاسيتيب، أنقرة، تركيا وذلك خلال الفترة من يناير 2008م إلى ستمبر 2009 م. شملت الدراسة 39 طفلاً يعاني من إصابات في الجذع العلوي أو الجذع المتوسط للضفيرة العضدية وذلك بعد الولادة، وكانت أعمارهم تتراوح ما بين 7–12 عاماً. لقد تم تقييم مستقبلات الحس العميق في كِلي الكتفين السليم والمُصاب وذلك وفق زوايا حركية قُررت سابقاً، حيث كان من المقرر أن تصل إلى 10% و30% و90% من أصل الحركة السالبة لزوايا تباعد مفصل الكتف وذلك بمعدل سرعة يصل إلى 2° / ثانية.

النتائج: أشارت الدراسة بأن هناك اختلافاً كبيراً بين الكتف المُصاب والسليم وذلك من ناحية زوايا التباعد التي كان من المُقرر أن تصل إلى 10% و30% من أصل الحركة السالبة لزوايا تباعد مفصل الكتف، وكانت القيِم المطلقة لنتائج تقييم مستقبلات الحس العميق في الكتف المُصاب أعلى من تلك النتائج التي وصلت إليها مستقبلات الحس العميق في الكتف السليم.

خاتمة: أشارت الدراسة بأن هناك عجزاً في مستقبلات الحس العميق بعد إصابات الولادة، ولذلك فإن تداعي شبكة مستقبلات الحس العميق في مثل هذه الإصابات سوف يؤثر خلال الوقت على الوظيفة الحركية لمفصل الكتف.

Objectives: To evaluate the proprioceptive sensory input in the shoulder joint affected by obstetrical brachial plexus injuries (OBPI).

Methods: This controlled study included 39, 7-12-year-old children with upper and/or middle trunk OBPI, and it took place in the Department of Physiotherapy and Rehabilitation, Faculty of Health Science, Hacettepe University, Ankara, Turkey between January 2008 and September 2009. The proprioceptive evaluation was carried at both affected and normal sides, at predetermined target angles, which were determined as 10%, 30%, and 90% of the shoulder passive abduction angle and at the rate of 2°/s speed.

Results: A statistically significant difference was observed between affected and normal sides at 10% and 30% of the target angles. Absolute values of the affected side proprioception score were found to be higher compared to the normal side.

Conclusions: A decrease in the proprioceptive sense in OBPI was observed. Therefore, a deteriorated proprioceptive network will eventually, over time, affect functionality in this type of injury.

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Proprioceptive sense is performed by sensory stimuli from mechanoreceptors located in the joints, tendons, joint capsules, and skin. In the upper extremity, the brachial plexus transmit these inputs to the CNS via efferent neurons. The data registered by the CNS convert into a motor response again via the brachial plexus with efferent neurons.[1] Deafferentation of proprioceptive receptors may affect the motor coordination and/or joint stabilization. Sarlegna et al[2]

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reported that proprioceptive deafferentation causes deviations in the agonist/antagonist muscle activation causing interruptions in motor coordination and joint position stimuli. Obstetrical brachial plexus injuries (OBPI) take place by traction of the brachial plexus during delivery.[3] The C5, C6, C7, and sometimes C4 roots, which are most affected during OBPI, comprise upper and middle trunks of the brachial plexus and are responsible for the innervation of anterior and inferior structures of the shoulder. These innervations are carried out by the axillary and suprascapular nerves, which also innervate the ligament, capsule, and synovial membrane of the shoulder and glenohumeral joint. Furthermore, these nerves take charge in the muscle sustaining shoulder stabilization.[4] During obstetrical brachial plexus upper trunk injuries, because of the deafferentation of receptors, this proprioceptive plexus/network corrupts. Poor static and dynamic stabilizers, along with the motor and sensory incapacity in the shoulder, may reduce the proprioceptive input. In the literature, using the results of proprioceptive evaluations in patients with traumatic brachial plexus injuries, shoulder arthroplasty, osteoarthritis, or instabilities, studies found that the affected side, compared to the healthy side, is less capable in sensing the joint position.[5-7] However, there is a lack of studies investigating the proprioceptive sensory in OBPI, which causes anomalies, especially in the shoulder joint and peripheries. The purpose of the present study was to evaluate the proprioceptive sensory input in the shoulder joint affected by OBPI.

Methods. The present study included 39 children diagnosed with OBPI. All the children were treated surgically and consulted by an orthopedic surgeon at the Department of Physiotherapy and Rehabilitation, Faculty of Health Science, Hacettepe University, Ankara, Turkey between January 2008 and September 2009. All patients and their parents were informed of the study and informed consent forms were obtained from all participants. The study was approved by the Medical, Surgical, and Pharmaceutical Research Ethics Committee of Hacettepe University Medical Faculty (Registration No. LUT 06/71). Study inclusion criteria of the study were brachial plexus (BP) upper and/or middle trunk involvement (C5, C6, C7), age range of 7-12, and the suitability of the child for the evaluation process, and having been operated on for shoulder internal rotation contracture (latissimus dorsi transfer to rotator cuff and subscapularis and pectoralis major releasing) in the past. In the proprioceptive measurement period, these children were not included in a rehabilitation program under the supervision of a physiotherapist. In this period, home exercises included stretching and range of motion exercises performed by the families. Study exclusion criteria were bilateral BP injury, total lower truncus injury, and any different musculoskeletal and mental illness that will affect the evaluation process.

The proprioceptive evaluation was performed using the joint position sense. Proprioceptive measurement was carried out with a Prosport 1000 PMS (Tümer Engineering, Co., Ankara, Turkey). This device was designed to measure the passive movement and passive reposition sense of the shoulder and knee joints. It was previously utilized by Ulkar et al[8] to evaluate passive position sense of shoulder joints in healthy individuals, and proved to be valid and dependable. Detailed information regarding the measurements and test protocols was provided to the participants. They were also told why, and how to use the button that stops the angular movement.

Measurements were carried out while the participants were sitting, with thigh and back supported, on a chair that was adjusted to their height so that their feet rest firmly on the floor (**Figure 1**). The start position was determined as 90° elbow flexion and the forearm supported complete shoulder abduction (0° shoulder abduction). The sitting position used during final measurements was determined after 5 pilot measurement trials to obtain the most accurate results. A passive angular movement of 2°/s was set for measurements.[4] The target angle to be measured was determined as the 10%-30%-90% of the shoulder passive abduction angle.[1,5,9] Before all measurements, shoulder passive angles that will be used in determining the target angles were recorded avoiding scapular

Figure 1 - Illustrates the positions in which the measurements were carried out.

dyskinesia. The participants were notified of the start of the test by a gentle tap on the arm. The device starts the passive movement 1-10 seconds after the initiation of the test. The rotational arm maintains the motion until the target angle is reached. Before retreating to the starting point, the device keeps its position for 10 seconds. After 10 seconds, the rotational arm retreats to its original position at the same speed. Next time, the patient is asked to hit the stop button when the rotational arm reaches the target angle. For each angle, 3 measurements were carried out and the score closest to the target angle was included in the calculation. Proprioceptive measurements were performed for both affected (study group) and healthy (control group) sides of the upper extremity of the cases.

Statistical analysis. Statistical calculations were performed using the Statistical Package for Social Sciences (SSPSS Inc., Chicago, IL, USA) 11.5 for Windows. *P*-values less than 0.05 were considered significant. A normal distribution was not observed, thus, the Wilcoxon test was used to compare the in-group values.

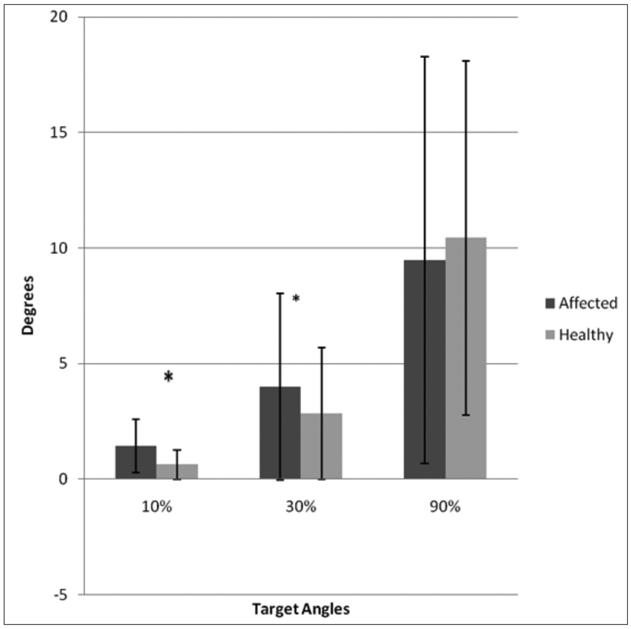

Figure 2 - The absolute values (degrees) of proprioception measurements of the affected and healthy side at 10%, 30%, and 90% of target angles (*$p<0.05$).

Results. To test the operability of subjects, 39 children (19 girls/20 boys) were randomly selected. The data gathered from the cases were compared using statistical methods. The target angle in proprioceptive evaluations was determined as the 10%-30%-90% of the shoulder abduction passive range of motion (ROM). Obtained data received the "-" sign if below the target value, and "+" if exceeding the target value. However, the "-" and "+" signs have no effect on the results because the absolute values of the measurements were included in calculations. Any absolute value closer to zero denotes an approximation to the target angle. As a result of the measurements, a significant difference was found between the affected and healthy sides at 10% and 30% of target angles (**Table 1**). The absolute mean values of the proprioception measurements regarding the affected side were higher compared with the healthy side (**Figure 2**).

Discussion. In the present study, the joint position sense of the affected shoulder was found to be less sensitive compared to the healthy side in 10% and 30% target angles. Mechanoreceptors located in the muscles, capsules, tendons, skin, and ligaments are sensitive to tension and the amount of tension on these structures varies at each angle of the joint. Previous studies evaluated joint position sense measurements carried out at various angles within the physiological range of motion of joints.[9,10] Differences in the joint position sense at various angles in the knee, thigh, and shoulder have been observed.[7,11,12] In the present study, measurement angles were selected as 10%, 30%, and 90% of the shoulder passive movement angle. Proprioceptive sense plays an important role in coordinated movements, antagonist and agonist movements of muscles, regulation of the timing of extremity in multi-joint movements, and determining the movement direction.[3,13] Development of proprioceptive sense in children has been the subject of several studies. Hay et al[10] reported that proprioceptive sense increased dramatically in the age range of 5-7 and the rate of increase was reported to be very low in adolescence and adulthood. Therefore, in this study the age range of 7-12 years was selected because the developmental changes in proprioceptive skills become stable beyond the ages of 7-8.

Effects of visual, vestibular, and tactile sensations on proprioception mechanisms are well known.[9] In the present study, in order to reduce the visual and auditory inputs, the children were blindfolded and they were supplied with earphones, through which they would hear loud music that they would like to listen (**Figure 1**).

Table 1 - Comparison of healthy and affected sides results of proprioceptive evaluation.

Proprioceptive evaluation in target angles	Z-value	*P*-value
Healthy side 10%-Affected side 10%	-3.309	0.001
Healthy side 30%-Affected side 30%	-2.206	0.027
Healthy side 90%-Affected side 90%	-0.668	0.504

To evaluate a movement sense, a joint must be moved at a rate where the individual is able to perceive the movement. Proprioceptive tests cannot be performed at a functional joint pace (fast) as a perception period is needed.[1] Previous studies evaluated shoulder joint position sense measurements carried out at different speeds within range of motion of joints.[9,10] In this study, the measurement rate was determined as 2°/sec.

In the present study, the proprioceptive sense of the patients was found to be higher in both 10% and 30% of the target angle. This result suggests that the improvement of proprioceptive sense in the initiation of movement occurs earlier than the other phases of movement. Because of the over-abduction of the shoulder, over-tension of the entire capsule and surrounding structures and increased sensitivity of receptors as well as better proprioceptive sense are expected.[13] However, in the present study, at the 90% of the target angle, no statistically significant difference was found with the unaffected arm. The reason for this outcome may be children's loss of attention towards the end of the slow measurement process. It takes too long to reach the 90% of the target angle in the 2°/sec measurement speed. Children showed signs of restraint towards the end of the measurements and attempted to press the button early. One of the limitations of the study was the absence of groups of children with BP total and lower truncus injuries to compare the effects of different types of injuries on proprioceptive sense. Another limitation is the absence of measuring proprioceptive sense on other shoulder movements, such as shoulder external rotation.

In conclusion, we found that proprioceptive sense decreases in OBPI. Deafferentation of proprioceptive receptors may affect motor coordination and/or joint stabilitation.[3] Therefore, deteriorated proprioceptive network will eventually affect functionality in this type of injury in the long run.[14] In further studies, considering the changes in the proprioceptive sense in the affected side in parallel with the increase in age and the function of the normal side of samples would increase the efficiency of this study.

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