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ORIGINAL ARTICLE

Impact of spine alignment on the rotator cuff in long-term wheelchair users

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Background: We investigated the impact of poor seated posture on the prevalence of rotator cuff tears (RCTs) among wheelchair-dependent individuals with long-standing paraplegia.
Methods: The study included 319 patients. Lateral radiographs of the spine were collected from a database and analyzed to assess the global spinopelvic alignment (SPA). Magnetic resonance images of both shoulders were obtained to detect the presence of cuff tears. Patients were divided into 2 groups: Group RCT-I included all patients with cuff tears (right, left, or bilateral), whereas group RCT-II consisted exclusively of patients with bilateral cuff tears. We used the classification systems developed by Kendall et al and Roussouly et al to assess the sagittal spine alignment and SPA, respectively. Univariate and multivariate analyses were performed. To fit both models (groups RCT-I and RCT-II) to the data, the 4 spine curves according to Roussouly et al were subdivided into 2 groups: Group SPA-I included both type 1 and type 2, whereas group SPA-II included both type 3 and type 4.
Results: Magnetic resonance images showed a cuff tear in 192 patients (60.19%) (group RCT-I). Among those, 37 patients (11.60%) had tears in both shoulders (group RCT-II). In group RCT-I, 70.31% of the patients had a kyphotic-lordotic posture. The kyphotic-lordotic posture, a longer duration, and a more rostral neurologic level of injury were highly associated with cuff tear prevalence. In group RCT-II, the multivariate analysis showed that only the duration of spinal cord injury was significantly associated with RCTs.
Conclusion: Thoracic hyperkyphosis was associated with a markedly high rate of RCTs. The data from this study may provide support for developing preventive strategies.
Level of evidence: Level III; Cross-Sectional Design; Epidemiology Study

Keywords: Rotator cuff tears; paraplegia; poor sitting posture; spinal cord injury; hyperkyphosis; wheelchair users

The ethics committee of the University of Heidelberg approved this study (application No. S-047/2007).

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Rotator cuff tear (RCT) is one of the most common and debilitating conditions affecting the shoulder. Chronic spinal cord injury (SCI) is commonly associated with the occurrence of RCT, leading to an even higher RCT rate in patients with chronic SCI compared with able-bodied subjects.[1,11]

Although the exact pathophysiology of RCT is controversial, mechanical impingement has been found to be a primary mechanism in the development of rotator cuff disease, which can eventually result in RCT.[5,39,44] The majority (>70%) of shoulder pain reported among individuals with paraplegia is diagnosed as mechanical impingement.[35] Among individuals with paraplegia with SCI who use a manual wheelchair for mobility, poor sitting posture, repetitive overhead arm positioning, and scapulothoracic dyskinesia may all contribute to subacromial impingement.[29,32,38]

Scapular position and motion particularly affect shoulder impingement symptoms.[24] Biomechanical studies have shown that the scapula of most wheelchair users tends to move into or toward anterior tilt, downward rotation, and protraction,[28,34] positions thought to be associated with shrinkage of the subacromial space.[21]

In SCI, the ability to control sitting posture actively (ie, trunk stability) is essential for proper scapulothoracic orientation and subsequently for efficient performance of functional tasks with the upper extremity.[8,42] Accordingly, it has been found that patients with less trunk stability (high thoracic neurologic level of injury [NLI]) experience more shoulder deficits than those with more trunk stability (low thoracic NLI).[33,41] With decreasing trunk stability, SCI patients tend toward a posterior pelvic tilt and an increase in thoracic kyphosis as a compensatory strategy to improve sitting balance and functional reach.[16,43]

Of particular interest is the relationship between altered spinal posture in the sagittal plane and RCT rate. Central to our study is the report of Yamamoto et al[45] on the impact of faulty posture in the standing position on RCT in the general population. They showed that compared with an ideal posture, any postural abnormality according to Kendall et al[20] (kyphotic-lordotic, flat back, swayback) was an independent predictor of RCT. A relevant question arises here as to what extent a similar association might be observed in wheelchair-bound individuals with long-standing paraplegia. In this study, we investigated the impact of (1) the global spine alignment and (2) the NLI on RCT rates in long-term wheelchair-using patients with chronic paraplegia after SCI.

Materials and methods

Subjects

This is a retrospective cross-sectional study of the impact of spine alignment on the rotator cuff in long-term wheelchair users. A total of 319 subjects from the Spinal Cord Injury Center at Heidelberg University Hospital were evaluated. The selection criteria were as follows: (1) subjects had been wheelchair dependent for a minimum of 10 years; (2) they did not have an active shoulder infection and had not previously undergone surgery on the shoulder; (3) they were physically and mentally willing and able to comply with the scheduled magnetic resonance imaging (MRI) examination; (4) they did not have known cervical disc herniation, cervical or thoracic syringomyelia, tetraplegia, or advanced degenerative joint disease of the spine; (5) they did not have a history of soft-tissue injury of the upper extremities and had not undergone previous surgery of any kind on the upper extremities; (6) there were no contraindications for MRI studies; and (7) lateral radiographs of the spine, not older than 6 months, were available in an archiving database.

Demographic data such as age, sex, duration of spinal cord injury (DSCI), and NLI were recorded. Portions of the data from these patients have been used in recently published studies[1-3]; however, the impact of postural alignment on RCT has not been analyzed.

MRI scans

MRI scans of both shoulders were performed in the oblique coronal, oblique sagittal, and axial planes on a 1.0-T scanner (Philips Medical Systems, Hamburg, Germany) to detect the presence of RCTs regardless of tear location, size, and thickness. All images were analyzed by the same experienced musculoskeletal radiologist.

Evaluation of spinopelvic alignment

We preferred to perform the visual assessment based on lateral radiographs, as the prediction of spinal curves in wheelchair-dependent individuals on the basis of photographs would be much more difficult. The radiographs were obtained in the upright sitting position on a standardized horizontally surfaced table and digitized. All measurements (pelvic incidence, pelvic tilt, and sacral slope) were done by means of dedicated software (Surgimap; Nemaris, New York, NY, USA). All images were assessed by 2 experienced spine surgeons. Interobserver agreement was also evaluated with κ statistics. When the 2 surgeons disagreed about image assessment, consensus was reached by discussion.

For the sagittal morphologic study of the spine curvature, subjects were divided according to the Kendall classification[20] as follows: ideal alignment, characterized by a normal curve of the spine with a neutral position of the head and pelvis; kyphotic-lordotic posture, in which the cervical spine is hyperextended, the thoracic spine is hyperflexed, the lumbar spine is hyperextended, and the pelvis is tilted anteriorly; flat-back posture, characterized by flattening of the lower thoracic spine and lumbar spine with posterior pelvic tilt; and swayback posture, characterized by posterior displacement of the upper trunk and anterior displacement of the pelvis, as well as posterior tilt of the pelvis (Fig. 1).

Spine curvature and balance are also affected by the pelvic orientation and position in the sagittal plane. According to Legaye et al,[22] the key anatomic parameter for determining the spinal balance is the pelvic incidence, that is, the angle between the line perpendicular to the middle of the cranial-sacral endplate and the line joining the middle of the cranial-sacral endplate to the center of the bicoxofemoral axis. The pelvic incidence can vary significantly from person to person but remains an anatomic constant for each individual after puberty throughout the pelvic range of motion. The sacral slope is the angle between the horizontal line and the cranial-sacral endplate tangent. The pelvic tilt is the angle between the vertical line and the line joining the middle of the sacral plate and the center of the bicoxofemoral axis. With reference to the classification of