The glenohumeral joint is inherently unstable, due to the small amount of contact area between the large humeral head to the shallow glenoid fossa. This unique structure provides a large range of motion (ROM), but leaves the joint vulnerable to subluxation/dislocation and strain, which commonly occur as a result of participation in overhead sports such as tennis, baseball, and javelin. Contact sports, such as rugby, have a high rate of shoulder injuries, with tackling or being tackled as the major causative factor.

Context: A reduction in joint position sense (JPS) is sometimes a consequence of shoulder injury that may adversely affect the ability to maintain dynamic joint stability. Objective: To compare shoulder JPS between previously injured and noninjured judokas. Design: Cohort study. Participants: Twenty-nine noninjured subjects (10.93 ± 3.45 years) and eleven injured subjects (15.09 ± 3.39 years). Main Outcome Measures: JPS was tested at 45˚ and 80˚ of shoulder external rotation at 90˚ of abduction. Results: No significant difference in JPS was found between previously injured and noninjured judokas at either joint position. Conclusion: Despite evidence that JPS acuity decreases following shoulder injury, this study did not demonstrate a difference in average error between previously injured and noninjured judokas. Uncontrolled confounding factors, such as age and time since injury, may have affected the results. Sport-specific shoulder joint loading patterns may also be an important factor that affects JPS. Key Words: overhead throwing athletes, proprioception, injury risk
effort to gain maximum external rotation ROM, which is believed to create laxity that allows excessive anterior humeral head translation. The relationship between over-head activities and shoulder injuries has been attributed to forceful and repetitive movements that utilize a wide range of shoulder motion, such as that utilized by throwing athletes to generate ball velocity.

The combination of mechanical instability and impaired proprioception is widely believed to be responsible for elevated susceptibility to shoulder injuries. Proprioception is considered to be a combination of joint position sense (JPS) and kinesthesia. Whether poor JPS is a cause or a consequence of injury is not known. Poor JPS could render the joint capsule, ligaments, muscles, and tendons of the shoulder vulnerable to injury, and microtrauma may adversely affect the sensorimotor contribution to dynamic joint stability.

A number of authors have reported proprioceptive deficits in individuals following traumatic shoulder injury. Herrington et al. found reduced JPS acuity in rugby players who had previously sustained a shoulder injury, despite surgery and/or rehabilitation. The same group of researchers also found that muscle activation was altered in subjects with traumatic shoulder injuries. The purpose of this study was to determine whether adolescent judokas who have sustained shoulder injuries demonstrate poorer JPS than those who have not been injured.

**Procedures and Findings**

Forty members of the same Judo club (13.5 ± 2.89 years) participated in this study. The noninjured group consisted of 29 judokas (10.93 ± 3.45 years), whereas the injured group consisted of 11 previously injured or currently injured judokas (15.09 ± 3.39 years). Injuries included a complete supraspinatus rupture, which had been surgically repaired, rotator cuff strains, acromioclavicular joint sprains, and glenohumeral subluxations. The injuries occurred over a period that ranged from 7 weeks to 4 years prior to testing. All of the injured participants had returned to full participation in sport-related activities. All participants provided informed consent, and the study procedures were approved by an institutional research ethics committee.

Participants were instructed to reproduce a 45° and 80° angle of external rotation at 90° of abduction while lying supine on a plinth (Figure 2). The participants were blindfolded and a screen was placed in front of each participant’s face to conceal identity. A researcher passively positioned the arm at the target angle and held it there for 5 seconds (Figure 3) while a photograph was obtained with a digital camera (Sony SteadyShot DSC-W80, 7.2 mega-pixels resolution) that was positioned 2.8 m from the participant’s shoulder. The arm was passively moved back to the start position and the participant was instructed to actively reproduce the angle selected by the researcher. The participant was instructed to say “OK” when the target angle was believed to have been reproduced and to hold it there while a photograph was obtained. This procedure was repeated a total of three times for both the 45° and 80° angles and for both extremities, which permitted calculation of intraclass correlation coefficients for reproducibility of joint positioning. The photographs were uploaded to a personal computer and joint angles were determined through the use of ImageJ software (National Institutes of Health, Available at: http://rsbweb.nih.gov/ij). The angle was measured according to the method described by Herrington et al. The target angle was subtracted from the reproduced angle to provide an absolute error score (degrees) and the values for the three trials were averaged. Differences between the injured group and non-injured group were analyzed by paired samples t-tests at an alpha level of ≤ 0.05.

The JPS measurements demonstrated good reproducibility for both the 45° target angle and the 80° target angle (Table 1). There were no significant differences in JPS (absolute error) at either 45 (8.95 ± 6.71° vs. 9.00 ± 7.89°) or 80 degrees (8.40 ± 7.03° vs. 8.67 ± 7.01°) between the groups (Figure 4).
Figure 2  Participant repositioning arm for JPS test.

Figure 3  Researcher position arm for JPS testing.

TABLE 1. Intraclass Correlation Coefficients for 3 Measurements of Shoulder JPS

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Figure 4  Comparison of JPS scores between groups.
Discussion

The results failed to demonstrate a significant difference in JPS between injured and noninjured judokas. These findings are in contrast to previous evidence that injured athletes demonstrate poorer JPS compared to noninjured athletes.\textsuperscript{21,24-26} Numerous confounding factors may have been responsible for the lack of difference between groups, including differing subject demographics, time from injury to JPS testing, or some mechanism of shoulder injury associated with judo that does not necessarily result in poor JPS.

The displacement of the glenohumeral joint during throws such as the \textit{morote seoi nage} and \textit{ IPPON SEOI NAGE} begin with the shoulder externally rotated in approximately 90˚ of abduction, with the opponent positioned behind the thrower (Figure 1). The thrower proceeds with the movement by bringing the opponent over the shoulder. Although this motion differs from a baseball pitch or tennis serve, it does involve a large range of external rotation and completion of the movement in internal rotation. The major difference is the magnitude of load imposed on the judoka’s shoulder musculature, which exceeds the body mass of the opponent. The mass of a baseball or tennis racket is considerably smaller, but they are moved at much higher velocities (i.e., up to 7000˚/sec).\textsuperscript{3} Repetitive high-velocity overhead motions ultimately result in excessive external rotation ROM, reduced internal rotation ROM,\textsuperscript{6,27} and an increase in internal rotator strength in relation to external rotator strength.\textsuperscript{4,28} This alteration in strength and mobility is believed to contribute to injury susceptibility\textsuperscript{28,29} and could play a role in development of poor JPS scores.

Herrington et al.\textsuperscript{21} found that previously injured rugby players had an average error of 6.7 ± 3.4˚ for the 45˚ angle and 4.1 ± 0.8˚ for the 80˚ angle. Dover et al.\textsuperscript{17} found that asymptomatic throwing athletes had average error of 5.0 ± 5.1˚ and Voight et al.\textsuperscript{30} found an average error of 3.3 ± 1.2˚ in the dominant prefatigued throwing shoulder. The average error value that we observed was approximately 9˚ for both groups. A possible explanation for this finding may be the long-term effect of judo participation on shoulder function. Dover et al.\textsuperscript{17} found that throwing athletes demonstrated poorer JPS than nonthrowing athletes. Thus, factors such as sport-specific joint loading, age, and level of competition may influence JPS to a greater extent than shoulder injury for athletes who participate in some sports.\textsuperscript{31}

The average age of our subjects was 13.5 years, whereas the studies of Herrington et al.\textsuperscript{21} and Dover et al.\textsuperscript{17} involved older subjects (24.8 years and 19.0 years, respectively). Children often present generalized joint laxity and poor proprioceptive acuity, which tends to improve with an increase in age.\textsuperscript{31,32} Growth spurts are believed to be associated with reduced body awareness compared to adults.\textsuperscript{33} Fatoye et al.\textsuperscript{31} reported poor to moderate repeatability for JPS testing in subjects aged 9.9 ± 2.1 yrs. Differences in developmental maturity between the injured and noninjured groups may have influenced our results.

Previous JPS research suggests that measurements are more accurate at the end-range of movement, where elongation of capsuloligamentous fibres creates greater mechanoreceptor stimulation.\textsuperscript{34} Thus, injured athletes may exhibit higher error scores in a mid-range position,\textsuperscript{21} which was the case for a subject in this study who had sustained a shoulder injury 7 weeks prior to JPS testing. Average time from injury to JPS testing for the other injured subjects was 2.39 ± 1.39 years. Potzl et al.\textsuperscript{26} suggested that “re-tensioning” of capsuloligamentous structures was a possible explanation for improvements in JPS that were observed in patients who had been surgically treated for anterior instability. Conversely, Herrington et al.\textsuperscript{21} found impaired JPS in rugby athletes who had received surgery and completed a rehabilitation program. Most shoulder injuries in rugby result from direct contact during tackling, which may result in a long-term reduction in JPS.

Conclusion

Despite evidence that JPS acuity decreases following shoulder injury, this study did not demonstrate a difference in average error between previously injured and noninjured judokas. Uncontrolled confounding factors, such as age and time since injury, may have affected the results. Sport-specific shoulder joint loading patterns may also be an important factor that affects JPS.

References


