EVALUATION OF GLENOHUMERAL MUSCLES DURING PROVOCATIVE TESTS DESIGNED TO DIAGNOSE SLAP LESIONS

Vanessa Wood, Michelle Sabick, Ron Pfeiffer, Seth Kuhlman, Jason Christensen, Mike Curtin, Kurt Nilsson, and Kevin Shea

1Center for Orthopaedic & Biomechanics Research, Boise State University,
2Intermountain Orthopaedics

INTRODUCTION
Despite considerable advances in the understanding of glenohumeral (GH) biomechanics and glenoid labral pathologies, arthroscopy remains the only definitive means of SLAP lesion diagnosis [3]. Unfortunately, natural GH anatomic variants limit the reliability of radiographic implications [2]. Accurate clinical diagnostic techniques would be advantageous due to the invasiveness, patient risk, and financial cost associated with arthroscopy. More than 20 provocative tests designed to elicit labral symptoms as a diagnostic sign have shown promising accuracy by their respective original authors, but follow-up studies generally fail to reproduce those findings. The purpose of this study was to compare the behavior of GH joint stabilizing muscles in seven promising provocative tests. Electromyography (EMG) was used to characterize the activation of GH joint stabilizing muscles, with particular interest in the long head biceps brachii (LHBB) behavior, as activation of the LHBB and subsequent tension in the biceps tendon should illicit labral symptoms in SLAP lesion patients [2].

METHODS
A cohort of 21 healthy volunteers without a history of shoulder pathology was recruited for this study (11 females, 10 males). The tests analyzed were Active Compression palm up and palm down (ACPU and ACPD) [8], Speed’s [1], Pronated Load (ProLoad) [9], Biceps Load I (Bicep I) [6], Biceps Load II (Bicep II) [5], Resisted Supination External Rotation (RSER) [7], and Supination Sign (Yergason’s) [10]. The tests were modified to be performed on a Biodex System II Dynamometer (Biodex Medical Systems, Shirley, NY) to improve reproducibility. EMG was used to record muscle activity for muscles surrounding the right GH joint, the long and short heads of the biceps brachii (LHBB and SHBB), anterior deltoid (DELT), pectoralis major (PECT), latissimus dorsi (LAT), infraspinatus (INFRA), and supraspinatus (SUPRA). Due to the location of the SUPRA deep to the trapezius, a single 44-gage fine-wire indwelling electrode was inserted to monitor its activity, and for the remaining muscles bipolar Ag-Ag-Cl surface electrodes were positioned over the muscle belly and parallel with the orientation of the muscle fibers. EMG data were recorded at 1250 Hz (Noraxon USA, Inc, Scottsdale, AZ) and filtered with custom MATLAB software. The subjects performed three trials of each test, and the test data were normalized to a percentage of effort based on

![Figure 1: Muscle activation of the SLAP tests.](image1)

![Figure 2: Muscle selectivity of the SLAP tests.](image2)
MVIC data. Muscle activity for each test was characterized by two variables, activation and selectivity. Muscle activation was defined as the muscle’s peak normalized EMG amplitude. Muscle selectivity was defined as the ratio of muscle activation for the muscle of interest over the sum of all seven muscles’ peak activations. A repeated measures analysis of variance (ANOVA) was performed to identify significant differences among tests for each muscle. A pair-wise t-test post-hoc analysis was performed to compare results between tests using a p-value sliding scale Bonferroni adjustment [4]. A paired-sample t-test was used to assess variances in behavior (p=0.05) between male and female groups.

RESULTS
Each test elicited a variance in muscle activation and selectivity (p=.000). Each muscle demonstrated significant differences in muscle activation and selectivity for at least one of the pairs of tests with the exception of the LAT for both variables and the INFRA for selectivity. Specifically the LHBB had a significant difference (p=.000) in activity between tests (Figure 1). The LHBB had the greatest activation for ACPU, Speed’s, Bicep I, and II without distinguishable differences in performance between them. ACPD and Yergason’s and Bicep I and II were statistically equivalent in eliciting LHBB activation. Both ACPU and Speed’s caused greater LHBB activation than ACPD, ProLoad, and Yergason’s. Bicep I and II caused greater LHBB activity than ProLoad, while ACPD had the weakest performance. LHBB selectivity results for the tests proved similar to those for muscle activation, where each test produced a variance in muscle selectivity (p=.000) (Figure 2). Bicep I and II produced the greatest LHBB selectivity of the group, performing better than ACPU, ACPD, ProLoad, and Speed’s. Yergason’s was also highly selective, performing better than ACPU and ACPD respectively. Bicep I and II, ACPU and ACPD, and Speed’s and ProLoad were equivalent in selectively activating the LHBB, while ACPU and ACPD had the worst LHBB selectivity of the group. RSER did not have significant LHBB behavior, and no differences were seen between male and female groups (p >.05).

DISCUSSION
ACPU, Speed’s, and Bicep I, and II elicited the largest LHBB activity, suggesting that during these tests more tension was applied to the bicep tendon. Bicep I and II were highly selective for the LHBB, which should reduce the number of potential sources for confounding results. Therefore in this study ACPU, Speed’s, and Bicep I, and II had the greatest potential for clinical SLAP lesion detection. Interestingly, these four tests shared design patterns relating to location of the applied load, forearm orientation, joint position, and line of pull, and these characteristics may prove valuable for optimizing SLAP test design and performance. Each test required active resistance to a load that was applied perpendicular to the palm of the subject’s hand. The load was resisted by either an isometric contraction (ACPU, Bicep I, and II) or by an isokinetic contraction (Speed’s). The forearm was supinated in all cases due to either the ‘palm up’ position (ACPU and Speed’s) or the ‘curl’ position (Bicep I and II). Each test applied the load in one of two joint positions that placed the LHBB and biceps tendon in a direct line of pull of the superior labrum. For ACPU and Speed’s, the shoulder was flexed to a maximum of 90° with the elbow fully extended, and for Bicep I and II the shoulder was abducted at or above 90° with the elbow flexed at 90°. These unique test characteristics should be further evaluated to determine their role in SLAP test performance.

REFERENCES