

Electromyographic Analysis of the Biceps Brachii during Provocative Tests

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— Abstract —

The electromyographic activity of four muscles(biceps, supraspinatus, infraspinatus and subscapularis) was measured from non-dominant shoulders of 12 volunteers by six different provocative test for the biceps pathology. The provocative tests were Speed, Yergason, Ludington, Heuter, O'Brien and the abduction-extension test. Each test was performed in a force of 30% of maximal voluntary contraction. The levels of activity of the biceps were higher than those of the other rotator cuff muscles only in Speed's test : 28% in the biceps, 26% in the infraspinatus, 25% in the supraspinatus and 21% in the subscapularis. The levels of activity of the biceps as a percent of MMT(maximal manual test) were higher in Speed's(42%) and O'Brien's test with the arm supinated(42%). Speed's test can isolate the activity of biceps better than the other tests but it is a nonspecific test by which the biceps tendon was also activated within other rotator cuff muscles.

Key Words : Biceps brachii, Rotator cuffs, Provocative test, Electromyography

INTRODUCTION

A long neglected structure of the shoulder, the biceps tendon has begun to receive greater attention over the past few years. Nowadays it is well accepted that the biceps tendon pathology coexists with impingement syndrome, rotator cuff pathology and glenohumeral instability.

There have been several provocative tests performed in an attempt to elicit the symptoms of biceps pathology such as the abduction-extension test³⁾, Speed's test⁶⁾, Ludington's test¹⁵⁾ and Yergason's test²⁴⁾. However, no definite dynamic test has been shown to identify biceps pathology with a high degree of sensitivity or specificity. Moreover, a superior glenoid labral lesion that was named as "SLAP" lesion

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clearly remains a diagnostic dilemma. A successful provocative test should maximally activate the muscle being tested, minimally activate the synergists and reliably produce symptoms in the affected individuals.

The purpose of this article is to analyze the electromyographic activity of the biceps muscle and rotator cuff muscles in normal subjects during provocative tests in order to determine which method best isolates the activity in biceps.

MATERIALS and METHODS

Non-dominant shoulders of 12 healthy volunteers who have had no history of shoulder pathology were studied. All subjects were males with the mean age of 31 years. Electromyographic signals were recorded from 4 different muscles of biceps brachii, supraspinatus, infraspinatus and subscapularis during provocative tests. The provocative maneuvers that were tested were Speed, Yergason, Ludington, Heuter⁸⁾, O'Brien¹⁶⁾ and the abduction-extension test. Speed's test was performed with the arm in 90 degrees of scaption, the elbow extended and the forearm in supination. The examiner then resists the attempts of the volunteers to flex the upper extremity further forward. Yergason' test was performed with the arm at the side, the elbow flexed to 90 degrees and the forearm in supination. The examiner then resists the volunteers' attempt to supinate the forearm. Ludington's test was performed with the arms behind the head in a position of abduction and external rotation. Heuter's test was performed in two parts. In part I, the elbow was flexed in 90 degrees and the

forearm was supinated and in part II, the forearm was pronated. The examiner then resists the attempt of the volunteers to flex the elbow. O'Brien test was also performed in two parts. In part I, the arm was flexed 90 degrees and adducted 15 degrees ; the elbow was extended and the arm was in full pronation. In part II, the arm was placed in a similar position except that the arm was maximally supinated. The examiner then resists the attempt to further flex the arm from this position. The abduction-extension test was performed with the arm in a position of marked extension, supination and 30 degrees of abduction. The examiner then resists the attempt to further elevate the arm from this position.

Each test was performed in a force of 30% of maximal voluntary contraction, which was controlled and monitored with the aid of a standard force couple. Surface electrodes were used for the biceps and 50 μ m dual and single wire electrodes (Nicolet Biomedical Inc., U.S.A) were placed intramuscularly in the supraspinatus, infraspinatus and subscapularis using the technique of Basmajian and DeLuca²⁾. Surface and wire electrodes were attached to ground plates. Correct placement of electrodes was verified by the electrical stimulation of the muscles or by a technique of maximal manual testing¹¹⁾. The signals from the electrodes were transmitted using a MP100WSW(BIOPAC systems Inc., U.S.A), which can convert from analog to digital signals and transmit up to 6 muscles simultaneously(Fig. 1). The EMG signal was sampled at a rate of 200Hz using a high pass filter of 20Hz. Electromyographic data were collected during 5 trials of 5 second period each and the

interval between trials was 30 seconds. The lowest and the highest values were discarded. The values obtained from the three trials were integrated and converted to RMS(root mean square) voltages for the quantitative measurement(Fig. 2). The preliminary data were being reported as percent activity per muscles as a function of the total activity in all 4 muscles. For statistical analysis of the results, one-way ANOVA-Turkey method was applied using 7.5 version of SPSS program.

RESULTS

1. The levels of activity

The levels of activity of the biceps were higher than those of the other rotator cuff

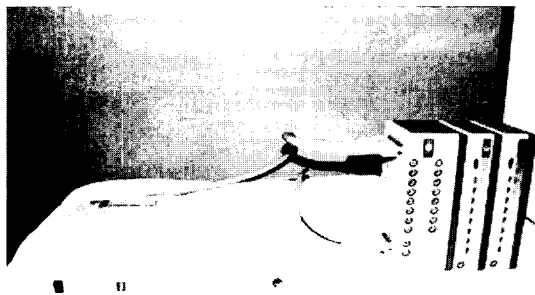


Fig. 1. MP100WSW(BIOPAC systems Inc.,U.S.A), which can convert from analog to digital signals and transmit up to 6 muscles simultaneously.

muscles only in Speed's test : 28% in the biceps, 26% in the infraspinatus, 25% in the supraspinatus and 21% in the subscapularis. But there was no statistical significance($p>0.05$). In the other tests, the levels of the activity of the biceps were always lower than the other rotator cuff muscles : 24% in Yergason's test, 25% in Heuter's and the abduction-extension test. In O'Brien test with the arm pronated, the levels of activity were higher in the supraspinatus(30%) than in the infraspinatus(28%), in the subscapularis(23%) and in the biceps(19%). In O'Brien test with the arm supinated, the levels of activity were similar with one another : 27% in the supraspinatus, 26% in

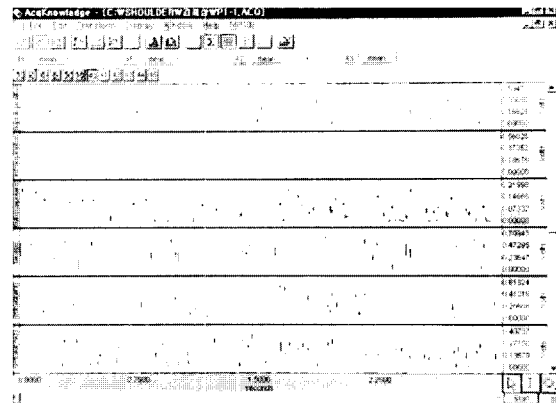


Fig. 2. Electromyographic signals, converted to RMS(root mean square) voltages for the quantitative measure.

Table 1. The levels of activity 4 muscles.

Provocative test	Supraspinatus	Infraspinatus	Subscapularis	Biceps
Speed	25%	26%	21%	28%
Yergason	24%	29%	23%	24%
Heuter, part I	25%	27%	22%	25%
Heuter, part II	26%	27%	22%	26%
Ludington	27%	27%	23%	22%
O'Brien, part I	30%	28%	23%	19%
O'Brien, part II	27%	26%	21%	26%
Abduction-extension	26%	27%	21%	25%

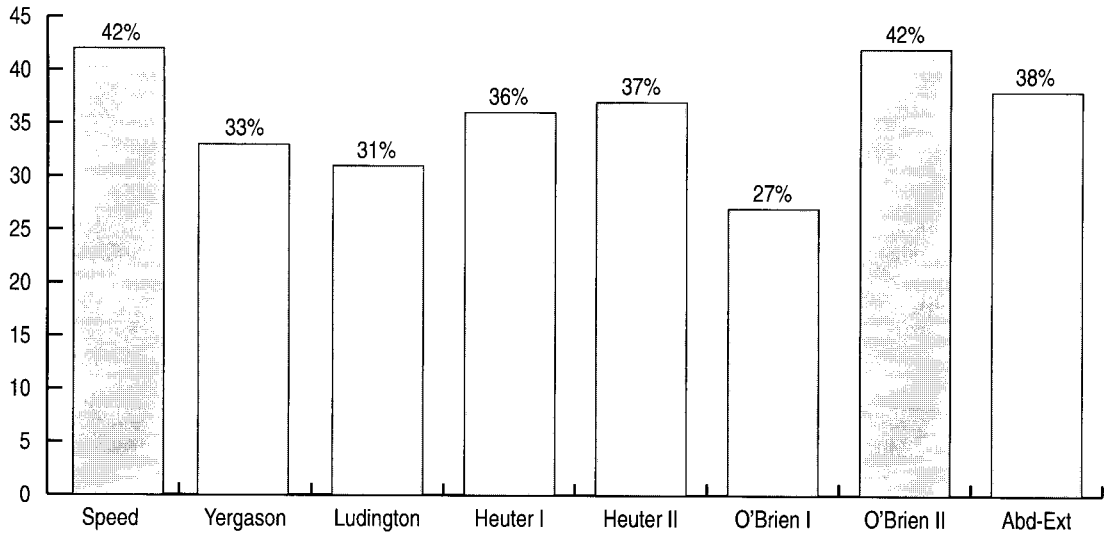


Fig. 3. The levels of activity of the biceps as a percent of MMT.

the infraspinatus and biceps and 21% in the subscapularis (Table 1).

2. The levels of activity of the biceps as a percent of MMT

The levels of activity of the biceps as a percent of MMT (maximal manual test) were greater in speed's test (42%) and O'Brien test with the arm supinated (42%) than in the other test: 33% in Yergason, 31% in Ludington, 36% in Heuter (Part I), 37% in Heuter (Part II), 27% in O'Brien's test with the arm pronated and 38% in the abduction-extension test (Fig. 3).

DISCUSSION

The role of the long head of biceps brachii was generally accepted as a dynamic stabilizer of the glenohumeral joint^{7,10,17,22} and depressor of the humeral head¹⁸. However, the actual biomechanics and contribution of the biceps tendon to the overall stability of the shoulder still remain controversial. In 1988, Rowe¹⁹

found a hypertrophy of the biceps tendon in many cases of large rotator cuff tear. He thought this is in response to the unrestricted superior humeral migration, thereby implicating the biceps as a head depressor and active dynamic stabilizer of the shoulder. Kumar et al.¹² and Itoi et al.⁹ in their cadaveric study, demonstrated that the biceps brachii contributed to the anterior stability of the shoulder. Andrews et al.¹¹ have found considerable motion present in the biceps-labral complex when viewed arthroscopically as the biceps muscle was stimulated and also noted the significant amount of lifting of the anchor as well as compression of the humeral head. Lippmann¹³, however, postulated that the biceps tendon was a purely passive player about the shoulder and could not identify any appreciable motion in the biceps tendon when the biceps muscle was stimulated without motion at the elbow or shoulder. Yamaguchi et al.²³ also observed that there was no significant biceps activity in any

shoulder, including patients with rotator cuff tear. They suggested that the function of the long head of the biceps would be passive.

Many authors used the electromyographic study to investigate the role of biceps tendon^{2,5,21)}. They demonstrated that the biceps acted as a contributing force in the motion of forward flexion and abduction of the shoulder when the arm was in neutral or external rotation. Ting et al.²¹⁾ noted the increased biceps activity in the patient with rotator cuff tears and Glousman⁷⁾ found increased activity in patients with glenohumeral instability. At present, it is well established that the biceps pathology is concomitant with rotator cuff disease, instability of the shoulder and acromioclavicular joint problems. So one must investigate further to rule out other problems so as not to miss the true etiology of the biceps problem³⁾. Yet the findings of physical examination in patients with bicipital symptoms vary widely.

The provocative tests for the biceps tendon pathology or superior glenoid labral pathology can be divided into a couple of tests : the test by which the symptoms occur, secondary to tension generation in the offending structure and the one by which the mechanical symptoms occur such as painful catching and popping. Speed's, Yergason's, Heuter's and the abduction-extension test are tests which can be attributed to symptoms that occur secondary to tension generation. Recently some authors designed new tests such as the compression-rotation test²⁰⁾, and the crank test¹⁴⁾, all of which are the tests by which the mechanical symptoms occur. In general, successful provocative tests should maximally activate the muscle

being tested, minimally activate the synergists present and reliably reproduce symptoms in affected individuals. In 1998, Bennett⁴⁾ evaluated the clinical results of Speed's test by direct arthroscopic visualization. They reported a specificity of 13.8%, a sensitivity of 90%, a positive predictive value of 23%, and a negative predictive value of 83%. They concluded that the Speed's test was a nonspecific but sensitive test for macroscopic biceps-labral pathology. In our study, the levels of activity of the biceps were higher than those of the other rotator cuff muscles in Speed's test compared to the other tests. But there was only a little difference of the levels of activity between muscles : 28% in the biceps, 25% in the supraspinatus, 26% in the infraspinatus and 21% in the subscapularis. Also there was no statistical significance ($P > 0.05$). The levels of activity of the biceps as a percent of MMT was the highest in Speed's test (42%) and O'Brien's test with the arm supinated (42%). Therefore, we believe that Speed's test is a better test than the other test but is a nonspecific one by which the biceps tendon was activated within other rotator cuff muscles during the test.

In 1998, O'Brien et al.¹⁶⁾ designed the new test for diagnosing the labral tear and acromioclavicular joint abnormalities. The test was considered positive if pain was elicited when the arm was maximally pronated and was reduced when the arm was supinated. They thought that the tension and shear force on the bicipital labral complex when the test was performed with the arm pronated. And they reported that 53 of 56 patients whose pre-operative examinations indicated a labral

tear had a confirmed labral tear upon surgery. In our study, the levels of activity of the biceps in O'Brien's test with the arm pronated(19%) was less than those with the arm supinated(26%). The levels of activity of the biceps as a percent of MMT was also less in the test with the arm pronated(27%) than those with the arm supinated(42%). These results suggest that more tension is generated within the biceps in the position of O'Brien's test with the arm supinated than pronated. It does not correspond with the phenomenon in O'Brien's test that the pain is elicited in the position with the arm pronated. This also suggests that O'Brien's test is a provocative maneuver by which the pain reproduced is not associated with the tension generated within the biceps tendon.

CONCLUSION

No method of provocative test can isolate the biceps activity prominently, compared to the other rotator cuff muscles. Speed's test can better isolate the activity of biceps than the other tests but is a nonspecific one by which the biceps tendon was also activated within other rotator cuff muscles. We think that it is necessary to devise a new test which can better isolate the activity of the biceps, minimally activate the synergists and reliably produce symptoms.

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— 국문초록 —

상완 이두 건 병변에 대한 유발 검사시의 근전도 분석

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본 논문의 목적은 상완 이두 건의 병변을 진단하기 위한 여러 가지 유발 검사 중 어떤 검사가 가장 많이 상완 이두 근을 활성화시키는지 알아보고자 함이다. 저자들은 12명의 건강한 지원자들의 견관절에 대하여 상완 이두 건의 병적인 상태에 대한 유발 검사를 시행하면서 네 가지 근육, 즉 이두 근, 극상근, 극하근 그리고 견갑하근에 대한 근전도를 시행하여 정량적으로 분석을 하였다. 유발 검사로는 Speed 검사, Yergason 검사, Ludington 검사, Heuter 검사, O'Brien 검사 그리고 외전-신전 검사 등을 시행하였다. 각각의 검사는 수의적 최대 수축의 약 30% 정도의 힘을 주게 한 상태에서 시행되었다. 상완 이두 건의 활성화의 수준은 Speed 검사에서만 다른 회전 근 개의 근육보다 높게 나타났다. 즉 상완 이두 근에서는 28%, 극하근에서는 25%, 극상근에서는 25% 그리고 견갑하근에서는 21%의 활성도를 각각 나타내었다. 상완 이두 근의 도수적 최대 근력 수축에 대한 근육 활성화의 수준은 Speed 검사와 전완을 회내 시킨 상태에서의 O'Brien 검사에서 다른 검사보다 높게 나타났다. Speed 검사는 다른 검사에 비해 상완 이두 근의 활성도를 좀 더 잘 단독화 시킬 수 있었으나 다른 회전 근 개의 근육들도 같이 활성화되었기 때문에 특이적이라고는 할 수 없었다.

색인 단어 : 상완 이두 근, 회전 근 개, 유발 검사, 근전도 검사