LIMITATIONS OF ISOKINETIC TESTING TO DETERMINE SHOULDER STRENGTH AFTER ROTATOR CUFF REPAIR

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ABSTRACT

Some investigators have reported incomplete data when using isokinetic testing as a means of analyzing shoulder strength after rotator cuff repair. An explanation provided has been that the subjects could not reach the speed at which the machine was set. The purpose of this study was to determine if strength data could be generated for all motions being tested by using not only the one or two speeds employed by others, but three speeds across the spectrum of those available. Inclusion criteria were a minimum of two years since surgery with a normal contralateral shoulder. All eligible subjects had isokinetic testing of the non-operated shoulder followed by the operated shoulder, in flexion, abduction and external rotation, tested at 60˚, 120˚ and 180˚ per second. Fourteen patients were eligible and tested. Isokinetic data showed deficiencies in strength in the operated shoulder compared to the opposite side for abduction, external rotation and flexion of 14%, 27% and 20% respectively. In 10/123 (8%) of the tests, the patients could not reach the preset velocity to yield valid data. One patient could not place and maintain the operated arm in the test position of 90˚ of shoulder abduction. There was a significant deficiency in abduction at only one of three speeds. This study confirms that isokinetic testing is a powerful tool that lends itself well to producing objective data on shoulder strength after rotator cuff repair, but it also has the limitation that some patients cannot reach the preset velocity for some motions, or place and maintain the operated arm in the test position for the movements being tested. Therefore, to optimize the chances of obtaining isokinetic data for all movements after rotator cuff repair, we suggest using speeds for all motions and consideration of scapular, frontal and sagittal planes for testing.

INTRODUCTION

Over recent years, various studies have reported good results for surgical treatment of open, mini-open and arthroscopic rotator cuff repairs.[1-11] Some of these studies have employed objective testing.[1,2,3,4,5,6,7] Isokinetic testing has been reported as an objective, useful, reliable and accurate means of analyzing shoulder strength after rotator cuff repair.[2,3,5,6] A review of the literature found that some reports had incomplete isokinetic data for their patients.[2,3,4] In the paper by Walker et al.,[2] four of 46 patients had incomplete isokinetic data. In the study by Grana et al.,[4] only 33 of 54 had isokinetic evaluation, but the authors did not elaborate on the incomplete evaluations. Rabin and Post[3] reported that only 33% of their patients could generate enough torque to begin the test, and only 13% completed the test.

Reports of strength following rotator cuff repair using isokinetic testing, employ one or two speeds. It is customary to use a slow speed for strength and a fast speed for power, with the optimum test speeds being unknown.[2] Investigators have reported results using 60˚ per second,[6] 90˚ per second,[3,5] and both 60˚ and 120˚ per second.[2] Shklar and Dvir [12] have used 60˚, 90˚ and 120˚ per second to test healthy volunteers.

We hypothesized that using three speeds to test patients having had rotator cuff repairs would facilitate obtaining isokinetic data for all motions being testing in these subjects. The objective of this study was to determine the efficacy of using isokinetic testing at speeds of 60˚, 90˚ and 120˚ per second in minimizing loss of isokinetic data.

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METHODS

Inclusion criteria for study entry were: a minimum of two years since rotator cuff surgery, no procedures to the shoulder other than those under investigation, an asymptomatic pain-free contralateral non-operated shoulder, no inflammatory lesion of either shoulder which could affect function, and informed consent to participate in the study. All rotator cuff repairs were performed using open techniques by two staff surgeons at two hospitals—Kingston General Hospital, Ontario, and Hotel Dieu Hospital, Ontario.

All subjects had isokinetic testing using the Cybex II isokinetic dynamometer (Lumex, Ronkonkoma, New York) incorporating the Cybex Data Reduction Computer. The non-operated side was tested first,followed by the operated side. Shoulder flexion, abduction and external rotation were tested with five repetitions at each of three different speeds: 60˚, 120˚ and 180˚ per second. The order of movement patterns and speeds was determined randomly. For all testing, a minimum of five minutes was permitted between the testing of the different movement patterns, and a minimum of two minutes between testing at the different speeds. Verbal encouragement for maximal speed, and as full a range of motion as possible, was provided throughout the testing procedure.

The isokinetic testing was done according to the protocol per Cybex. For flexion, the subject was supine with the axis of rotation of the shoulder joint aligned with the axis of rotation of the Cybex dynamometer arm. The handgrip and Cybex lever arm were adjusted to permit full elbow extension. For testing of abduction, the subject was seated on the bench tilted 40˚ from the vertical. The Cybex dynamometer was tilted backward, also to 40˚, to ensure that it and the subject's arm were in the same plane of movement. For testing of external rotation, the subject was supine with the arm abducted to 90˚. The upper arm was secured by a Velcro strap into a padded V-shaped support so the upper arm was parallel to the floor. The rotational axis of the dynamometer was aligned with the rotational axis of the shoulder joint. The forearm was at 90˚ to the upper arm as the subject grasped the hand grip.

Results were given as a relative percentage deficiency in strength of the operated side compared to the non-operated side. Data was examined with a paired t-test.

RESULTS

Retrospective chart review of 52 consecutive patients with rotator cuff repairs identified 14 that fit the inclusion criteria and provided data for analysis. The average age was 58 years old (range, 37 to 78). There were 13 males and one female. The average time from onset of symptoms until repair was 15 months (two weeks to 13 years). The dominant arm was repaired in nine and non-dominant in five. Time since repair averaged four years (two to nine years). The type of open repair was side-to-side in four, and attachment to a trough in ten.

Analysis of the isokinetic data for shoulder abduction using the t-test showed a significant deficiency in strength ($p<0.05$) of the operated shoulder only at the speed of 120˚ per second. The average deficit in strength across all speeds for shoulder abduction was 14%.

All isokinetic data related to shoulder rotation was for 13 subjects only. This is because one subject was unable to place and maintain the operated arm in the test position of 90˚ of shoulder abduction.

Application of the t-test to the data for shoulder external rotation showed a significant deficiency at all three speeds tested ($p<0.05$). The average deficit in strength across all speeds for shoulder external rotation was 27%.

Application of the t-test to the data for flexion showed significant weakness of the operated shoulder compared to the non-operated side ($p<0.05$) at all three speeds tested. The average deficit in strength across all three speeds for shoulder flexion was 20%.

In ten out of 123 tests (8%), there was a 100% difference between the operated and non-operated shoulders: subjects eight and 13 at 180˚ in flexion; subject six at 60˚ and 120˚; subject 11 at 180˚; subject 13 at 120˚ and 180˚ in abduction; subject 12 at 60˚, 120˚ and 180˚ in external rotation.

DISCUSSION

Over the years, there has been an evolution from open to mini-open to arthroscopic surgery to treat rotator cuff tears. In studies comparing and contrasting the results of different surgical techniques, some investigators have reported clinical grading of strength after rotator cuff repair, while others have used maximum isometric contraction to gauge strength.[1,8] These methods test strength at a single joint position. Isokinetic testing has the advantage of allowing dynamic torsional forces to be recorded throughout the functional range of motion.

Using isokinetic testing, Kirschenbaum et al., Rokito et al. and Walker et al. have found strength values of 104%, 142% and 97%; 90%, 91% and 84%; 80%, 90% and 75% for abduction, external rotation and flexion, respectively, at one year following rotator cuff repairs.[2,5,6]

Converting the amount of strength deficit found in our study to the corresponding relative strength values of the operated versus opposite shoulder yields results of 85%, 73% and 80%. Although no conclusions concerning the effect of surgical repair of rotator cuff tears could be made due to our retrospective study design and small sample size, our results obtained are in general agreement with those reported in the literature, supporting the validity of our method of isokinetic testing.

With our method of isokinetic testing we were able to generate objective data amenable to analysis. However, we discovered that there was an instance in which the data indicated that at a speed of 120˚ per second, there was a 100% deficiency in performing shoulder abduction on the operated arm compared to the non-operated side, while for the same motion at 60˚ per second, the opposite was true. The explanation for this phenomenon lies in the way the apparatus works.

The machine is designed to record a subject's attempt to exceed the preset velocity. It is this attempted acceleration that the machine measures and converts into moments around the dynamometer axis. If a subject does not reach this preset value, a "0" output is registered. Consequently, regardless of the absolute value recorded on the comparison side, provided some value is recorded, a 100% deficit will be registered when bilateral comparisons are made. Therefore, the comparison is not quantified, but rather is arbitrary, and no useful data for analysis is yielded for that speed. Data for that particular motion must be obtained using a different testing speed. These phenomena must be suspected whenever a 100% deficit is measured. Upon closer examination of all of the data, we discovered that this occurred in 10 out of 123 (8%) of the tests, and involved various patients and testing speeds. In addition, when considering the pooled data, there was a significant deficiency in abduction at only one of three speeds. These findings demonstrate that, similar to other studies, we also had incomplete isokinetic data. However, because we used three speeds to test each motion, we were able to find a speed whereby a measurement of subject performance could be registered for each motion.

If we had only used the one or two speeds routinely employed in previous studies, there would have been instances where no data for a particular movement would have been obtained. Specifically, in subjects eight and 13, we would not have obtained data for flexion if only 180˚ was used; in subject six, we would not have obtained data for abduction if either 60˚ or 120˚ were used; in subject 11, we would not have obtained data for abduction if only 180˚ was used; in subject 13, we would not have obtained any data for abduction if either 120˚ or 180˚ were used.

Another problem encountered in using the Cybex II isokinetic dynamometer was that one subject could not place their arm in the test position of 90˚ of shoulder abduction for testing of external rotation. Leroux et al. reported that 56 of their 128 patients were excluded from isokinetic testing following anterior acromioplasty, sometimes combined with rotator cuff repair, because of pain and articular range limitations.[13] We were not sure from this that they had the same problem we found. Other authors have reported isokinetic testing of external rotation in normal volunteers employing the scapular rather than traditional frontal or sagittal planes.[14,15]

Although this is a different patient population, it is worth considering testing rotator cuff repairs in several planes in order to find a circumstance in which some measurement of subject performance can be registered. We had not anticipated this positioning problem, and when it was discovered we could not logistically retest internal rotation for all of our patients using the scapular plane.

In seeking a reference in which to compare postoperative results, it was noted that preoperative power testing in the presence of rotator cuff lesions is limited by restricted range of motion and pain. Heterogeneous patient characteristics restrict the use of standardized values from healthy individuals. Therefore, in this study the patient's contralateral shoulder was used as the control and we restricted the subjects investigated to those having asymptomatic contralateral shoulders. Shklar and Dvir,[12] and Ivey and colleagues,[16] have reported that there is no statistical difference in isokinetic testing between dominant and nondominant shoulders in normal volunteers, therefore providing support for our method of obtaining controls. Watson[17] reported that the results of rotator cuff repair continued to improve postoperatively, reaching a plateau at two years after surgery. Therefore, we selected patients that were a minimum of two years post-operative to maximize their ability to perform the isokinetic te sting. All of these factors resulted in a small but unique subgroup of the total cuff repairs (14/52) that were done over the investigation period.

In conclusion, this study confirms that isokinetic testing is a powerful tool that lends itself well to producing objective data on shoulder strength after rotator cuff repair. However, unlike the situation with normal volunteers, we found that when used in patients after rotator cuff repair, some subjects were not able to reach the preset velocity and were not able to place and maintain the operated arm in the test position. Therefore, to optimize the chances of obtaining isokinetic data for all movements after rotator cuff repair, we suggest using speeds of 60˚, 120˚ and 180˚ per second for all motions, and consideration of scapular, frontal and sagittal planes for testing.

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