Effect of Gravity Correction on Shoulder Average Force and Reciprocal Muscle Group Ratios

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Abstract:

This study examined the effect of gravity correction on concentric and eccentric average force of the right and left side shoulder rotator muscles and on the external/internal rotation reciprocal muscle group ratios. Thirty-three males were tested on a Kinetic Communicator dynamometer at 150 deg/sec from a seated position with the shoulder abducted to 90 deg and positioned along the frontal plane. Gravity correction procedures were followed prior to testing, and both the gravity-uncorrected (GU) and gravity-corrected (GC) values were obtained from the dynamometer's software. Paired t-tests indicated the gravity correction procedure increased every value obtained during external rotation and decreased all values obtained during internal rotation. Also, the concentric and eccentric external/internal rotation reciprocal muscle group ratios were all higher as a result of the gravity correction procedure. These findings were consistent with previous reports on the effect of gravity correction on lower extremity muscle groups. In particular, gravity correction significantly added to the muscle group opposed by gravity (external rotators) and detracted from the muscle group assisted by gravity (internal rotators). Therefore correction for the effects of gravity is recommended during isokinetic assessment of the shoulder internal and external rotator muscle groups.

Article:

Gravity correction is an acknowledged component of valid strength assessment of the quadriceps and hamstring muscle groups.[3,4,21,24] Strength measurements tend to overestimate the strength of muscles assisted by gravity and to underestimate the strength of muscles opposed by gravity.[10,15,20,24] Failure to correct for the effects of gravity also confounds determination of the hamstring/quadriceps reciprocal muscle group relationship. Gravity

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correction tends to reduce hamstring force and increase quadriceps force. Therefore determination of the hamstring/quadriceps reciprocal muscle group ratio from values uncorrected for the effect of gravity tends to inflate the ratio.[2,9,10]

Several reports of isokinetic strength assessment of the shoulder internal and external rotator muscle groups can be found in the literature. [1,5-8,11-14,16-19,22,23] Only two of these reports indicated that a gravity correction procedure had been followed. [16,17] The effect of gravity on the normative strength and reciprocal muscle group ratios in reports that did not use a correction procedure is unknown.

The purpose of this study was to determine the effect of gravity correction on concentric and eccentric average force of the shoulder internal and external rotator muscle groups. A comparison was also made between the external/internal rotator reciprocal muscle group ratios determined from gravity-uncorrected and -corrected average force values.

METHOD SUBJECTS

Thirty-three male subjects (mean age = 21.09 yr, mean ht = 180.49 cm, mean wt = 78.99 kg) participated in the study after giving their informed consent in accordance with institutional human investigation committee guidelines. Subjects were excluded from participating in the study if they reported any history of injury to either the right or left side shoulder girdle complex.

	GUC	GC	*t*	p
NDOMCONER	119.24(30.18)	129.49(31.55)	12.71	.0001
NDOMECCER	164.06(33.97)	174.33(35.83)	12.61	.0001
NDOMCONIR	135.76(31.21)	125.46(29.87)	−12.12	.0001
NDOMECCIR	207.36(44.30)	197.00(42.13)	−12.45	.0001
DOMCONER	127.30(25.84)	138.61(26.67)	−22.23	.0001
DOMECCER	162.61(31.02)	173.82(31.86)	−22.62	.0001
DOMCONIR	136.52(35.67)	125.42(34.47)	23.04	.0001
DOMECCIR	206.67(53.13)	192.46(53.04)	4.63	.0001

Table 1: Paired t-tests comparing gravity-uncorrected (GUC) and gravity-corrected (GC) concentric (CON) and eccentric (ECC) average force of dominant (DOM) and nondominant (NDOM) side shoulder internal (IR) and external (ER) rotator muscle groups.

INSTRUMENTATION AND TEST PROTOCOL

Subjects were tested for concentric and eccentric average force (newtons) of the right and left shoulder internal and external rotator muscle groups with a Kinetic Communicator (Kin Com, Chattecx Corp., Chattanooga, TN) at 150 deg/sec. Each subject was tested from an upright seated position with legs extended forward and feet resting on a chair. Subjects were secured to

the test chair with straps at the waist and chest, and the axis of rotation of the glenohumeral joint was aligned with the axis of the dynamometer. The elbow was flexed to 90 deg and the shoulder was abducted to 90 deg and positioned along the frontal plane. Subjects were tested through 85 deg of motion, from 90 deg of external rotation to 5 deg of internal rotation.
A warm-up session consisted of five submaximal concentric and eccentric practice trials for both the internal and external rotator muscle groups. Following a brief rest period, subjects performed a minimum of three maximal concentric and eccentric contractions of the internal rotator muscle group and then the external rotator muscle group. Additional trials were performed if necessary to obtain three reproducible concentric and eccentric force curves. A preload force of 25 newtons was established for all test conditions.

GRAVITY CORRECTION PROCEDURE

Gravity correction procedures were employed prior to testing both the right and left shoulders. In each instance, the limb was moved to an angle within the range of motion tested. This angle was then recorded relative to the horizontal plane, with above denoted as positive and below as negative. Subjects were then instructed to completely relax the limb on the loadcell while the system measured the force due to gravity. Once this procedure was completed, it was then possible to retrieve either the gravity-uncorrected or -corrected force values from the dynamometer's computer software.

DATA ANALYSIS

Values were obtained from the dynamometer's software for both gravity-uncorrected and -corrected right and left shoulder internal and external rotation concentric and eccentric average force in newtons. Paired t-tests were computed to determine if any differences existed between the gravity-uncorrected and -corrected values for both the dominant and nondominant side concentric and eccentric internal and external rotation values.

To determine the right and left side concentric and eccentric reciprocal muscle group ratios, the external rotation average force values were divided by the internal rotation values. Paired t-tests were then computed to determine if any differences existed between the reciprocal muscle group ratios derived from the gravity-uncorrected and -corrected average force values.

A Bonferroni correction was used to adjust p values for the eight gravity ($.05/8 = p < .006$) and four reciprocal muscle group comparisons ($.05/4 = p < .01$).

RESULTS

The comparison between gravity-uncorrected and gravity-corrected average force values for all movements tested is presented in Table 1. The gravity correction procedure increased every value obtained during external rotation and decreased all values obtained during internal rotation.

Table 2 and Figure 1 present the effect of gravity correction on determination of the shoulder external/ internal rotation reciprocal muscle group ratios. The dominant and nondominant side concentric and eccentric ratios were all higher as a result of the gravity correction procedure.

	GUC	GC	*t*	p
DOMCONER/IR	.97(.20)	1.15(.26)	−13.18	.0001
DOMECCER/IR	.81(.16)	.94(.17)	−8.25	.0001
NDOMCONER/IR	.89(.18)	1.05(.22)	12.80	.0001
NDOMECCER/IR	.80(.12)	.90(.13)	13.68	.0001

Table 2: Paired t-tests comparing gravity-uncorrected (GUC) and gravity-corrected (GC) dominant (DOM) and nondominant (NDOM) shoulder concentric (CON) and eccentric (ECC) external/internal (ER/IR) rotation reciprocal muscle group ratios.

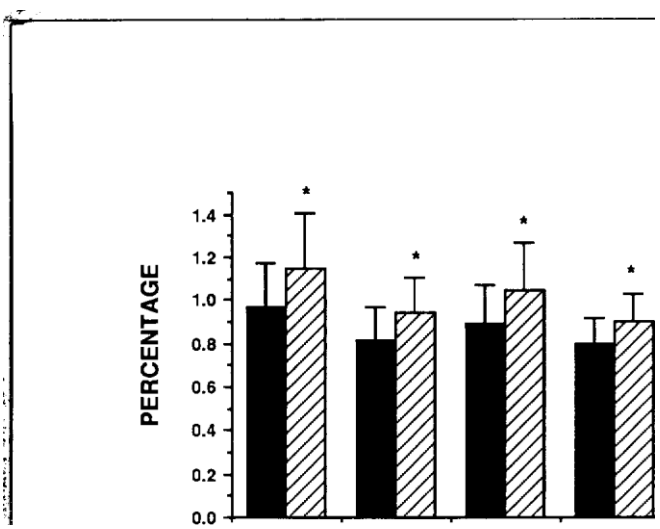

Figure 1: Effect of gravity correction on dominant (D) and nondominant (ND) concentric (CON) and eccentric (ECC) external/internal rotation reciprocal muscle group ratios. Asterisk indicates gravity-corrected (GC) ratios significantly greater than gravity-uncorrected (GUC) ratios.

DISCUSSION

The major finding of this investigation was that the gravity correction procedure had a significant effect on both the shoulder internal and external rotation average force values. Gravity correction significantly added to the muscle group opposed by gravity (external rotators) and detracted from the muscle group assisted by gravity (internal rotators). The effect of gravity correction appeared to be similar for both the dominant and nondominant sides, and for both concentric and eccentric modes of contraction

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Comparison of our shoulder external/internal (ER/ IR) rotator reciprocal muscle group ratios with other reports in the literature is very difficult due to variations in subject population, body position, and test velocity. Several other investigators assessed concentric strength of the shoulder internal and external rotator muscles from the supine position and with the arm in a 90 deg abducted position.[1,6,8,13,18,23] Test velocities in these investigations ranged from 60 to 300 deg/sec, and the range of shoulder ER/IR reciprocal muscle group ratios was from .62 to .80. The uncorrected concentric ER/IR ratios in our investigation were somewhat higher and ranged from .89 to .97. Two factors would seem most likely to account for this apparent discrepancy between ratios. Our investigation assessed shoulder rotational strength from a seated position and the other studies assessed strength from a supine position. Also, the instrumentation used in our study assessed strength of the internal and external rotator muscle groups separately, while the other investigations used a dynamometer which assesses strength of these muscle groups in a continuous and reciprocal fashion.

Hageman *et al.*[12] assessed both concentric and eccentric peak torque of the shoulder rotators from a seated position, but did not employ a gravity correction procedure. The test position was also slightly different in that the humerus was in a 45 deg abducted position. The ER/IR rotation ratios calculated from the mean values presented in their paper were .63 and .62 for concentric and eccentric modes of contraction, respectively. These ratios were also considerably lower than ours.

Only two studies could be found that reported a gravity correction technique during assessment of shoulder rotation strength. Ng and Kramer[16] used a similar dynamometer but a slightly different test position. Unfortunately, the authors did not report ER/IR reciprocal muscle group ratios, nor did they present mean values from which the ratios could be determined. Otis *et al.*[17] used a different dynamometer to assess shoulder rotation strength with the humerus abducted to 90 deg, but from a supine body position. Nonetheless, calculation of the shoulder ER/IR ratios from their mean values revealed a range of .77 to .86, which is somewhat closer to the ratios found in our investigation.

The relationship of shoulder external to internal rotation strength has long been of special interest to those involved in the preseason screening and rehabilitation of athletes. We propose that assessment of these muscle groups from a seated position with the humerus abducted to 90 deg more closely resembles the position of the body and arm found during most throwing activities. Our findings also suggest that the external rotator muscle group is stronger relative to the internal rotators when assessed from this position. Indeed, the gravity correction procedure employed in our investigation revealed a concentric external rotation strength value that exceeded the strength of the internal rotator muscle group. Further research should examine the strength of these muscle groups in a variety of athletic populations from this test position using a gravity correction procedure.

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