THE INFLUENCE OF FREESTYLE AND BACKSTROKE SWIMMING ON THE PEAK TORQUE AND MUSCLE BALANCE OF THE ROTATOR CUFF

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This study examined the effect of swimming on rotator cuff shoulder strength and balance. Elite freestyle (FS) (n=6) and backstroke (BS) (n=6) swimmers and a control group (CG) (n=12) undertook concentric isokinetic testing in prone (P) and supine (S) positions. Between groups, FS produced greater peak torques for internal rotation in both positions. FS produced greater peak torques in P position, whilst BS had a tendency for greater peak torques in S position, suggesting swimmers produce higher torques in a stroke-specific body position. FS and BS had lower external:internal rotation (ER:IR) ratios compared to CG in P position, whilst FS had a lower shoulder ER:IR ratio in the S position. This suggests that FS gain in IR strength with an unchanged ER strength.

KEY WORDS: swimming, rotator cuff, muscle balance, isokinetic strength, peak torque.

INTRODUCTION: A competitive swimmer may cover 10,000 to 14,000 metres per day, six to seven days per week. This equates to approximately 16,000 shoulder revolutions per week (Scovazzo et al., 1991). Amongst competitive swimmers, 38 % to 75 % have had a history of shoulder pain (Kennedy and Hawkins, 1974; McMaster and Troup, 1993; Richardson et al., 1980). The effects of the repetitive shoulder action of freestyle swimming have identified over-developed internal rotators, while the external rotator strength remains unchanged (McMaster et al., 1991; McMaster et al., 1992). Such imbalances may predispose injury (Ciullo, 1996) or conversely enhance swimming performance. Previous swimming studies have tested in a variety of positions and have predominantly utilised freestyle swimmers or else grouped all swimmers together (Beach et al., 1992; Falkel et al., 1987; McMaster et al., 1991; McMaster et al., 1992). As such, data pertaining to the other three competitive strokes is conspicuously absent from the literature. Further, only one study to date has tested swimmers in both the prone and supine positions, failing however to report the reliability of these testing positions (Falkel et al., 1987). This investigation was undertaken to test unilateral isokinetic shoulder strength of internal and external rotation in elite freestyle and backstroke swimmers. A control group was used to analyse the influence of swimming on the strength and muscle balance of the rotator cuff musculature. The aims of this investigation were to examine: (i) the influence of freestyle and backstroke swimming separately on peak torques and muscle balance ratios of internal and external shoulder rotation; (ii) elite swimmers in testing positions that closely simulate the swimming action; and, (iii) the reliability of testing in the prone and supine testing positions.

METHOD: Elite freestyle (n=6) and backstroke (n=6) swimmers participated in this study. Elite is defined as swimmers who have competed at national level or international level. A control group consisted of 12 males who had not had any formal swimming training and did not swim regularly.

All tests utilised the KIN-COM" isokinetic dynamometer to determine peak torque for internal and external shoulder rotation. Correction for gravity was performed for every participant prior to each testing position. The testing protocol began by positioning the participant lying either in the prone or supine position, with their shoulder abducted to 90 ° and the elbow flexed at 90 °. The isokinetic tests were performed concentrically at 60 °/sec and 240 °/sec, in that order, for each shoulder. Test positions were conducted in a random order between subjects. All sessions began with internal rotation tested first for each speed and position followed by external rotation. All tests were intermittent concentric contractions. Participants performed three maximal concentric contractions of internal rotation and external rotation, with a 10 second rest between each movement.

Analysis Methods: Mean and standard deviation was calculated for each test speed, position and movement, and examined using one-way between group ANOVA tests with

Scheffe Post-Hoc analysis. Dominant and non-dominant shoulders were compared using a paired t-test. The supine and prone positions were compared using a paired t-test. Significance level was $p<0.05$. Reliability data was calculated on control subjects only ($n=8$) and reported as intraclass correlation coefficients (ICC). An estimation for the standard error of measurement (SEM) was obtained from the ICC values, using a pooled standard deviation from the test and retest values.

RESULTS:

Abbreviations: IR – internal rotation; ER – external rotation; S – supine; P – prone; 60" – 60°/s; 240° – 240°/s; ER:IR – external:internal rotation ratio.

Table 1 Peak Torque Values

TEST	FREESTYLE N.m	BACKSTROKE N.m	CONTROL N.m
IR-S-60°	200.75 218.88 [c]	183.08 ± 28.49	160.00 ± 25.70
IR-S-240°	193.25 ± 13.61 [c]	172.25 ± 26.20	157.50 ±22.62
ER-S-60°	131.19 ± 27.60	147.5 ±26.34	126.29 ±30.04
ER-S-240°	121.25 ± 10.64	138.16 ±18.20	116.00 ± 17.55
IR-P-60°	211.16 ± 33.42 [bc]	175.41 ±35.74	170.30 ± 27.97
IR-P-240°	205.31 ±31.28 [bc]	164.91 ± 28.34	165.34 ± 26.00
ER-P-60°	159.08 ± 14.42	134.16 ± 47.3	154.42 ± 24.70
ER-P-240°	152.08 ± 10.33	127.67 ± 42.36	146.46 ± 22.37

Each table value is the average of the two individual shoulder peak torques.
All values are mean ± standard deviation.
[b] significantly different from backstroke.
[c] significantly different from control.

Table 2 External Rotation : Internal Rotation Ratios

TEST	FREESTYLE	BACKSTROKE	CONTROL
ER:IR-S-60°	0.65 ± 0.09 [bc]	0.81 ± 0.12	0.75 ± 0.06
ER:IR-S-240°	0.63 ± 0.22 [bc]	0.81± 0.08	0.74 ± 0.07
ER:IR-P-60°	0.76 ± 0.13 [c]	0.74 ± 0.14 [c]	0.91 ± 0.07
ER:IR-P-240°	0.76 ± 0.16	0.75 20.10	0.88 20.06

Each table value is the average of the two individual shoulder ratios.
All ratio values are mean ± standard deviation.
[b] significantly different from backstroke.
[c] significantly different from control.

Peak Torque (Prone vs Supine Position): The freestyle swimmers produced significantly greater results in the prone testing position in the ER-60 °, ER-240 ° and ER:IR-240 ° tests. There was also a trend for greater values in the prone position for the IR-60°, IR-240 ° and ER:IR-60 ° tests. The backstroke swimmers demonstrated no significant differences between the prone and supine positions, however, there was a trend for greater peak torque values in the supine position for all tests. The control group produced significantly greater results in the prone position compared to the supine position in the ER-60 °, ER-240 °, ER:IR-60 ° and ER:IR-240 ° tests.

Peak Torque (Dominant Vs Non-dominant Shoulder): No significant differences were observed between dominant and non-dominant torque values or ratios for the freestyle or backstroke groups, irrespective of speed, position or movement. The control group produced significantly greater results for the dominant shoulder compared to the non-dominant shoulder in the ER-S-60 °, ER-S-240 °, ER:IR-S-60 °, ER:IR-S-240 °, ER:IR-P-60 ° and ER:IR-P-240 ° tests.

DISCUSSION: The influence of the repetitive stroking of swimming on the strength of the internal and external rotators in swimmers is determined by comparing results to that of the control group. The results of this investigation demonstrate that freestyle swimmers produced significantly greater peak torque values for internal rotation compared with the control group in both the prone and supine testing positions. However, there were no significant differences between these two groups in external rotation. These results are in agreement with other studies (Beasley, 1989; McMaster et al., 1992), suggesting that the external rotators of freestyle swimmers maintain normal strength levels while the internal rotators are over-developed due to the repetitive mechanics of swimming. No significant differences in any internal or external rotation tests were demonstrated between the backstroke swimmers and control group. However, the backstroke swimmers demonstrated a non-significant trend to produce greater peak torque values in the supine position compared to the control group. With respect to testing position, swimmers produced greater peak torques for both internal and external rotation when tested in a position that simulates their body position in the water. The freestyle swimmers produced greater peak torque values in the prone position when compared to supine testing. Specifically, freestyle swimmers produced significantly higher peak torque values for external rotation in the prone position, with a tendency for greater peak torque values for internal rotation. The backstroke swimmers also demonstrated a tendency for all peak torque values to be greater in the supine position.

Training-induced muscle imbalances have been previously reported, theorised to be the result of the physiological adaptation of muscle tissue to the specific training demands. The external:internal rotation ratio has been shown to be influenced by athletic background (Codine et al., 1997; Wilk et al., 1993). In this study, freestyle and backstroke swimmers had significantly lower shoulder external:internal rotation ratios compared to the control group in the prone position. Freestyle swimmers also demonstrated lower shoulder external:internal rotation ratios compared to the backstroke and control groups in the supine position. These findings, together with the differences between the groups in the prone internal rotation peak torque tests, suggest that the grouping of swimmers regardless of stroke (as other studies have done) may blur the specific nature of the adaptations. Further, testing protocol can play a major role in the ratios obtained, with ratio differences resulting between the prone and supine testing positions within all three groups.

The muscle balance results between dominant and non-dominant shoulders in both the freestyle and backstroke groups indicated no significant differences. This balance between shoulders was expected and is essential for a sport such as swimming that relies on an even distribution of strength between shoulders to maintain an efficient stroking pattern in the water. Therefore, comparisons between shoulders (assuming one is injury-free) may identify imbalances or injury causation, and assist with rehabilitation.

Peak torque studies of external and internal shoulder rotation mainly report the external:internal ratio (Beach et al. 1992; Codine et al. 1997; Falkel et al., 1987; McMaster et al., 1991; McMaster et al., 1992; Wilk et al., 1993). The prone position yielded greater ICC's at both 60 °/s and 240 °/s when compared to supine testing with respect to ratio data. However, for peak torque values, the supine data demonstrated greater ICC values for internal and external rotation at both speeds. The standard error of measurement (SEM) for the external:internal ratio for the prone tests was calculated to be 0.02 for both speeds, and 0.07 (60 °/sec) and 0.04 (240 °/sec) in the supine position.

CONCLUSION: It is recommended that the prone position should be used when testing freestyle swimmers for internal and external rotation strength of the rotator cuff, as it produces the highest peak torque values and it is a body position-specific test. Similarly, backstroke swimmers should be tested in the supine position for the same reasons. The lower muscle balance ratios for freestyle swimmers are due to the gain in internal rotation strength with unchanged external rotation strength, suggesting that the internal rotators are over-developed due to the repetitive mechanics of swimming. Further research into peak torque values of swimmers should not group all four competitive strokes together, as significant differences occur between freestyle and backstroke swimmers. It is suggested that the peak torque data from both the dominant and non-dominant arms is important in identifying muscle imbalances across the shoulders and possible predisposition to injury, and for assisting with rehabilitation and muscle balance maintenance. The ICC values suggest that measurement of the external:internal rotation ratio is more reliable in the prone position. However, ICC values were calculated on the control group only.

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