

MUSCLE PERFORMANCE OF THE SHOULDER ROTATORS IN UNIVERSITY TENNIS PLAYERS

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Muscle imbalance has been identified as one of the cause for shoulder injuries among tennis players. The aim of this study was to investigate the isokinetic work ratios of eccentric antagonist to concentric agonist shoulder rotators during the service action among University team tennis players, and compare them between dominant and non-dominant arms. Tennis players with no previous history of shoulder problems were recruited from the University team (N=20). Isokinetic testing of the shoulder rotators were performed using the Cybex Norm™ isokinetic system. Results revealed no significant differences in work ratios between the dominant and non-dominant side during the acceleration or deceleration phase of the tennis serve. It was concluded that among asymptomatic tennis players a good balance existed between the internal and external rotators which can be quantified using work ratios.

KEY WORDS: tennis, muscle imbalance, shoulder rotators, isokinetic testing, work ratios.

INTRODUCTION: The effect of muscle imbalance on performance and injury prevention in athletes is a contemporaneous area of research in sports biomechanics. In tennis, the high velocity and repetitive movements such as the service action place the shoulder under enormous stress (Chandler et al., 1992). Kibler et al (1988), reported that the shoulder was the joint most injured in tennis players, and these injuries were classified as overload injuries. It was concluded that a significant loss of glenohumeral internal rotation which progressed with age and years of tournament play, made the athlete susceptible to shoulder injury. Further research investigated the strength of the shoulder internal and external rotators in tennis players, because the loss of rotation was also associated with a possible muscle imbalance. Chandler et al (1992) studied college level tennis players for bilateral shoulder internal and external rotation strength and found that a higher peak torque was produced during internal rotation in the dominant arm compared to the non-dominant arm. However the external rotators that decelerate the arm during the deceleration phase of the tennis serve, did not show similar difference in peak torque. It was suggested that without subsequent strengthening of the external rotators, the athletes can be predisposed to shoulder injuries, and therefore it was proposed that external rotator strengthening exercises would perhaps help maintain an optimal external to internal rotation strength ratio which may prevent or lessen the severity of repetitive overload injuries. To investigate this proposal further, Treiber et al (1998) investigated the effects of strength training on the rotator cuff which play an important role in shoulder rotation and found that it increased both internal and external rotation torque and improved the functional performance which was measured as an increase in the velocity of the serve. In all these investigations only the concentric contraction of the external rotators were studied, however during the tennis serve especially the acceleration phase and deceleration phases the external rotators work eccentrically to balance the concentric contraction of the internal rotators.

A recent study tested the external rotators eccentrically (Ng and Lam 2002), however this study was carried out among badminton players, and hence its findings may not be applicable to a cohort of tennis players. The study investigated the work ratios of eccentric antagonist to concentric agonist shoulder rotators and compared these between dominant and non-dominant shoulders. The investigation revealed significant differences in work ratios between the dominant and non-dominant shoulder. The study concluded that rehabilitation following injuries should aim at developing an optimal antagonist/agonist work ratios. Although previous studies among tennis players have concluded that muscular imbalances predisposes them to shoulder injuries, there is a paucity of evidence on quantifying this possible imbalance using outcome measures such as work ratios among a

cohort of asymptomatic tennis players. This study directly addresses this lack of normative evidence. This study also incorporates the eccentric testing of antagonist muscles. Therefore the aim of the study was to investigate the isokinetic work ratios of eccentric antagonist to concentric agonist shoulder rotators during the service action among University team tennis players, and compare them between dominant and non-dominant arms. The null hypothesis tested was "There will be no difference in the isokinetic work ratios of eccentric antagonist to concentric agonist shoulder rotators, between the dominant and non-dominant arm". It is hoped that with the evidence on the work ratios of the internal and external rotators in tennis players, clinicians may be better placed to prevent shoulder injuries, and may inform both tennis players and clinicians of the optimal ratio which will aid in the rehabilitation of shoulder injuries.

METHOD:

Data Collection: Twenty subjects (11 male, 9 female) aged between 18 and 23 (Mean age of 20) were recruited from the University of Nottingham Tennis team. All subjects trained and competed for the University on a weekly basis during the academic year. Ethical approval was obtained from the Medical school Ethics committee, University of Nottingham. The following exclusion criteria were adhered to during the recruitment process

- Presence of shoulder pain
- Excessive shoulder laxity
- A past medical history of either shoulder surgery, or injury in the past year requiring rest and/or cessation of participation in tennis.

The work done during both concentric and eccentric contractions of the internal and external rotators of the shoulder were recorded using the Cybex Norm™ isokinetic system. The work done was expressed as a percentage of the body weight of the subject. The work ratios were then calculated using the following formulae:

Work ratio 1 = $\frac{\text{Work done as a \% of body weight during eccentric contraction of ext. rotators}}{\text{Work done as a \% of body weight during concentric contraction of int.rotators}}$

Work ratio 2 = $\frac{\text{Work done as a \% of body weight during eccentric contraction of int. rotators}}{\text{Work done as a \% of body weight during concentric contraction of ext.rotators}}$

The differences in work ratios between the dominant and non-dominant arms were analysed.

Subjects were randomly allocated to begin testing on either dominant or non dominant arm. The same investigator performed the measurements, data collection and data analysis.

Each subject performed five minutes of warm-up stretch and active exercise to the upper limb prior to testing. The warm-up exercises were exercises that would be performed before a tennis game and in order to standardise the duration and sequence of these exercises a complete written instructions with illustrations were provided to each subject.

After the warm-up, the subjects were positioned in accordance with the guidelines provided by the Cybex Norm™ isokinetic system. In brief, the subjects were positioned in supine, with their shoulder which was being tested in 90° abduction and elbow at 90° flexion. The trunk and pelvis were firmly secured by straps, as was the elbow. The wrist was held in neutral, so that the hand could comfortably grip the handle of the upper limb test adaptor. The axis of rotation of the shoulder was aligned with the axis of the isokinetic dynamometer. The subject operated a safety button with the other hand, to stop testing if any discomfort was experienced. It was ensured that subjects moved the arm of the dynamometer through their entire range of shoulder rotation without any discomfort, and range of motion (ROM) stops were set accordingly. The shoulder rotation ROM was recorded for all subjects. Both concentric and eccentric muscle activity for shoulder internal and external rotation were tested at a speed of 60deg/sec and 120deg/sec. Each subject was given five sub maximal practice trials to familiarise with the movements, which was followed by three trials of

maximum contractions. Following testing on one arm the same procedure was repeated for the contralateral arm. Throughout the testing subjects were given standardised verbal instructions based on a protocol sheet.

Data Analysis: Data obtained on work ratios were analysed using SPSS (version 14) statistical software. Descriptive analysis was carried out on the data which included measures of central tendencies, and the normality of the data was tested using the Shapiro-wilk test. If the data was normally distributed, it was analysed using parametric tests such as the paired t-test and if the data was not normally distributed the non parametric equivalent test which is the Wilcoxon signed ranked test was used. Inferential statistics were performed to analyse the differences in work ratios between the dominant and non-dominant arms. A significance level of $p \leq 0.05$ was set to reject the null-hypothesis.

Table 1: Mean and standard deviations of all work ratios recorded during the 3 trials performed by each subject for both dominant and non-dominant sides

Dominant	N	Mean \pm Std.dev	Non-Dominant	N	Mean \pm Std.dev
WR1 at 60 deg/s	20	0.90 \pm 0.41	WR1 at 60 deg/s	20	1.02 \pm 0.42
WR2 at 60 deg/s	20	2.10 \pm 0.53	WR2 at 60 deg/s	20	2.35 \pm 2.68
WR1 at 120 deg/s	20	1.04 \pm 0.60	WR1 at 120 deg/s	20	1.18 \pm 0.58
WR2 at 120 deg/s	20	2.24 \pm 1.13	WR2 at 120 deg/s	20	2.31 \pm 1.84

RESULTS: The results of the descriptive analysis of the work ratios of the dominant and non-dominant sides are presented in table 1

Following descriptive analysis the normality of each of the variables were tested using the Shapiro-wilk test and most of the variables were found to be not normally distributed. Hence the wilcoxon signed rank test was used. The results of these tests are presented in table 2.

Table 2: The results of the comparisons of work ratios between Non-dominant and dominant arm using the wilcoxon signed ranked test. The result highlighted in bold and * indicate statistically significant difference.

Comparisons Non-Dominant to Dominant		Z	Significance (P value)
Work Ratio 1	60 deg/s	-1.904	0.057
Work Ratio 2	60 deg/s	-1.979	0.048*
Work Ratio 1	120 deg/s	-1.157	0.247
Work Ratio 2	120 deg/s	-0.672	0.502

The analysis of difference between the work ratios of dominant and non-dominant arm reveal no statistically significant difference apart from the results of work ratio 2 performed at a speed of 60 deg/s which was statistically significant ($p=0.048$).

DISCUSSION: The work ratios tested in this study i.e. work ratio 1 and 2 corresponded to the acceleration phase and the cocking phase respectively. During the cocking phase when the shoulder is moved to the extreme of external rotation, results show that work ratio 2 (table1) was approximately 2:1 which indicates that the work done by the concentric contraction of external rotators was twice compared to the eccentric contraction of the

internal rotators. However the results of work ratio 1 are approximately 1:1 (Table 1), and work ratio 1 mainly corresponds to the acceleration phase of the tennis serve when the internal rotators concentrically contract and the antagonist external rotators eccentrically contract. Previous studies (Chandler et al 1992 and Treiber et al 1998) did conclude that a lack of optimal muscle balance between the internal and external rotators contribute to shoulder injuries. In this study the participants were asymptomatic and therefore based on the conclusion of the previous studies this may be due to an optimal balance of the muscles indicated by the work ratio1 being approximately 1:1 (dominant side) during the acceleration phase, which is the fastest phase of the serve. There were no significant differences in work ratio 1 between the dominant and non-dominant side (table 2), which is not similar to a previous study (Ng and Lam, 2002). Ng and Lam (2002) carried out their study among badminton players, and on a slightly older cohort (mean age 29 years), the investigators also tested the subjects on specific parts of the range of motion of shoulder rotation. The difference in methodologies highlighted above may have contributed to the difference in results. However the magnitudes of the work ratios were in a similar range as reported by Ng and Lam (2002).

This study has provided a method of quantifying the muscle imbalance among tennis players. It may be logical to conclude from this study that an optimal work ratio tends to be approximately 1:1 indicating a balance between the internal and external rotators. However this conclusion can be robustly defended only upon establishing that this work ratio does not exist among tennis players who have been diagnosed with shoulder injuries or symptomatic.

CONCLUSION: It can be concluded from this study that in subjects with asymptomatic shoulders the work ratios during the acceleration phase on the dominant side do not significantly differ from the non-dominant side and they tend to be well balanced. However if its established this balance is disturbed either at the beginning or after the diagnosis of shoulder injury the focus of rehabilitation can be directed towards to restoring this balance during the acceleration phase. Regular screening of player's work ratio can also possibly prevent further injuries.

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