Brief Communication

Profile of isokinetic rotator cuff muscle performance in adolescent state-level weightlifters

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Abstract

Objectives: This study aimed to determine isokinetic profiles of rotator cuff muscle strength and power in adolescent state-level weightlifters.

Methods: Nineteen young state-level weightlifters performed concentric strength tests of the upper limbs using an isokinetic dynamometer. Peak torque/body weight was measured for each weightlifter in dominant and non-dominant limbs.

Results: Peak torque/body weight was significantly different in external rotation ($p < 0.05$); however, there was no significant difference in internal rotation between the limbs. No significant difference was found in time to peak torque between the dominant and non-dominant limbs ($p > 0.05$). Time to peak torque in external rotation was less in the dominant than in the non-dominant limb. However, opposite results were obtained in external rotation, whereby time to peak torque was longer in the dominant limb compared to the non-dominant limb. Similarly, no significant difference was found between dominant and non-dominant limbs in terms of average power ($p > 0.05$).

Conclusions: The findings of this study may help in establishing potential imbalance in variables of muscular contractions between dominant and non-dominant limbs of weightlifters. This may help to maximise performance and minimise potential shoulder injury.

Keywords: Isokinetic; Power; Shoulder; Strength; Weightlifting

Introduction

Weightlifting is a sport that demands dynamic strength and power and involves multi-joint movement and whole body lifting. During snatch and clean and jerk, athletes need to generate an extremely high peak force and contractile rate of force development with consequent high power output and contractile impulse. Weightlifting requires a high level of both upper and lower body dynamic force with the vertebral musculature serving as stabilisers throughout the different phases of lift. In addition, equal strength in the arms is required to maintain heavy loads above the lifter’s head for a few seconds, with fully extended arms during the catch phase that put extra pressure on the shoulder muscles. As timing is crucial during the lift, muscular power is also important in weightlifting. Power can be defined as the ability to produce large output of force in a short period of time. Therefore, weightlifting requires great muscle strength and power to lift the maximum load in a short period of time.

The rotator cuff group consist of 4 muscles, namely the supraspinatus, infraspinatus, teres minor, and subscapularis. Their main function is to provide stability to the glenohumeral joint during arm elevation as well as other joint motions such...
as shoulder flexion and extension. The glenohumeral joint reportedly assists the catch and pull during snatch. Furthermore, synchronised activation of the rotator cuff muscles is essential during humeral elevation to prevent the humeral head from moving superiorly and causing shoulder impingement. This is an important aspect in competitive weightlifting, whereby the weight will be increased following successful attempts. Consequently, this will put more pressure on the shoulder joint. Therefore, strength of rotator cuff muscles is essential to stabilise and maintain the normal position of the shoulder joint during a lift.

Despite the popularity of the sport, previous studies have reported that more than 36% of weightlifting-related injuries involve the shoulder joint complex due to the extra pressure placed on the shoulder muscles, particularly during the first pull and catch phases. Moreover, most of the injuries among weightlifters occur at the shoulder area rather than at the knee and back. This is because the shoulder joint is highly mobile compared to other joints such as the knee and hip. The shoulder joint gains its stability through surrounding muscles that use balanced force to secure the position of the humeral head in the glenoid cavity. Nevertheless, flexing the shoulder into an extreme overhead position during lifting can greatly increase the risk of shoulder injuries. Due to the abovementioned factors, it is imperative to strengthen the rotator cuff muscles to minimise the risk of injury.

Despite the bilateral use of both dominant and non-dominant upper shoulders in competitive weightlifting, many studies have focused on overhead sports such as tennis, volleyball, and handball that involve the use of the shoulder joint complex due to the extra pressure placed on the shoulder muscles, particularly during the first pull and catch phases. Moreover, most of the injuries among weightlifters occur at the shoulder area rather than at the knee and back. This is because the shoulder joint is highly mobile compared to other joints such as the knee and hip. The shoulder joint gains its stability through surrounding muscles that use balanced force to secure the position of the humeral head in the glenoid cavity. Nevertheless, flexing the shoulder into an extreme overhead position during lifting can greatly increase the risk of shoulder injuries. Due to the abovementioned factors, it is imperative to strengthen the rotator cuff muscles to minimise the risk of injury.

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Materials and Methods

Subjects

Nineteen state-level weightlifters (16 males, 3 females) aged 14.74 ± 1.4 years (range, 13–17 years), with height of 1.58 ± 0.09 m (range, 1.42–1.72 m) and body weight of 62.82 ± 16.24 kg (range, 45.9–96.6 kg) voluntarily participated in our study. Subjects were recruited from a group of state-level adolescent weightlifters with at least 2 years of experience in competitive weightlifting. Those who had undergone rehabilitative programs for any shoulder injury in the prior 2 years were excluded from the study. The study was approved by the human research ethics committee of the local university. The study protocol was in compliance with the Declaration of Helsinki, 1975. All participants and their legal guardians were informed of the experimental procedures. Upon agreement, signed consent forms were obtained.

Testing procedure

Muscular strength was measured according to a standard protocol using an isokinetic dynamometer (Multi-Joint System 3 Pro; Biodex Medical Systems, Shirley, NY, USA). Strict adherence to the guidelines of the Biodex isokinetic dynamometer operation manual was followed for positioning of the subject, calibration, correction for gravity, familiarisation, and strong verbal encouragement. Subjects were familiarised with the use of the dynamometer and testing procedure prior to measurement. The testing session began with a 10-min warm-up and stretching emphasising the shoulder area.

The seated position with 45° shoulder abduction in the scapular plane was used to evaluate the concentric variables of peak torque/body weight, time to peak torque, and average power both in external and internal rotation. With the subject seated, the chair was rotated 15° towards the side opposite the tested shoulder. The dynamometer was rotated 20° backwards relative to the frontal position of the chair. The dominant side was determined by asking the subject. Next, the dynamometer was tilted 50° upward from 0° in neutral position. The shoulder and elbow were attached to the dynamometer and the shaft dot was aligned right or left, depending on the shoulder of interest, and secured with a locking knob. The subject was then moved into position. The dynamometer was raised to align with the axis of rotation of the glenohumeral joint. The chair and seatback were adjusted for comfort. The elbow was flexed at 90° and a cushion pad was used to support the elbow. The range of motion (ROM) was set to 40° internal and 50° external rotation, so that total ROM would be 90°. The ready position was 40° of internal shoulder joint rotation. The testing angular velocity was set at 120°/s and the shoulder was corrected for gravity before the test. The subjects were asked to perform 2 sets of 12 repetitions each, with verbal encouragement and a 60-s rest between sets. Visual feedback from the computer screen was not allowed. All movements were performed in concentric mode.

The present study used the seated position with 45° of shoulder abduction in the scapular plane to evaluate the concentric variables of peak torque/body weight, time to peak torque, and average power. It was shown that 45° of shoulder abduction in the scapular plane is the best position for testing, and reliability for measurement of internal and external rotation at optimum peak torque for the shoulder joint has been reported. In addition, this position offers optimal comfort and a stable physiological position for more consistent measurement of shoulder rotation by placing the muscle in a stable position.

Statistical analysis

The biomechanical data for peak torque/body weight, time to peak torque, and average power were analysed using IBM SPSS Statistics for Windows, (Version 22.0. IBM, Armonk, NY, USA). A paired sample t-test was used to compare the values of peak torque/body weight, time to peak torque, and average power between the dominant and non-dominant shoulder. The accepted level of significance was set at $p < 0.05$. All data were expressed as mean ± standard deviation (SD).

Results

Tables 1 and 2 summarise the descriptive data and results from the paired t-test for the shoulders in internal or external
The peak torque/body weight of the dominant shoulder was significantly greater than in the non-dominant shoulder. On both sides, the peak torque/body weight of internal rotation was significantly greater than that of external rotation. There was no significant difference in time to peak torque between dominant and non-dominant internal and external rotation. There was no significant difference in average power between dominant and non-dominant internal and external rotation. However, both shoulders showed greater power in internal rotation compared with external rotation.

**Discussion**

The purpose of this study was to evaluate the isokinetic profile of muscle performance in adolescent state-level weightlifters to determine values that could be used to improve performance as well as reduce the risk of injury. There have been few studies regarding isokinetic rotator cuff strength and power (peak torque/body weight, time to peak torque, and average power) among advanced level weightlifters.

Shoulder muscular strength is important for various degrees of joint movement and stability. Our study found a significant difference in peak torque/body weight between the dominant and non-dominant shoulder with internal rotation at 120°/s. Our findings can be compared to those of Cahalan and colleagues, in which the dominant side peak torque in concentric internal rotation was significantly greater than in the non-dominant shoulder at 180°/s and 300°/s. However, the data obtained were from sedentary participants instead of athletes. Similarly, Perrin et al. found greater peak torque values for the right shoulder compared to the left shoulder among right-hand-dominant pitchers, swimmers, and non-athletes. The contradictory result among the non-athletes might be due to differences in lifestyles and daily activities. In contrast to internal rotation, no significant difference was obtained for external rotation. Similar results were found among elite volleyball players at concentric speeds of 60°/s, 180°/s, and 300°/s.

Weightlifters must possess equal strength and muscle balance in both arms as this directly influences performance. For example, at the end of explosive snatch or jerk movement, balanced shoulder muscular strength is needed to maintain the overhead lift for a certain period of time. Furthermore, the difference of muscle strength between dominant and non-dominant limbs in general should be within the range of 10%–20%. In the present study, the difference in the peak torque/body weight was within the range for internal rotation. However, in external rotation, the calculated difference was less than 10%. We speculated that this difference was due to weightlifting exercise such as a high pull and power snatch that uses both upper limbs simultaneously. Our study also involved a smaller number of participants compared to previous studies.

**Conclusion**

Peak torque/body weight was significantly different between limbs in external rotation (p < 0.05), but not in internal rotation. No significant difference was found in time to peak torque between the dominant and non-dominant limb (p > 0.05). Similarly, no significant difference was found between dominant and non-dominant limbs in terms of average power (p > 0.05).

**Recommendation**

The findings of this study can be used by coaches and athletes in developing strength in the external and internal rotators of the shoulder joint. Although our results are specific to adolescent weightlifters, the findings may also apply to athletes in other sports that emphasise the use of both upper limbs (e.g., hammer throw, swimming).

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**Conflict of interest**

The authors have no conflict of interest to declare.

**Ethics approval**

The study was approved by the human research ethics committee of Universiti Sains Malaysia (USM/JEPeM/14110457).
Authors’ contributions

SS wrote the original protocol, secured funding, and wrote the final manuscript. MFAR was responsible for recruitment and treatment during the trial, data handling during the trial, data analysis and interpretation of results. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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