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# Determination of upper extremity muscle strength profile of Turkish weightlifting national team athletes

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*SUMMARY*

*This study aimed to determine the upper extremity isokinetic muscle strength profile of Turkey male weightlifters and shed light on the exercise and training program by sharing these results with the athletes and all team working presently in the weightlifting sports area.*

*This study included 21 weightlifters, who did not have any orthopedic problems, did professional weightlifting for at least 2 years, were cooperative, had a cognitive state required for the assessment, and volunteered to participate in the study. The tests were performed using an isokinetic dynamometer system at angular velocities of 60°/s and 240°/s during concentric contractions. The protocol was applied separately to the right and left extremities for the shoulder internal rotation/external rotation and elbow flexion/extension movements.*

*The peak torque of internal rotation in the shoulder joint was found to be higher than that of external rotation, and the extension peak torque in the elbow joint was higher than the peak torque of flexion. External/internal rotation rate in the shoulder joint at 240 °/s velocity was lower compared with the rate at 60°/s velocity and also at the rates accepted to be normal for both angular velocities. The elbow flexion/extension rate on the dominant and nondominant sides ranged outside of the rates accepted as normal for both angular velocities.*

*The present findings can guide the weightlifting athletes to reduce the sports injuries that may occur in shoulder and elbow joints and increase their sports performance.*

*Key words: Isokinetic, muscle strength, upper extremity, weightlifting*

## INTRODUCTION

Performance sports compel the limits of the human body. Increasing the muscle strength for performance improvement and combination of this strength with techniques are the main factors for compelling the limits in the weightlifting field where the technique, explosive power, and flexibility are at the highest level (1,2). The complex structure of weightlifting necessitates examination of muscle strength and the effects of this strength on the body (3). Dynamic stability of the muscles surrounding the upper extremity and shoulder belt is needed for performing a movement successfully in weightlifting (3). A strength imbalance between the muscles that participate in the movement leads to failure in performing the movement successfully and presents a risk factor for upper extremity injuries in athletes. The literature reports that 68.9% sprain and tendinitis are seen in weightlifters. The regions of injuries in professional weightlifters are the lumbar region (23.1%), knees (19.1%), shoulders (17.7%), hands (10%), and elbow (2.5%) (4,5). It is known that the agonist/antagonist muscle strength imbalance is among the risk factors in sports injuries (6). Therefore, objective assessment of muscle strength in all athletes is crucial to the sportive success of athletes and prevention of injuries. Despite several studies in the literature exploring the upper extremity isokinetic strength profile in various sports fields such as swimming, handball, volleyball, tennis, water polo, cricket, judo, and basketball (7-22), no study has examined the upper extremity isokinetic muscle strength characteristic in weightlifters.

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The present study was performed to (1) determine the upper extremity isokinetic muscle strength profile of weightlifters and (2) shed light on the exercise and training program by sharing these results with the athletes and team working with them.

## MATERIALS AND METHODS

This study was conducted to determine the characteristics of upper extremity isokinetic muscle strength in weightlifters. It included 21 national Turkish weightlifters, who did not have any orthopedic problems, did professional weightlifting for at least 2 years, were cooperative, had a cognitive state required for the assessment, and volunteered to participate in the study. The descriptive characteristics, including age, height, weight, and the dominant-side data of the athletes, were recorded. All the athletes and trainers who agreed to participate in the study were informed about the study purpose, the assessments contained in the study, and the benefits of the study before starting the study. The study had voluntary participation, and was approved by the ethics committee [13/06 (349)].

Isokinetic muscle strength was assessed using the ISOMED 2000® (Ferstl, Germany) device. The athletes did jogging for 10 min to warm up before starting the tests. Following the warmup, the athletes were taken separately to the isokinetic device to perform the measurements, and the device was adjusted according to their personal anthropometric structures. The weight values were entered into the computer during the test, and the program was set. Whether the movement width of the joint to be tested was appropriate according to the angles to be tested was determined by having the athletes make a sample move at an extremely low speed. At the same time, the gravity effect was set to zero. The joint angles were adjusted in the assessment by considering the joint movement intervals of the persons and the measurement characteristics of the device. The test angles for the shoulder internal rotation (IR)/external rotation (ER) movement were as follows: An assessment was made in the scapular neutral position between 0° ER and 90° IR (the definitions and the protocol used in ISOMED 2000 device) angles for the shoulder flexion/extension movement in the sitting position between 125° flexion and 10° extension angles.

All the isokinetic strength measurements were carried out in the sitting position. The shoulder joint IR and ER movements were measured as the arms of the athletes were at 45° abduction in the scapular plane and the shoulders were at 90° flexion. This position was selected because the stress on the rotator cuff was minimal in this position compared with the position where the arms were at 90° abduction in the frontal plane (12,22). On the contrary, previous studies reported that this position was the most reliable position for assessing the shoulder IR and ER strength (14). The elbow joint flexion and extension movements were measured as the volar side of the hand faced the person. This position was selected because it was the position for carrying weights by athletes.

The assessment protocol: The athletes made the IR/ER movement submaximally at 90°/s velocity five times, warmed up, and comprehended the movement. Following the warmup movement and a 30-s rest, they made the maximal IR/ER five times at 60°/s velocity. Again after a 30-s rest, they made the maximal IR/ER movement 15 times at 240°/s velocity, and the test was completed. The assessments were carried out bilaterally for each joint. First, the dominant side was assessed, and 3 min later, the nondominant side was assessed. The same protocol was applied for the elbow joint the next day. All measurements were performed by an examiner with 3 years of experience during a single test session. The muscle strength was evaluated in terms of peak torque (PT) and average power, calculated from five repeated measurements at an angular speed of 60º/s and 15 repeated measurements at an angular speed of 240º/s. The PT was normalized by body weight (PT/W, percent of torque produced per kg of BW) to allow comparisons in terms of maximum muscle strength in the shoulder and elbow joints.

The data collected on the isokinetic muscle strength of the athletes were analyzed using Statistical Package for Social Sciences Inc. (IL, USA) for Windows Release 22.0 statistical package program. The descriptive statistics of the variables were determined. The results were expressed as median and standard deviation. Whether the data fitted the normal distribution was examined using the Shapiro–Wilk test, which was defined according to the sample number. Then, the Wilcoxon test was performed for comparing the groups, followed by data analysis.

## RESULTS

The demographic characteristics of the athletes are shown in Table 1.

The PT, PT/W, and the degree and number of repetitions of the PT are shown in Table 2. The shoulder joint IR PT value was found to be higher than that of ER. The PT value for the shoulder ER and IR at 60°/s velocity and for the elbow flexion

Table 1: Basic characteristics of the study participants.

| | X ± SD |
|---|---|
| Age (year) | 16.19 ± 1.43 |
| Height (m) | 1.67 ± 0.06 |
| Weight (kg) | 65.63 ± 11.24 |
| BMI (kg/m²) | 22.76 ± 3.34 |
| Sports age (year) | 4.3 ± 0.8 |

and extension movement occurred at the second to third repeat on average, at 240°/s velocity for the shoulder ER and IR at the fifth to seventh repeat, and at the fifth to sixth repeat for the elbow flexion and extension. The angle where the PT occurred in the shoulder joint at 60°/s velocity was approximately 45°–46° and 66°–69° for the IR and ER, respectively, similar to those on the dominant and nondominant sides (32°–33° and 54°–46°, respectively, at 240°/s velocity). The angle where the PT occurred for the elbow at 60°/s velocity was approximately 77°–78° of flexion and 77–81° of extension for the flexion and extension, respectively, similar to those on the dominant and nondominant sides. At 240°/s velocity, it was 46–48° of flexion and 91–92°of extension, respectively, for the flexion and extension movements.

The ratio of the shoulder ER/IR and elbow flexion/extension and comparison of dominant and nondominant sides are shown in Table 3. ER/IR was approximately 47%–67% for the dominant side at 60°/s in weightlifters, approximately 59%–77% for the nonant side, approximately 37%–57% for the dominant side at 240°/s velocity, and approximately 33%–53% for the nondominant side. In the present study, the elbow extension PT value was found to be higher than the elbow flexion PT value. The elbow flexion/extension percentage on the dominant and nondominant sides was determined as 88% and 83% at 60°/s velocity and as 77% and 72% at 240°/s velocity, respectively. The difference between the right and left sides was found to be more than 10% at the shoulder IR and elbow flexion at 60°/s velocity and the shoulder ER and elbow flexion at 240°/s velocity.

## DISCUSSION

The present study was performed to determine the upper extremity isokinetic muscle strength profile of weightlifters. The PT, PT/W,

Table 2: Peak torque, peak torque/weight, and the degree and number of repetitions of peak torque.

| Shoulder | Internal rotation | | | External rotation | | |
|---|---|---|---|---|---|---|
| Test speed | D side | N-D side | P* | D side | N-D side | P* |
| 60°/s PT (N/m) | 54.96 ± 13.88 | 49.84 ± 11.57 | 0.058 | 30.93 ± 6.47 | 28.38 ± 6.26 | 0.014* |
| 60°/s PT/W (N/kg) | 0.79 ± 0.27 | 0.76 ± 0.21 | 0.203 | 0.51 ± 0.25 | 0.46 ± 0.26 | 0.002* |
| Degree (˚) | 46.04 ± 12.63 | 45.28 ± 17.77 | 0.434 | 66.33 ± 11.99 | 69.09 ± 7.32 | 0.390 |
| Repetitions (piece) | 2.80 ± 1.28 | 3.00 ± 1.44 | 0.641 | 2.95 ± 1.46 | 2.61 ± 1.32 | 0.375 |
| 240°/s PT(N/m) | 50.45 ± 11.62 | 48.77 ± 12.23 | 0.251 | 23.89 ± 8.81 | 21.09 ± 6.40 | 0.013* |
| 240°/s PT/W (N/kg) | 0.74 ± 0.21 | 0.73 ± 0.21 | 0.543 | 0.36 ± 0.12 | 0.31 ± 0.09 | 0.003* |
| Degree (˚) | 32.42 ±8.77 | 32.95 ± 6.52 | 0.163 | 54.14 ± 12.94 | 46.85 ± 14.13 | 0.004* |
| Repetitions (piece) | 7.23 ± 4.04 | 7.71 ± 4.16 | 0.728 | 5.28 ± 4.67 | 4.90 ± 4.19 | 0.467 |
| Elbow | Flexion | P* | Extension | P* | | |
| 60°/s PT (N/m) | 45.40 ± 12.14 | 40.90 ± 8.43 | 0.005* | 49.66 ± 8.31 | 50.10 ± 11.87 | 0.629 |
| 60°/s PT\W (N/kg) | 0.67 ± 0.21 | 0.61 ± 0.16 | 0.009* | 0.78 ± 0.25 | 0.75 ± 0.25 | 0.112 |
| Degree (˚) | 77.80 ± 18.26 | 78.38 ± 22.28 | 0.673 | 77.23 ± 10.47 | 81.38 ± 14.81 | 0.271 |
| Repetitions (piece) | 3.33 ± 2.79 | 2.71 ± 2.30 | 0.619 | 3.19 ± 2.29 | 2.95 ± 1.43 | 0.840 |
| 240°/s PT (N/m) | 33.50 ± 9.78 | 29.76 ± 8.16 | 0.033* | 43.54 ± 8.98 | 41.07 ± 7.76 | 0.086 |
| 240 °/s PT/W (N/kg) | 0.51 ± 0.17 | 0.65 ± 0.18 | 0.012* | 0.45 ± 0.15 | 0.60 ± 0.15 | 0.011* |
| Degree (˚) | 46.52 ± 11.36 | 91.61 ± 11.64 | 0.340 | 48.19 ± 11.35 | 92.52 ± 9.95 | 0.924 |
| Repetitions (piece) | 6.14 ± 4.04 | 5.66 ± 3.43 | 0.601 | 6.80 ± 4.28 | 5.38 ± 5.03 | 0.844 |

*P < 0.05: Wilcoxon signed-rank test s: Second D: dominant N-D: nondominant, PT: peak torque, PT/W: peak torque/ weight

Table 3: Ratio of the shoulder external/internal rotation and elbow flexion/extension and comparison of the dominant and nondominant sides.

| Joint | Test speed | ER/IR% | | P* | D/N-D side% | |
|---|---|---|---|---|---|---|
| | | D side | N-D side | | IR | ER |
| Shoulder joint | 60°/s | 57.80 ± 10.75 | 59.21 ± 18.29 | 0.664 | 113.3 ± 31.2 | 109.3 ±19.4 |
| | 240°/s | 47.10 ± 9.41 | 43.82 ± 9.06 | 0.099 | 106.18 ± 16.2 | 113.36 ±19.9 |
| | | Flex/ext% | | | D/N-D side % | |
| | | D side | N-D side | P* | Flex | Ext |
| Elbow joint | 60°/s | 88.49 ± 18.17 | 83.23 ± 16.30 | 0.106 | 111.66 ± 21.6 | 105.72 ±19.4 |
| | 240°/s | 76.9 ± 16.26 | 72.53 ± 15 | 0.217 | 115.63 ± 25 | 108.45 ±19.87 |

*P < 0.05: Wilcoxon signed-rank test, s: Second(s), ER: external rotation, IR: internal rotation, D: dominant, N-D: nonominant, Flex: flexion, Ext: extension

dominant/nondominant percentage of the athletes at 60°/s and 240°/s velocities, percentage of the shoulder IR/ER, and shoulder flexion/extension percentage were assessed, and the upper extremity isokinetic muscle strength profile of the weightlifters was determined.

The shoulder joint IR PT value was found to be higher than the ER PT value in the present study. Considering the studies conducted on the shoulder IR and ER in athletes in the literature, IR PT value was shown to be higher than ER PT value (7-11, 23). This outcome was in accordance with the literature and expected in the present study because, considering the muscles surrounding the shoulder, the number of muscles responsible for IR in the shoulder joint was higher than the number of muscles responsible for ER and they were larger in size and stronger (24). Another result of the present study was the repeat number where the PT occurred: athletes achieving the PT value at the 1st repeat and athletes achieving the PT value at the 15th repeat. The results showed that the number of repeats must be increased with the increase in the assessment velocity to reach the PT. Owing to the lack of studies and limited information, it is believed that more extensive large-sample studies need to be conducted on this subject.

No study in the literature was conducted on the angle values where the shoulder ER and IR and elbow flexion and extension PT occurred. This novel study investigated the shoulder ER and IR and elbow flexion and extension PT angle values in weightlifters. It is believed that the integration of the angles where the PT occurred and the movement analysis data of weightlifting sports, and the development of appropriate exercise and training programs, can improve the sportive performances of weightlifters. Furthermore, it is thought that knowing the angles where the PT occurred may guide the establishment of a rehabilitation program in case of a possible injury to the athlete.

In the present study, shoulder ER/IR rotation rate, elbow flexion/extension rate, and dominant/nondominant rate were estimated as a percentage. These data were crucial because the presence of a balance between the agonist/antagonist muscle strength and the destruction of the balance could make the person prone to injuries (25) Studies by Ivey et al and Ng and Kraemer on normal healthy individuals and recreational athletes demonstrated the ER/IR ratio to be 66%–75% (26,27). Alderink and Kuck found this ratio for the shoulder ER/IR to be 66%–75% (28). Batalha et al assessed the concentric shoulder ER and IR PT of 60 young swimmers at 60°/s and 180°/s angular velocities in their study and determined that ER/IR ratio ranged between 70% and 77% (9). Saccol et al measured the shoulder ER and IR PT at 60°/s and 180°/s angular velocities in elite child tennis players and found that this ratio changed between 68% and 96% (23). Considering other studies reported in the literature, the ER/IR ratio was reported as 65%–74% in cricket players (11), 72%–74% in male handball players (15), 78%–85% in professional swimmers (10), 66%–70% in adolescent handball players (16), 72%–78% in women volleyball players (8) 61%–64% in normal healthy male individuals, and 67%–69% in healthy women individuals (7). The present study found that the ER/IR was approximately 47%–67% for the dominant side at 60°/s in weightlifters, approximately 59%–77% for the nondominant side, approximately 37%–57% for the dominant side at 240°/s velocity, and approximately 33%–53% for the nondominant side. The studies in the literature showed that this ratio varied according to the sports fields because each sports field involved specific movements and, therefore, muscle groups developed adaptations unique to the sports. Therefore, the ratio of the agonist/antagonist muscles varied according to healthy individuals because certain muscle groups in different sports fields contracted stronger and faster. It is believed that a lower ER/IR ratio at 240°/s in the present study depends on the IR muscles to contain fast-contracting white muscle fibers. The function of fast-contracting muscle fibers is to lift the bar above the head in the movements made during weightlifting. It is necessary to sustain the static stabilization position of the upper extremity muscles and the muscles surrounding the shoulder for keeping the bar above the head. Therefore, the assessment of both strength and velocity parameters at 60 and 240º/s during the isokinetic assessment may be a valuable guidance. It was seen that the assessments were made at 60 and 180º/s generally. No assessments found that were carried out at 240º/s on weightlifters. Performing assessments at 240º/s is crucial for athletes. The present study found that the ER/IR ratio at 60º/s, which was in accordance with the literature, was lower at 240º/s velocity. A decrease in this ratio was an expected outcome in the assessments carried out at 240º/s velocity because the white muscle fibers were more active. The angular velocities where this ratio existed were as important as the ER/IR ratio during the assessment of the study results. Therefore, it must be considered that the agonist/antagonist ratio can change depending on the fiber types contained by the muscles when the angular velocities change (29). No comparison was made for the findings obtained at 240º/s in the present study because no study available in the literature was conducted on weightlifters. Therefore, this subject needs further investigation.

Keeping in view the studies conducted in the literature, the elbow extension PT values were reported to be higher than the flexion PT values (17, 18). In the present study, the elbow extension PT value was found to be higher than the elbow flexion PT value, consistent with the previous findings. However, considering previous studies conducted on the elbow flexion and extension ratio, it was suggested that the flexion/extension ratio must be between 90% and 100% at low isokinetic velocities (30°s and 60°/s) (30,31). Knapik and Ramos performed a study on 352 male soldiers. Concentric elbow flexion and extension PT was measured at 30, 90, and 180°/s velocities only on the dominant side, and the flexion/extension ratio was determined as 114% and 109% at 30º/s and 90º/s velocity (27). In addition to these studies, Ellenbecker and Mattalino conducted a study on professional baseball players and found the flexion/extension PT ratio to be 103% and 101% on the dominant and nondominant sides, respectively (32). The elbow flexion/extension PT ratio on the dominant and nondominant sides at 90°/s in elite male child tennis players was found to be 97% and 108%, respectively (33). In the present study, the elbow flexion/extension percentage on the dominant and nondominant sides was evaluated as 88% and 83% at 60°/s velocity and between 77% and 72% at 240°/s velocity, respectively. The agonist/antagonist muscle strength balance within the elbow joint (in contrast to the shoulder joint) is crucial for preventing sports injuries. It is suggested in the literature that this ratio is close to 1:1. This balance may be disrupted in weightlifting as in many other sports fields due to the nature of the sports. This in turn generates risks for sports injuries. In the present study, this ratio dropped to 72%, in contrast to the studies conducted on other athletes in the literature. This outcome is an indication that extension muscles are stronger than flexor muscles. Considering the injury ratio of the elbow joint shown as 2.5% in the literature, it is believed that the present study might guide weightlifters and professionals working in this field.

Kannus conducted a study on isokinetic assessments and reported that higher than 10% difference between the right and left extremities was abnormal (34). The present study found that the difference between the right and left sides was more than 10% at the shoulder IR and elbow flexion at 60°/s velocity and the shoulder ER and elbow flexion at 240°/s velocity. It must be remembered that an imbalance of the muscle strength between the right and left sides can form a basis for scoliosis because the waist and spine injuries and scoliosis are frequently encountered problems due to the nature of weightlifting sports. Therefore, it is thought that symmetrical exercises in the training of weightlifters can diminish the aforementioned possibilities and improve the sportive performance.

The limitation of the present study was that the PT values were not compared based on age and gender because the athletes were few and all were males.

## CONCLUSIONS

Muscle strength is a significant parameter in sportive performance. Isokinetic assessment is an objective method used to measure muscle strength. The present study determined the typical characteristics of upper extremity muscle strength in weightlifters using an isokinetic dynamometer. The results revealed the muscular strength characteristics of Turkish professional weightlifting athletes. It is believed that the development of the upper extremity training program in the light of these results can improve the sportive performance and diminish sports injuries.

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