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Shoulder Invertors and Evertors Torque Production of Handball Players

by

Inese Pontaga[1], Janis Zidens[2]

The shoulder joint is prone to dislocation due to poor fit, great range of movement (ROM) and weak supporting muscles. The most important muscle group providing joint stability is the rotator cuff group. The aim of our investigation was to determine the shoulder rotator cuff muscle strength and balance specific to handball players. The shoulder joint motions in the internal – external rotation were investigated using dynamometer system "REV – 9000" Technogym. Eleven male handball players with injury – free shoulder joints participated in the investigation. Their mean age was 22 ± 2 years, height 190 ± 5 cm and weight 91 ± 11 kg. The shoulder internal - external rotation isokinetic movements were tested in the plane of scapula at slow (60º/s) and fast (180º/s and 240º/s) angular velocities. The shoulder evertor/invertor torque ratio values were calculated in the ROM with the step 10º. The difference between peak torque values produced by dominant and non-dominant shoulders invertors and evertors is none significant, respectively, at low and high angular velocity of movements. A significant difference was revealed between the dominant and non-dominant shoulder invertors average power at high angular velocity (240º/s). At lower velocities (60º/s and 180º/s) the power asymmetry between both arms is not observed. The shoulder external/ internal rotator torques ratio for handball players in the middle part of the ROM is close to 80% at all tested angular velocity values.
Keywords: *shoulder joint, muscles balance, dynamometry and handball.*

[1] Latvian Olympic Team, Annas Sakses Str.19, Riga, LV 1014, Latvia;
[2] Latvian Academy of Sports Education, Department of Sport Games, Brivibas Str.333, Riga, LV 1006, Latvia. e-mail: inesep65@hotmail.com

Introduction

Normal joint functions depend on good balance between the agonist–antagonist muscle groups. The shoulder (glenohumeral) joint is the most mobile joint in the human body with the greatest range of motion. Therefore the shoulder joint is prone to dislocation due to relatively poor bony fit and limited supporting musculature. The most important muscle group, providing joint stability is a rotator cuff group (Speer 1995). Fatigue in any of these muscles (for example, from repeated throwing) causes disbalance and increased risk of shoulder joint injuries.

Altered normal agonist–antagonist muscle group torque ratio is often observed for sportsmen with extensive repeated overhead movements (baseball, water polo, swimming, etc., Whiting and Zernicke (1998).

Fleisig et al. (1995) investigated pitching mechanics of baseball players using three dimensional cameras to detect the movements of body parts from reflective markers on the extremities and device with radar gun for ball speed detection. From their data: the instant of maximum internal rotation torque during arm cocking and the instant of maximum compressive force during arm deceleration were found as two critical points for shoulder kinetics. The most overuse injuries occur at these two instants or in the short time period between them. These results confirm the important role of the rotator cuff muscles.

Shoulder rotator cuff balance is characterized by shoulder external–internal rotator muscle group torques ratio. The external–internal rotator torques ratio for non-athletes and sportsmen of different disciplines is investigated by many authors, for example Codine et al (1997); Bartlett et al (1989); McMaster et al (1991). These investigations show that the sports discipline influences the rotator cuff balance (Codine et al, 1997). McMaster et al (1991) determined that the external to internal rotator ratios of water polo players were significantly lower for both arms at slow angular velocity of movements (30°/s) in comparison with nonathletes, but none significantly lower at the fast velocity of movements (180°/s): the internal rotators demonstrate an increased comparative strength. The increased shoulder internal rotators torque production is observed for baseball players (Codine et al, 1997; Bartlett et al, 1989), tennis players (Codine et al, 1997) etc.

The aim of our investigation was to determine the shoulder rotator cuff muscle strength and balance specific to handball players in relation to velocity of movements.

Material and Methods

The shoulder joint motions during internal–external rotation were investigated using a dynamometer system “REV – 9000” Technogym. Eleven male handball players from the team of Latvian Academy of Sports Education participated in the investigation. Their mean age was 22 ± 2 years, height 190 ± 5 cm and weight 91 ± 11 kg. All shoulder joints were injury – free, without signs of instability and painless during the movements.

To measure the internal and external rotator variables, the athleteswere seated on the “REV – 9000” bench with the elbow resting on the input shaft. The dynamometer level arm was adjusted to the length of the forearm of the athlete. The elbow was flexed to 90°. The humerus was abducted at a right angle (90°) to the trunk. The internal and external rotation movements were performed the scapular plane. Greenfield et al (1990) determined that the shoulder external rotational strength values in the scapula plane were significantly higher than in the frontal plane and therefore testing may be preferable in the scapula plane. The range of movements was from 20° of the shoulder external rotation to 100° of the internal rotation (Figure 1). To exclude trunk movements, the chest and pelvis were stabilized using straps. The athletes feet were placed on the support.

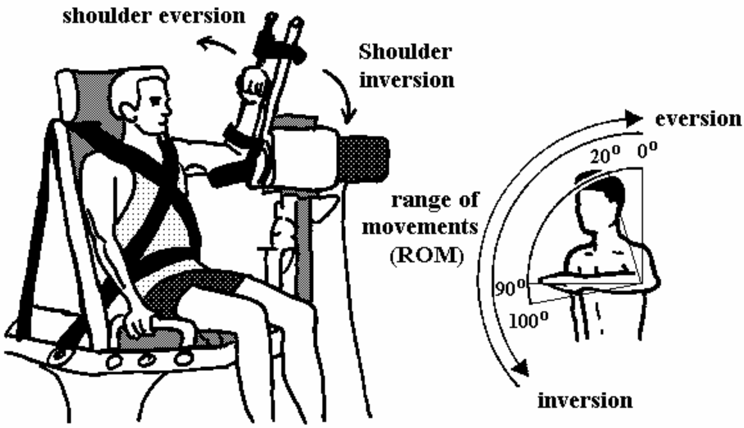

Figure 1 The position and range of motion used for testing shoulder internal and external rotation strength

The shoulder internal and external rotation isokinetic movements were tested at slow angular velocity of movements (60°/s – degrees per second) and fast movements (180°/s and 240°/s).

The measurements were corrected for effects of gravity. Before testing and between the different angular velocity values, passive inversion–eversion motions were performed during 90 seconds, while angular velocity of the passive motions was medium (120º/s).

Internal – external rotation movements were repeated 5 times at the velocity of 60º/s and 180º/s, respectively, and 20 times at the velocity 240º/s. Peak torque value and time to reach peak torque were obtained from the best repetition. The average work and power were detected from all movements at each angular velocity.

The internal – external rotator muscle groups were compared for dominant and non-dominant arm of handball players at three angular velocities.

Then the shoulder evertor/invertor torque ratio values were calculated at the range of motion (ROM) with the step 10º: at the angular positions of ROM 30º, 40º, 50º, 60º, 70º, 80º and 90º.

Results

The handball players shoulder invertors of the dominant arm produced not significantly higher peak torque values at slow and fast velocity of movements (p>0,05), Table 1. The time to reach peak torque did not differed significantly for both arms (p>0,05). The average work for all values of the velocity of movement was greater for the dominant arm, but the difference between the dominant and non-dominant arm was not significant (p>0,05).

Table 1. Variables of shoulder invertor muscle group of handball players

Angular velocity of movements [°/s]	Peak torque [Nm]	Time to reach peak torque [s]	Average work [J]	Average power [W]
60º/s D	80 ± 12	0,74 ± 0,23	101 ± 42	53 ± 15
N	73 ± 15	0,80 ± 0,27	87 ± 17	51 ± 11
180º/s D	69 ± 11	0,31 ± 0,09	81 ± 19	111 ± 25
N	59 ± 14	0,29 ± 0,06	75 ± 16	102 ± 26
240º/s D	63 ± 10	0,27 ± 0,06	73 ± 15	133 ± 23
N	53 ± 8	0,31 ± 0,07	64 ± 14	107± 23*

D – dominant arm, N – non-dominant arm

** - The difference between the dominant and non-dominant arm is significant (p<0,02).*

The average power at slow velocity of movement (60º/s) was the same for the dominant and non-dominant arm: 53 W ± 15 W vs. 51 W ± 11 W. During the fast movement the shoulder invertors produced greater power, and the difference between both arms was not significant at angular velocity of movement 180º/s, but at velocity 240º/s the dominant arm invertors produced significantly higher values of power (133±23 W) than the non-dominant arms produced (107±23 W) ($p<0,02$).

Table 2. Shoulder external rotator variables of handball players

Angular velocity of movements [°/s]	Peak torque [Nm]	Time to reach peak torque [s]	Average work [J]	Average power [W]
60º/s D	65 ± 12	1,15 ± 0,25	79 ± 12	44 ± 9
N	63 ± 12	0,94 ± 0,41	74 ± 18	42 ± 9
180º/s D	55 ± 8	0,34 ± 0,09	71 ± 14	97 ± 15
N	48 ± 10	0,34 ± 0,06	60 ± 16	80 ± 20
240º/s D	49 ± 10	0,33 ± 0,06	59 ± 11	98 ± 18
N	41 ± 8	0,32 ± 0,06	49 ± 14	82 ± 20

The shoulder external rotators produced torque values, that did not differ significantly from the dominant and non-dominant arms ($p>0,05$), but the peak torque values difference had a tendency to increase with the growth of angular velocity of movements (tab. 2). The time to reach peak torque is the same for both arms at slow and fast velocity of movements. The average work and average power produced by the evertors was not significantly higher in the dominant arm at fast angular velocities of movement (180º/s and 240º/s).

Table 3. Shoulder evertor/invertor torque values ratio (%) at different angular positions of ROM

Angular velocity of movements [°/s]	30º	40º	50º	60º	70º	80º	90º
60º/s D	92 ± 35	84±17	80±13	79±11	77±10	76±19	81±31
N	94 ± 21	84±12	81±11	81±13	79±17	78±16	69±27
180º/s D	108±26	90±18	80±13	81±13	80±17	76±33	68±43
N	89 ± 25	79±18	76±10	80±10	77±15	67±20	72±56
240º/s D	80 ± 50	108±46	83±18	76±15	71±13	72±20	67±36
N	120±29	112±19	80±26	82±21	68±15	65±26	59±39

The shoulder evertor/invertor torque ratio values were estimated in the range of motion (ROM) with the step 10º: at angular positions of the ROM 30º, 40º, 50º, 60º, 70º, 80º and 90º. The values of this ratio at 60º/s, 180º/s and 240º/s angular velocity are shown in table 3. The values of this ratio varied from 90 – 100 %. At extension it equaled (ROM 30º - 40º) 70 – 80 %, while during inversion (ROM 80º - 90º). In the middle part of the ROM: from 50º to 70º the evertor/invertor torque ratio value was close to 80 % and did not depended on the angular velocity of movements.

The evertor/invertor torque ratio values did not differ significantly for the dominant and non-dominant arms ($p>0,05$), and the difference between both arms were negligible.

Discussion

This investigation shows that the difference torque and power values between muscle groups of the dominant and non-dominant arms is velocity specific. Greater difference between the torque and power values of both arms is found at higher angular velocity of movements, but this difference is not significant. A significant difference in produced power is revealed only between shoulder invertors at fast movements 240º/s. These results seem to be objective and can be explained by the fact that fast movements are more specific to handball. Werner et al. (2001) determined relationships between throwing mechanics and shoulder distraction of baseball pitchers using three dimensional, high-speed video data. They detected that the shoulder internal rotation speed values were close to 10000º/s (mean 8286±2777 º/s). These speed values were approximately 30 times higher than the maximal angular velocity used in the test (240º/s).

McMaster et al (1991) evaluated shoulder external to internal rotator torque ratio for water polo players. They did not find significant differences between this ratio in the right (dominant) and left (non-dominant) arm at slow (30º/s) and high (180º/s) angular velocity values. These results are in agreement with our data because the difference of shoulder external-internal rotator torque ratios in the dominant and non-dominant arms in our tests was negligible.

Sport disciplines with regular, repeated overhead activities (throwing or swimming) cause an increase of the shoulder invertor torque values, which are high in comparison to torques produced by evertors (McMaster et al. 1991, Codine et al. 1997, Wilk et al. 1993). This research results indicated, that the external/internal torque ratio for handball players in the middle part of the range of motion was close to 80 %. It means, that the strength of both muscle groups (shoulder invertors and evertors) increased proportionally in the training process of handball.

Relative weakness of shoulder external rotators often lead to the development of shoulder joint pathology – instability, tendinitis of the shoulder girdle muscles, impingement, rupture of the rotator cuff muscles etc. (Jobe and Pink, 1993; Fu et al, 1991). These pathologies are frequent in sports with regular overhead movements.

Conclusions

1. The difference between peak torque values produced by the dominant and non-dominant arm shoulder invertors and evertors is not significant, respectively, at low and high angular velocity of movements.
2. A significant difference in average power is revealed between the dominant and non-dominant shoulder invertors at high angular velocity of movements (240°/s). At lower velocity of movements (60°/s and 180°/s), power asymmetry between both arms is not observed.
3. Shoulder external/internal rotator torques ratio for handball players in the middle part of the range of motion is close to 80% at all tested angular velocity values. This confirms, that strength of both muscle groups increases proportionally during the training process.

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