ISOKINETIC STRENGTH PROFILE OF SHOULDER ROTATORS IN DIFFERENT LEVELS OF TENNIS PLAYERS

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This study investigated characteristics of shoulder rotators in different levels of tennis players. The analysis focused on the examination of concentric and eccentric strength, and E/C ratio in order to identify the balance of eccentric and concentric strength of shoulder rotators. Results showed that (a) there were significant differences in concentric and eccentric strength of internal rotators between dominant and non-dominant shoulders in three angular velocities at the elite and local tennis players; (b) E/C ratios of shoulder internal rotators of local tennis players at three velocities were significantly higher than those of healthy men.

KEY WORDS: shoulder, tennis, isokinetic exercise, concentric strength, rotator cuff

INTRODUCTION: Since the 1980s, the concepts of isokinetic exercise have been widely used in the assessment and muscle strengthening of the athletes. The study of shoulder injury has become a topic of considerable interest, especially overhead sports like as tennis serve or pitching. Several investigations have quantified muscle strengths of shoulder external and internal rotators (Ellenbecker, 1999). Most of those research studies examined the concentric characteristics of shoulder rotators to identify the muscle imbalance (Chander, 1992). However, the research on the analysis of isokinetic eccentric strength was still deficient. Therefore, the purpose of this study was (1) to evaluate the isokinetic concentric strength, isokinetic eccentric strength, and ratio of eccentric and concentric strength to undertake the balance of agonists and anta-agonists muscle of shoulder rotators;(2) to examine the difference of muscle strength of shoulder rotators in elite tennis players, local tennis players, and healthy men.

METHODS: Thirty-six male subjects were divided into three groups: 12 elite tennis players, 12 local tennis players, and 12 healthy men. Subjects did not have any shoulder injuries during the previous 6 months, averaged 22 years of age, with an average height of 173 cm, and an average weight of 67kg. Each subject completed an entry questionnaire that included playing experience, history of upper extremity injury, current training regimens and training years. Each subject underwent extensive testing of both eccentric and concentric maximal torque productions of their dominant and non-dominant shoulders. Players were tested for both concentric and eccentric angular velocities were 60, 120 and 180 deg/sec strength of shoulder internal and external rotators. Subject were positioned a Kin-Com isokinetic dynamometer (Chattecx Corp., Chattanooga, USA) in the seated position. Tests were performed with the shoulder in abduction 90° and elbow flexion 90°. The range of motion for testing was set from internal rotation 65° to external rotation 70°. Subjects were given four practice repetitions at each speed before actual five maximal repetitions. Variables analyzed included peak torque of concentric and eccentric contraction of rotators, internal/external peak torque ratio. Paired t-tests were used to compare the dominant shoulder with the non-dominant shoulder in three groups, and One-way ANOVA tests were used to compare the difference of strength characteristics among three groups.

RESULTS AND DISCUSSION: The mean peak torque values of concentric and eccentric strength for shoulder internal and external rotators in three groups are shown in Table 1 and

Table 2 . There were significant differences in concentric and eccentric strength of shoulder internal rotators between dominant and non-dominant arms in three angular velocities at the elite and local tennis players (P< .05). No significant differences in concentric and eccentric strength of shoulder external rotators between dominant and non-dominant arms in three groups were found except concentric and eccentric strength of local players at 60 deg/sec. Mean concentric torque ratios of shoulder external-to-internal rotators are presented in Table 3. There was significantly difference between dominant and non-dominant arms in three angular velocities at the healthy men (P< .05). Only the external-to-internal rotators strength ratio for local tennis players at 180 deg/sec was significantly different between dominant and non-dominant arms, but no significant differences were found between dominant and non-dominant arm at eccentric torque ratios in all three groups and angular velocities. The eccentric-to-concentric ratio for shoulder external rotator was not significantly different among three groups. However, the E/C ratios of shoulder internal rotators of local tennis players at three velocities were significantly higher than those of healthy men (Table 4). The present study also revealed significant differences between dominant and non-dominant shoulders in concentric and eccentric strength of internal rotators in three angular velocities at the elite and local tennis players. However, the mean peak torque of eccentric strength was not significantly different between dominant and non-dominant shoulders in any angular velocities for healthy men. That indicated those healthy men did not often use maximal eccentric contraction to perform activities of daily life or recreation. Biomechanical research has identified high muscle activation of internal rotation during the forehand and serve, especially maximal effort of concentric muscle activation (Rhu, 1998; Ellenbecker, 1999). Previous investigations have found the internal rotation strength of the dominant arm in highly skilled tennis players, with little or no difference between extremities in external rotation strength. (Ellenbecker, 1999, Ellenbecker, 1992; Koziris, 1991). The results of this study matched this phenomenon. Mean concentric torque ratios of shoulder external-to-internal rotators between dominate and non-dominant arms in three angular velocities at elite and local tennis players were not significantly different, except in 180 deg/sec of local tennis players. In addition, we did not find significant side-to-side differences in elite and local tennis players. These may result from the regular weight training of bilateral extremities. From the result, the ratios of concentric external-to-internal rotators strength did not significantly change when the testing speeds increased. This result was similar to the previous study (Mikesky, 1995). The mean eccentric torque ratios of shoulder external-to-internal rotators strength showed no significant differences between dominant and non-dominant arms at eccentric torque ratios in all three groups and angular velocities. Some studies on swimmer, the values of external-to-internal rotators strength ratio about 0.7~0.71 for the 60 deg/sec concentric test (Beach, 1992). Also the E/C ratios of dominant shoulder internal rotators of local tennis players at three velocities were significantly higher than those of healthy men.

Table 1 Peak Torque of Isokinetic and Eccentric Strength of Shoulder Internal Rotators in Three Groups (Nm)

	Elite tennis players (mean±S.D.)	Local tennis players (mean±S.D.)	Healthy men (mean±S.D.)
D60CI	76.66±25.52*	78.75±18.93*	66.16±27.20*
D120CI	81.91±26.13*	77.75±20.90*	66.75±27.70*
D180CI	87.75±26.70*	81.66±23.23*	71.75±28.80*
ND 60CI	60.58±14.73*	55.91±16.44*	53.25±32.12*
ND120CI	59.25±14.94*	53.83±15.53*	50.33±23.37*
ND180CI	64.08±13.35*	59.25±11.40*	60.50±25.84*
D60EI	82.83±24.16*	88.00±17.36*	67.50±27.72*
D120EI	81.58±24.06*	86.00±15.40*	65.41±24.99
D180EI	86.25±25.06*	85.41±18.13*	64.08±23.84*

ND60EI	64.75±16.18 *	60.50±15.10 *	56.50±33.10 *
ND120EI	58.5 ±15.41 *	57.08±14.44 *	51.08±21.03
ND180EI	60.0 ±13.08 *	61.50±14.92 *	54.83±23.04

Note: *Significant differences concentric/eccentric peak torque between d & n-d side in 60, 120, 180 deg/sec; D60CI, D120CI, D180CI: 60,120,180 deg/sec concentric strength of internal rotator in dominant arm; ND60CI, ND120CI, ND180CI: 60,120,180 deg/sec concentric strength of internal rotator in non-dominant arm; D60EI, D120EI, D180EI: 60,120,180 deg/sec eccentric strength of internal rotator in dominant arm; ND60EI, ND120EI, ND180EI: 60,120,180 deg/sec eccentric strength of internal rotator in non-dominant arm.

Table 2 Peak Torque (Nm) of Isokinetic and Eccentric Strength of Shoulder External Rotators in Three Groups

	Elite tennis players (mean±S.D.)	Local tennis players (mean±S.D.)	Healthy men (mean±S.D.)
D60CE	69.41±20.78	66.33±19.01 *	57.91±35.34
D120CE	69.41±18.93	58.25±21.40	61.25±34.52
D180CE	75.25±17.94	62.33±14.69	62.75±32.20
ND60CE	62.33±22.62	53.91±10.00	56.91±42.69
ND120CE	64.66±23.60	51.41±14.72	57.25±35.08
ND180CE	68.75±24.47	59.08±9.04	64.00±35.10
D60EE	73.33±22.02	73.00±21.67 *	60.66±39.44
D120EE	71.58±19.69	60.58±23.97	64.50±39.51
D180EE	78.16±25.36	62.00±22.37	64.58±32.54
ND60EE	65.66±26.41	60.75±15.67 *	60.41±43.27
ND120EE	66.91±24.08	57.08±13.46	59.16±36.56
ND180EE	67.41±22.79	56.25±11.03	64.41±34.38

Note: *Significant differences eccentric peak torque between d & n-d side in 60deg/sec; D60CE, D120CE, D180CE: 60,120,180 deg/sec concentric strength of external rotator in dominant arm; ND60CE, ND120CE, ND180CE: 60,120,180 deg/sec concentric strength of external rotator in non-dominant arm; D60EE, D120EE, D180EE: 60,120,180 deg/sec eccentric strength of external rotator in dominant arm; ND60EE, ND120EE, ND180EE: 60,120,180 deg/sec eccentric strength of external rotator in non-dominant arm.

Table 3 Mean Concentric Torque Ratios of Shoulder External-to-Internal Rotators in Three Groups

	Elite tennis players (mean±S.D.)	Local tennis players (mean±S.D.)	Healthy men (mean±S.D.)
DEICR60	0.95±0.35	0.85±0.19	0.85±0.22 *
DEICR12	0.87±0.25	0.80±0.35	0.90±0.26 *
DEICR18	0.90±0.31	0.82±0.29 *	0.85±0.17 *
NEICR60	1.03±0.30	1.00±0.16	1.03±0.29 *
NEICR12	1.09±0.33	0.98±0.27	1.13±0.30 *
NEICR18	1.06±0.32	1.01±0.16 *	1.05±0.31 *
DEIER60	1.06±0.14	1.10±0.07	1.03±0.14
DEIER12	1.03±0.09	1.03±0.10	1.04±0.16
DEIER18	1.04±0.24	0.97±0.16	1.05±0.19
NEIER60	1.03±0.11	1.12±0.23	1.08±0.12
NEIER12	1.03±0.09	1.15±0.25	1.04±0.15
NEIER18	1.00±0.21	0.95±0.10	1.03±0.15

Note: *Significant differences concentric torque ratios of shoulder external-to-internal rotators between d & n-d side; DEICR60, DEICR12, DEICR18: 60,120,180 deg/sec concentric ratios of external-to-internal

rotators in dominate arm; NEICR60, NEICR12, NEICR18: 60,120,180 deg/sec concentric ratios of external-to-internal rotators in non-dominate arm; DEIER60, DEIER12, DEIER18: 60,120,180 deg/sec eccentric ratios of external-to-internal rotators in dominate arm; NEIER60, NEIER12, NEIER18: 60,120,180 deg/sec eccentric ratios of external-to-internal rotators in non-dominate arm.

Table 4 Eccentric-to-Concentric Ratios for Shoulder External and Internal Rotators

	Elite tennis players (mean±S.D.)	Local tennis players (mean±S.D.)	Healthy men (mean±S.D.)
D60ECI	1.09±0.12	1.13±0.12^	1.02±0.06^
D12 ECI	1.00±0.10	1.14±0.21^	0.99±0.08^
D18 ECI	0.99±0.11	1.08±0.19^	0.90±0.10^
ND60 ECI	1.07±0.11	1.09±0.10	1.06±0.12
ND12 ECI	0.98±0.06	1.07±0.09	1.04±0.18
ND18 ECI	0.93±0.09	1.03±0.09^	0.91±0.09^
D60ECE	1.06±0.14	1.10±0.07	1.03±0.14
D12 ECE	1.03±0.09	1.03±0.10	1.04±0.16
D18 ECE	1.04±0.24	0.97±0.16	1.05±0.19
ND60 ECE	1.03±0.11	1.12±0.23	1.08±0.12
ND12 ECE	1.03±0.09	1.15±0.25	1.04±0.15
ND18 ECE	1.00±0.21	0.95±0.10	1.03±0.15

Note: ^: Significant differences eccentric-to-concentric ratio for shoulder external and internal rotators between local tennis players and healthy men. D60ECI, D12 ECI, D18 ECI: eccentric-to-concentric ratios of internal rotators in dominate arm; ND60ECI, ND12ECI, ND18ECI: eccentric-to-concentric ratios of internal rotators in non-dominate arm; D60ECE, D12ECE, D18ECE: eccentric-to-concentric ratios of external rotators in dominate arm; ND60ECE, ND12ECE, ND18ECE: eccentric-to-concentric ratios of external rotators in non-dominate arm.

CONCLUSION: Muscle imbalance between external and internal rotators in local tennis players is noted. We may suggest that local tennis players need to notice the balance of eccentric and concentric strength of shoulder rotators to prevent or decrease the percentage of shoulder injury.

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