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Differences in Isometric Strength Between the Dominant and Non-Dominant Upper Extremity in Competitive Tennis Players

KEYWORDS: Tennis, Isometric Strength, injury prevention, Sport.

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ABSTRACT *Alteration in muscular imbalances between homolateral and contralateral limbs has been associated with increased risk of injury. The objective of this study was to compare the isometric peak force of the dominant and the non-dominant upper limb in competition tennis players. Maximal isometric voluntary contraction was tested in 12 male competition tennis players using a strain gauge connected to a portable MuscleLab™ 4000e. Dominant and non-dominant flexion/extension and rotation positions were tested atthe wrist, elbow and shoulder, and internal/ external rotation atthe elbow and shoulder. Significant differences were found for wrist flexion and extension, shoulder flexion and extension, internal arm rotation and the rest of the movements studied. The main finding of this study was to confirm the utility of isometric testing devices as a useful,inexpensive tool for evaluating strength ratios between the dominant and non-dominant side in tennis players.*

INTRODUCTION

Tennis practice requires high levels of power and strength for strokes and movement patterns(Girard, Lattier, Micallef, Millet, 2006). The high intensity and volume developed in training and competition play lead to many adaptations in various body tissues, especially in the dominant arm. Enhanced maximal metabolic vasodilatation in the dominant forearm(Sinoway, Musch, Minotti and Zelis, 1986), increased size in bone tissue from the homolateral limb(Ellenbecker & Roetert, 2003), and higher lean mass in the dominant upper extremity (Sanchís-Moysi, Idoate, Olmedillas, Guadalupe-Grau, Alayón, Carreras, Dorado and Calbet, 2010) have been described. Furthermore, previous studies reported specific isokinetic ratios between dominant and non-dominant arm rotation torquein shoulders, forearms and elbows(Forgiarini et al., 2010; Saccol et al. 2010; Ellenbecker & Roetert, 2003; Ellenbecker et al., 2006). Factors such as the contraction mode (concentric vs. excentric), the velocity rate (60, 120, 180 or 240 °/s) and the movement pattern (abduction, adduction, flexion, extension, internal and external rotation) seem to influence them (Shklar & Dvir, 1995). Alteration in isokinetic muscular imbalances has been associated with an increased risk of injury and could explain some overuse injuries in the homolateral upper limb(Ellenbecker, 1995; Ellenbecker & Roetert, 2003). When interlimb strength differences are higher than 10 to 15%, the risk of injury increases(Blache & Monteil, 2012). For these reasons, ongoing analysis of strength levels is essential, not only to improve performance, but also to prevent injuries. Unfortunately, isokinetic dynamometers have complicated protocols, require a lot of time for subject implementation, and are very expensive tools that are not available to everyone. The aim of this study was to analyze isometric ratios between dominant and non-dominant positions in the upper limb in competition tennis players using a low-cost strain gauge.

METHODOLOGY

Maximal isometric voluntary contraction was tested in 12 male competition tennis players from the Catalan Tennis Federation's International Tennis Centre in Cornellá (Spain). Inclusion criteria were no history of upper extremity surgery; no shoulder, back or knee pain for the past 12 months, and no rehabilitation for the same period. All players were right-hand dominant. Subjects performed three maximal voluntary contractions (3-5 seconds in duration) with one minuteof restbetween sets and 5 minutes between positions.Dominant and non-dominant flexion/extension and rotation positions were tested at the wrist, elbow and shoulder, and internal/external rotation at the elbow and shoulder. Maximal voluntary isometric peak force was measured at 100 Hz frequency using a strain gauge (500N) connected to a portable MuscleLab™ 4000e(Boscosystemlab, Rome, Italy). The normality of variable distribution was assessed using the Kolmogorov-Smirnov test. The relationship between quantitative variables was established by performing a linear correlation analysis and calculating the Pearson's linear correlation coefficient (r). A paired t-test was used to determine any significant differences between the mean values for the dominant and non-dominant arm. Statistical significance was set a priori at $p<0.05$. All statistical analyses were performed using SPSS for Windows 15.0(SPSS, Inc. Chicago, IL, USA).

RESULTS

The sample met the criteria of normality. All variables were significantly different in the dominant side compared to the non-dominant side. For wrist flexion and extension, shoulder flexion and extension, and internal arm rotation, significant differences were found with $p<0.001$, and in the case of the rest of the movements studied, with $p<0.05$. The average difference (%) between sides rangedfrom 10.7% (in external arm rotation) and 11.5% (in shoulder extension) to 26.4% (in internal arm rotation) and 24.6% (in wrist extension) (see Tables 1 and 2).

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Table 1: Isometric peak force results and mean isometric peak force difference (mean ± SD) between dominant and non dominant arm; paired sample *t*-test for differences in dominant and non dominant arm, and correlation coefficient (r) between isometric peak force in dominant and non dominant arm *(p<0.05), **(p<0.001).

	Isometric peak force			Dominant – Non dominant	
	Dominant (N)	Non dominant (N)		Mean difference (%)	r
Extension					
Wrist	157.4 ± 47.9	117.2 ± 30.6		24.6 ± 7.0**	0.87**
Elbow	199.2 ± 66.6	163.9 ± 45.7		15.3 ± 15.9*	0.96*
Shoulder	126.1 ± 29.4	111.3± 25.4		11.5 ± 4.2**	0.98**
Flexion					
Wrist	260.7 ± 65.3	219.1 ± 47.9		19.3 ± 18.1**	0.83**
Elbow	219.4 ± 64.3	192.6 ± 67.0		13.1 ± 13.0*	0.97**
Shoulder	197.0 ± 39.1	160.3 ± 28.5		17.6± 11.2**	0.78**
Rotation					
External	107.3 ± 30.1	96.5 ± 25.1		10.7 ± 9.4*	0.90**
Internal	197.8 ± 62.2	143.2 ± 41.6		26.4 ± 12.7**	0.85**

Table 2: Mean isometric peak force difference (mean ± SD) between flexion and extension and between internal and external rotation in dominant and non dominant arm; paired sample *t*-test (*p*) for differences between flexion and extension and internal and external rotation in dominant and non dominant arm, and between mean differences in dominant and non dominant arm (*(p<0.05), **(p<0.001)).

	Mean differences Dominant (%)	Mean differences Non dominant (%)	Dominant – Non dominant p (t-test)
Flexion - Extension			
Wrist	39.8 ± 7.2**	44.1 ± 8.2**	0.822
Elbow	23.7 ± 14.2*	30.0 ± 13.6**	0.480
Shoulder	38.2 ± 11.7**	30.6 ± 9.6**	0.006
Internal – external rotation			
Shoulder	48.6 ± 10.8**	33.6 ± 15.2**	0.003

DISCUSSION

The differences between homolateral and contralateral body sides appear to be greater in tennis than in other sports due to the high level of asymmetry. In our study, homolateral positions developed higher strength levels than contralateral ones for all positions, though the greatest differences were observed in shoulder positions. Shoulder internal rotation and flexion, wrist flexion and elbow extension were found to be most highly related to tennis strokes, especially in serves(Elliot, 2006; Elliott, Fleisig, Nicholls and Escamilia, 2003). The results of our study seem to indicate strength ratios between isometric and isokinetic values similar to those reported in previous studies. This confirms the usefulness of isometric tests as a strength assessment tool. Further, isometric tests have been conducted in many sports because of their ease of application and high test-retest reliability(McGuigan, Newton, Winchester and Nelson, 2010). Many isometric maximal strength tests, such as the mid-thigh isometric pull, correlate well with 1 repetition maximum and vertical jump performance(Mcguigan et al., 2010), and the position strongly influences the relationships that are observed with dynamic tasks (Haff, Stone, O'Bryant, Harman, Dinan, Johnson and Han, 1997). However the correlations between isometric and dynamic peak force appear to be lower at light load conditions (Kawamori, Rossi, Justice, Haff, Pistilli, O'Bryant, Stone and Haff, 2006), and when the joint angle in isometric assessment is selected so that it represents the joint angle at which peak force is developed in a dynamic pattern, the relationship between isometric and dynamic force-time increases (Murphy et al., 1995; Kawamori et al., 2006). More studies need to be conducted to establish isometric functional ratios.

CONCLUSSION

The main finding of this study was to confirmthe utility of isometric testing devices as an interesting and unexpensive tool to evaluate strength ratios between dominant and nondominant side in asymmetric sports.In tennis players, our study seems to confirmate the difference strength levels observed with other assessment tools between homolateral and contralateral upper limb, being observed significative differences in the maximum isometric peak force between both limbs in competition players.

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