PEAK FORCE DEVELOPMENT AND CHANGE OF DIRECTION IN TENNIS

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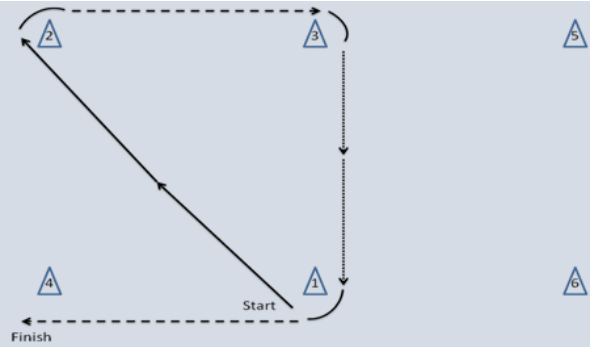
INTRODUCTION: The sport of tennis requires its players to have a number of athletic qualities. Three important attributes to success in the sport are speed, agility, and reactive ability (Cooke, 2011). Tennis players are often tested on these three traits using agility testing. This should be chosen with sport specificity in mind in order to see the best translation to on court performance and to mimic the physiological demands of the sport (Miller, 2012). The ability to change direction is crucial in a tennis match, with the average point requiring ≥8.7 changes of direction (Kibler, 2000). It is widely accepted in the field of strength and conditioning that improving an athlete's strength via periodized resistance training can help athletes improve force production characteristics. It can enhance stretch shortening cycle utilization (*DeWeese, et al. 2015*), a factor integral to speed and change of direction (COD) (DeWeese & Sams, 2015; Bompa and Haff, 2009). However, the findings on whether improvements in strength can improve COD performance have not been consistent (Keiner, 2014). Although *Keiner et al. 2014* found that strength training did have a positive effect on COD and maximum strength in the front and back squat with youth soccer players. Knowing how important COD is in the sport of tennis, the aim of this paper is to examine the relationship between countermovement jump peak force (CMJ PF) and change of direction in Division 1 men's tennis players.

METHODS: This research focused on using de-identified data from past testing sessions. In total the study included 10 subjects (n=10) and 20 data values. The jump tests were completed as part of a testing protocol that included anthropometric measurements, static and countermovement jumps, and maximal isometric mid-thigh pulls. The CMJ was chosen for further analysis due to the stretch shortening cycle that takes place during both the CMJ and COD movements. The jumps were conducted on force plates (Rice Lake, WI) and following a standardized warm-up protocol. The CMJ portion of the testing battery consisted of two warm-up jumps at 50% and 75% effort followed by a minimum of two maximal effort jumps with 0kg, 11kg, and 20kg. If a player's jump heights differed by >2cm they were instructed to perform an additional jump until this criteria was met. The CMJs with 0kg and 20kg were analyzed with LabVIEW software (National Instruments Corporation, Austin, TX) and the average PF was used for subsequent statistical analysis.

The box agility test was set-up with four cones placed 4.15 meters apart in a box formation. The testing protocol consisted of a 50% and 75% effort warm-up and two trials on both the right and left sides. As an example, a player performing a "right trial" would begin at cone #1 (figure 1) and then sprint diagonally to cone #2. From there the player side-shuffles to cone #3, backpedals to cone #1 and side shuffles through the finish line (cone #4). Two individuals used handheld stopwatches to time the test, their times were averaged for each trial. The timing began on the player's first movement and ended once the player's midline crossed the finish line. The results of all four agility trial times were averaged for statistical analysis.

Figure 1: Example of the box agility test from the right side



Using the Pearson correlation equation, average peak force values for each load were correlated, to the average box drill agility times in order to determine whether a relationship between peak force development and change of direction existed.

RESULTS: A correlation of 0.28 was found when comparing the athletes peak force (CMJ 0kg) to their Box agility test time (Figure 2). At 20 kg, the correlation was found to be 0.33 (PF CMJ 20kg vs. Box agility test time) (Figure 3). The data collected for the study is included in Table 1.

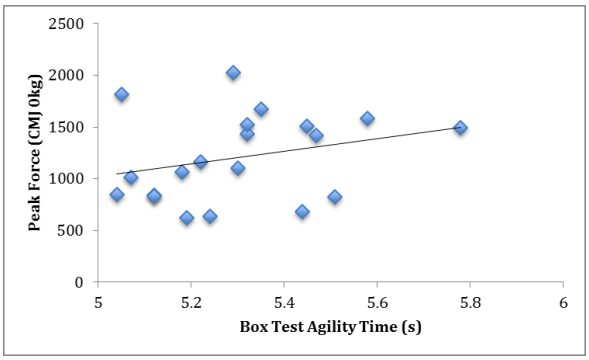


Figure 2: Scatterplot of Agility Time (s) and Peak Force (N) at 0kg

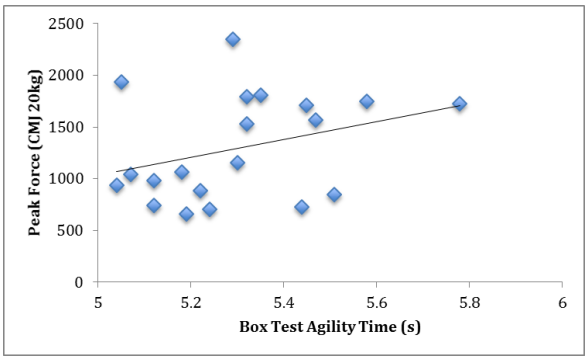


Figure 3: Scatterplot of Agility Time (s) and Peak Force (N) at 20kg CMJ

DISCUSSION: According to Hopkins (2002) the correlations established can be classified as small (0kg CMJ) and as moderate (20kg CMJ). Although the relationships analyzed in this research were not as strong as expected, they still provides beneficial conclusions. This study stresses the importance of including a comprehensive battery of testing to effectively measure

Athlete Number	Agility Time	PF (CMJ 0kg)	PF (CMJ 20kg)	Athlete Number	Agility Time
1	5.32	1433.23	1528.65	**7**	5.12
2	5.45	1509.95	1713.11	**8**	5.35
3	5.05	1816.04	1938.39	**9**	5.30
4	5.47	1416.75	1569.75	**7**	5.22
2	5.29	2027.71	2350.98	**1**	5.12
5	5.58	1583.09	1747.99	**5**	5.78
3	5.07	1010.89	1044.72	**2**	5.44
6	5.32	1523.94	1789.86	**8**	5.24
3	5.04	847.75	938.41	**9**	5.51
4	5.18	1066.86	1067.60	**10**	5.19

Table 1: Athlete box agility time (seconds) and CMJ peak force (N) at 0kg and 20kg

and monitor athletes; both physiological and sport-specific characteristics need to be tested to ensure a complete overview of fitness and performance is gathered. Also, this study focused on a sport where jumping is not a fundamental skill, it is therefore predicted that if this study was repeated on a jumping-intensive sport – such as volleyball – then a greater correlation could be found. Therefore, further research on whether the relationship between peak force and change of direction is recommended in order to develop a comprehensive understanding and overcome inadequacies of this study. Recommendations include using more reliable and accurate timing methods during agility test and increasing sample size.

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