The demands of a single elimination collegiate tennis tournament

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Headline

Despite the considerable body of literature describing the demands of tennis, little is known about the accumulated physiological and mechanical loads associated with collegiate tennis tournament play. While microsensors have been used extensively to quantify demands in a variety of sports, particularly accelerometry and GPS sensors, limited data exists describing the demands of tennis match play using such microsensors (1,2).

Aim. The purpose of this study was to use heart rate sensors and triaxial accelerometers to investigate the physiological and mechanical loads associated singles and doubles tennis play during a single elimination collegiate tennis tournament.

Methods

Athletes. Six male tennis players (20.6 ± 1.6 yr, 180.9 ± 2.1cm, 78.3 ± 3.8kg) participated in this study. Athletes were members of a nationally ranked (top three) NCAA DII men's tennis team. This investigation was approved by the Institutional Review Board and all participants completed and signed University approved informed consent.

Match Time. A total of 16 doubles and 17 singles hard court matches were played over a 4-day, single elimination tournament. A mean of six matches were played by each athlete and ranged from 1-11 matches played each athlete. Doubles matches were scored based upon an 8-game pro set doubles match with a 7-point tiebreak at 8-all. All singles matches followed the best of three sets format. Athletes were given 5-10 minutes to warm-up. Matches were divided into warm-up (WU) and match play (MP).

Operation of Wearable Device. Prior to the tournament, each athlete was familiarized with the wear and operation of the Zephyr^{TM} BioHarness (BH; Zephyr Technology Corporation, Annapolis, MD). Each BH included a Biomodule (version 3) and strap. The Biomodule contains a HR sensor and triaxial accelerometer which sample at 250 Hz and 100 Hz, respectively. BH data was downloaded to and analyzed with OmniSense^{TM} Analysis (version 4.1.4; Zephyr Technology Corporation, Annapolis, MD).

Accelerometry. The BH was used to collect acceleration data recorded as Impulse load (IL). IL is an accumulative measure of mechanical load that is equal to the sum of areas under the 3-axis accelerometry curves and expressed as N*s. IL only includes locomotor activity and impacts. Mean absolute IL and relative IL (IL/min) were calculated for doubles and singles WU and MP. The formula for IL is displayed below where x = g forces in the medio-lateral ("side-to-side") plane, y = g forces in the anterio-posterior ("forwards and backwards") plane, z = g forces in the vertical ("up and down") plane.

$$Impulse\ Load = \sum_{s=1}^{n} \frac{\sqrt{x_s^2+y_s^2+z_s^2}}{9.8067}$$

Heart Rate. In a separate session, BH were used to determine max heart rate (HRmax) for each athlete using the Yo-Yo Intermittent Recovery Test (Level 1), per previously established methods (3). HR responses to MP were recorded with BH, and HR was categorized in one of the five following HR zones; < 60% of HRmax (Zone 1), 60-75% of HRmax (Zone 2), 75-80% of HRmax (Zone 3), 80-90% of HRmax (Zone 4) and 90-100%

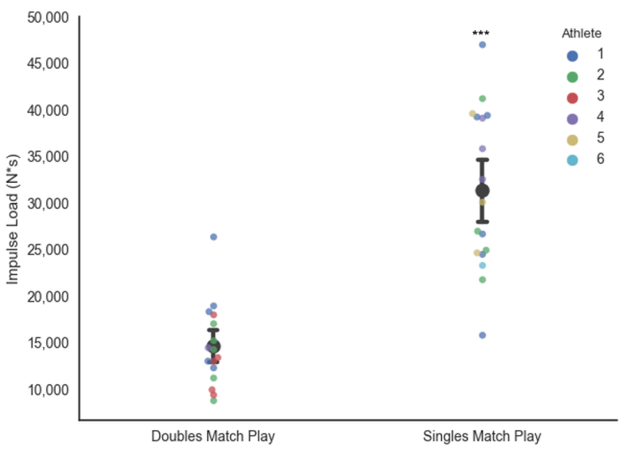

Fig. 1. Figure 1. Impulse Load during doubles and singles match play . ***, almost certainly different than doubles match play.

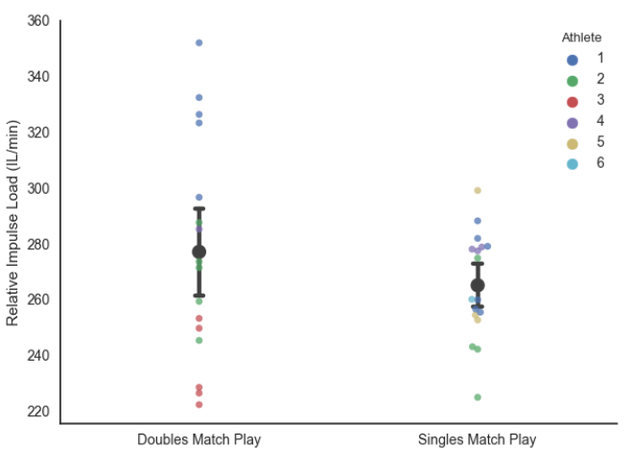

Fig. 2. Figure 2: Relative Impulse Load (IL/min) during doubles and singles MP

Table 1. Accelerometry loads

	Doubles WU	Singles WU	Doubles MP	Singles MP
IL (kN*s)	1.82 ± 0.39	1.95 ± 0.55	14.58 ± 4.43	31.31 ± 8.64
IL/min	284.56 ± 34.28	318.69 ± 31.50	277.11 ± 40.36	265.12 ± 19.17

of HRmax (Zone 5). Mean time and mean percent of total time in each HR zone was calculated for doubles and singles WU and MP.

Analysis. Data in the table and figures are presented as means with 90% confidence limits (CL) . All data were first log-transformed to reduce bias arising from non-uniformity error. Between-match format standardized differences in the different measures were compared to the smallest worthwhile change (SWC, 0.2 multiplied by the between-match deviation, based on Cohen's d principle) using magnitude based inferences. Each match was considered to be player-independent due to changes in opponents and likely large variations in tactics. These probabilities were used to make a qualitative probabilistic mechanistic inference about the true effect: if the probabilities of the effect being substantially positive and negative were both >5%, the effect was reported as unclear; the effect was otherwise clear and reported as the magnitude of the observed value. Threshold values for standardized differences were >0.2 (small), >0.6 (moderate), >1.2 (large) and very large (>2) (4).

Results

Table 1 provides a description of absolute IL and relative IL during double and single matches. Match duration was almost certainly longer for singles MP than for doubles MP (119 ± 34 vs 52 ± 14 min; ES: 2.61 ± 0.54, very large). Mean total accumulated tournament IL was 139 ± 100 kN*s. Absolute IL was almost certainly higher for single than for double matches (31 ± 9 vs 15 ± 4 kN*s, 2.51 ± 0.56, very large). Unclear dif-

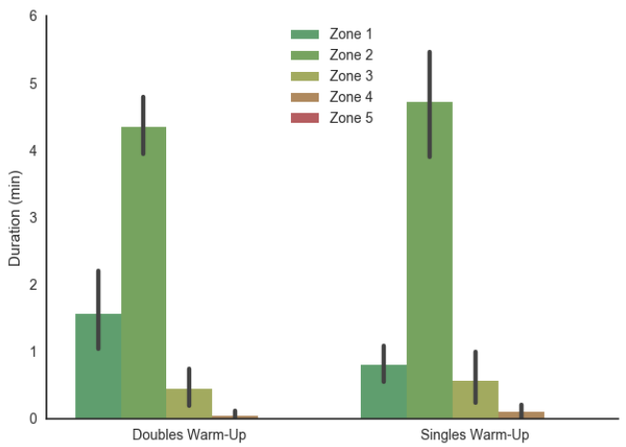

Fig. 3. Figure 3: Minutes in HR zones during WU

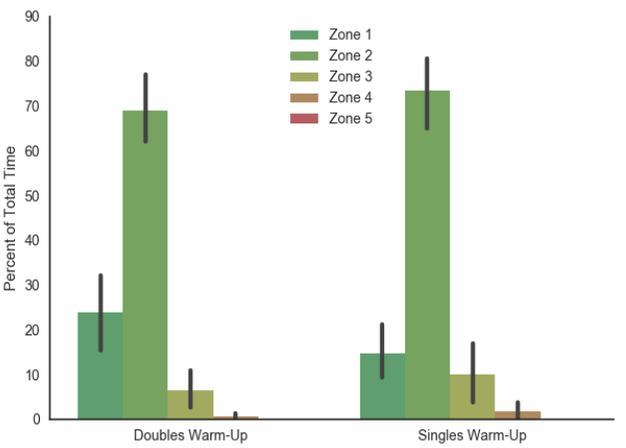

Fig. 5. Figure 5: Percent of time in HR zones during WU

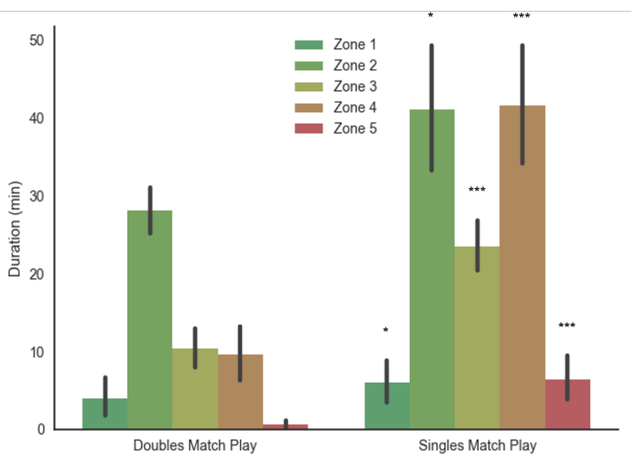

Fig. 4. Figure 4: Minutes in HR zones during MP. ∗ likely; ∗∗ very likely; ∗ ∗ ∗ almost certainly different than doubles match play.

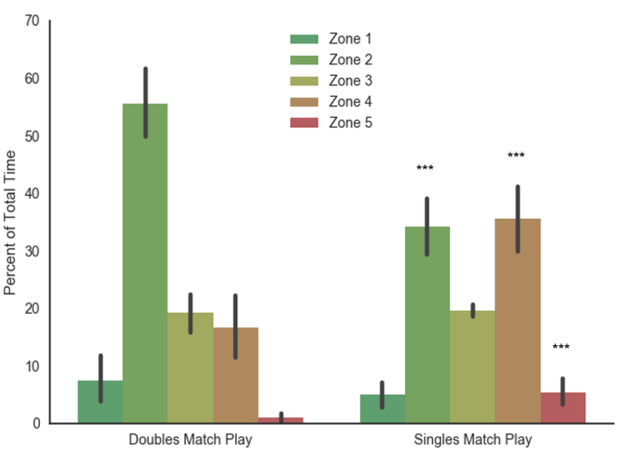

Fig. 6. Figure 6: Percent of time in HR zones during MP. ∗ likely; ∗∗ very likely; ∗ ∗ ∗ almost certainly different than doubles match play.

ferences were observed for relative IL between match formats (265 ± 19 vs 277 ± 40 N*s/min for single and double matches, respectively) The distribution of IL and IL/min during singles and doubles MP are illustrated in Figure 1 and Figure 2, respectively. Total time and percent of time spent in different HR zones between doubles and singles MP are detailed in Figures 3-6. The absolute time spent in each HR zones was likely to almost certainly longer during singles than during doubles for all HR zones (ES ranging from small to very large). Unclear differences between match formats were observed in the relative time spent in zone 1 (5 ± 6% vs 7 ± 10% for singles and doubles MP, respectively) and zone 3 (20 ± 3% vs 19 ± 8%). In contrast, the players spent relatively less time in zone 2 (34 ± 13% vs 55 ± 15%, ES: -1.31 ± 0.52, large) and more time in zone 4 (36 ± 15% vs 17 ± 13%, ES: 1.73 ± 0.93, almost certainly large) and zone 5 (5 ± 6% vs 1 ± 2%, ES: 0.98 ± 0.63, very likely moderate) during singles than during doubles MP.

Discussion

This is the first investigation of mechanical load via accelerometry completed in a men's collegiate tennis tournament. Athletes competing in collegiate tennis tournaments can often be expected to play at least one doubles and one singles match per day on consecutive days. Mean accumulated tournament total IL was 139 ± 100 kN*s, although some athletes accumulated 200-300 kN*s throughout the tournament. The single elimination nature of the tournament was responsible for the large variation in total accumulated IL, where total matches played by each athlete ranged from 1-11. The percent of total MP time spent in the highest two HR zones (4 and 5), were substantially higher during singles MP compared to doubles MP which agrees with prior research (5-7). However, the rate which mechanical loads accumulate, or IL/min, was similar between doubles and singles MP. Given that IL/min was similar between doubles and singles MP, while the cardiovascular demands are greater during singles MP compared to doubles MP, the activity profile of doubles and singles MP must differ. This may imply that doubles MP requires higher magnitude acceleration changes more frequently than singles MP, and may also mean more continuous unidirectional stepping during singles MP than doubles MP. Although the activity profile difference between doubles and singles MP is not clearly addressed in the literature, investigations of badminton partially support the above statements (6). Individual differences, particularly in the rate of mechanical loading should also be considered. For instance, Figure 2 demonstrates that there may be considerable differences in IL/min between athletes. Athlete 1 clearly accumulates IL more quickly than other athletes during doubles MP, but Athlete 2 accumulates IL at a rate slower than other athletes during singles MP. While factors that influence IL/min may be individual (playing style, ability, sex and age) or environmental (court surface, ball type and weather), Figure 2 illustrates to practitioners the importance of analyzing training loads on an individual basis. Lastly, WU activities last between 5-10 minutes, are completed with the opponent and include volleying, serving and returning serves. HR did not reach Zone 5 (90-100% of HRmax) at any time during doubles or singles WU, and a relatively small portion of the WU was spent in Zone 4 (80-90% of HRmax). However, considerable time was spent in Zones 4 and 5 during singles and doubles MP. For instance, more time was spent in Zone 4 than any other HR zone during singles MP. This suggests that WU activities consist almost entirely of stationary activities (i.e., serving and service return) with minimal, if any, intense running and repeat change of direction. Since short sprints and repeat change of direction make up a considerable portion of tennis MP (8), this indicates that pre-match WU may not prepare athletes appropriately for MP.

Practical Applications

- The physiological and mechanical loads of tennis MP measured in this study may help practitioners structure practices and prescribe training loads in collegiate tennis. For example, coaches may use the MP IL/min to select tennis and conditioning drills that are similar to, lower than or higher than the intensities encountered during MP depending on the current goals and phase of training.
- College tennis tournaments consist of both singles and doubles MP, and both match types are weighted equally when calculating team scores; although there are a greater number of singles than doubles matches played. Practitioners should be aware that the intensity (IL/min) is similar between singles and doubles MP but the activity profile likely differs substantially. Therefore, athletes should be adequately prepared for the demands of singles and doubles MP.
- Coaches should consider the potential problems with warm-up procedures in collegiate tennis. Tennis players often warm-up with their opponent and are only provided 5-10 min of warm-up time prior to beginning MP. Heart rate data from WU indicate that WU activities consist largely of stationary activities and include minimal, if any, short sprints and repeat change of direction. If the schedule permits, athletes may benefit from additional warm-up activities prior to official match warm-up.

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