The Influence of Fatigue on Specific Service Velocity and Accuracy in Division 1 Tennis Players: A Pilot Study

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ABSTRACT

Tennis is a highly demanding sport of aerobic & anaerobic endurance, which requires appropriate metabolic conditioning & mental focus to achieve successful performance. To our knowledge, the influence of a sport-specific fatiguing protocol on, & the relationship of a standard anaerobic capacity test to, service velocity & accuracy has not been previously established in NCAA D1 male & female tennis players.

Purpose: Examine the effects of fatigue on, & determine the relationship of peak power & anaerobic capacity to, serve velocity & accuracy in NCAA D1 male & female tennis players.

Methods: A convenience sample of 9 male ($\bar{x}$ age =19.8±1.2yrs, $\bar{x}$ height=182.3±6.9cm, $\bar{x}$ bwt=78.2±5.2kg, $\bar{x}$ BMI=23.6±2.1) & 6 female ($\bar{x}$ age =19.7±1.4yrs, $\bar{x}$ height=172.5±10.7cm, $\bar{x}$ bwt=61.8±12.9kg, $\bar{x}$ BMI=20.6±2.4) tennis players volunteered for the study. Subjects gave informed consent & completed the PAR-Q+ questionnaire. Subjects were measured with a stadiometer & scale. Subjects completed Wingate Tests (WT) on Day 1, followed by on-court performance testing & fatiguing protocol one week later on Day 2. Fatigue was induced by having subjects perform high-intensity side-to-side ground strokes to 85% of age-predicted heart rate max using the Tanaka formula. Subjects performed 10 consecutive serves to deuce & ad courts before & after the fatiguing protocol. A radar gun was used to measure serve velocity. An independent t-test was used to compare performance between genders, while a dependent t-test was used to determine performance differences within groups. The Pearson-product correlation was used to examine relationships among all variables. Significance level set at p≤0.05.

Results: Males differed significantly from females in height (182.3±6.9 vs 172.5±10.7cm, p=0.05), weight (78.2±5.2 vs 61.8±12.9kg, p=0.004), BMI (23.6±2.1 vs 20.6±2.4, p=0.02), peak power (PP) (964.2±88.8 vs 542.8±149.0W, p<0.001), relative PP (12.4±1.2 vs 8.7±0.7W/kg, p<0.001), anaerobic capacity (AC) (668.8±55.9 vs 384.5±82.5W, p<0.001), relative AC (8.7±0.6 vs 6.2±0.7W/kg, p<0.001), & serve velocity to deuce (106.3±10.0 vs 78.8±3.2mph, p<0.001; 97.1±9.3 vs 71.5±11.3mph, p=0.001) & ad (111.3±14.1 vs 82.0±12.8mph, p=0.001; 97.9±13.5 vs 72.0±13.8mph, p=0.003) courts before & after induced fatigue (IF). Mass & height were significantly related to serve velocity regardless of gender & court side before & after IF (r=0.64 to 0.76, p=0.10 to 0.001). Serve accuracy measures did not differ between genders to deuce or ad courts before or after IF. Serve velocity was slower within male & female genders to deuce (p=0.001, p=0.002) & ad (p=0.004, p=0.003) courts, respectively, after IF. Serve velocity to both serve sides was significantly correlated to all WT measures before (r=0.70 to 0.86, p=0.003 to <0.001) & after (r=0.75 to 0.87, p<0.001) IF, respectively. Neither BMI nor serve velocity outcome was related to any serve accuracy measure.

Conclusions: Biometric, WT, & serve velocity, after IF, differed between genders, while serve accuracy did not. Greater biometric measures (e.g. mass, BMI) were related to higher serve velocity regardless of gender or IF. Women appeared to tolerate IF as well as men for serve accuracy. Future research should include lactate testing to definitively determine anaerobic metabolism status, or at least the "talk test" if lactate testing is unavailable. The effects of other IF protocols (e.g. YOYO Intermittent Recovery Test) should also be examined in this population.

Practical Application: Tennis-specific anaerobic testing should include protocols that conclusively induce anaerobic metabolism. S&C programs should focus on improving anaerobic endurance & aerobic recovery with results demonstrating a rightward anaerobic threshold shift. S&C practitioners should consider sport-specific training regimens (e.g. sprint interval training, combined training, plyometrics) to improve the metabolic profile of D1 tennis players.

INTRODUCTION

Tennis is a highly demanding sport of aerobic and anaerobic endurance, which requires appropriate metabolic conditioning and mental focus to achieve successful performance[1]. To our knowledge, the influence of a sport-specific fatiguing protocol on, and the relationship of a standard anaerobic capacity test to, service velocity and accuracy has not been previously established in NCAA Division 1 male and female tennis players.

METHODS

A convenience sample of nine male (mean age =19.8±1.2yrs, mean height=182.3±6.9cm, mean bwt=78.2±5.2kg, mean BMI=23.6±2.1) and six female (mean age =19.7±1.4yrs, mean height=172.5±10.7cm, mean bodyweight=61.8±12.9kg, mean BMI=20.6±2.4) tennis players volunteered for the study. Subjects gave IRB-approved informed consent prior to participation, then completed the PAR-Q+ questionnaire. Subject height was measured with a stadiometer (Seca) and scale (GE). Subjects completed Wingate Anerobic Tests (WAT) on Day 1, which was followed by on-court performance testing & fatiguing protocol one week later on Day 2. Fatigue was induced by having subjects perform a series of high-intensity side-to-side ground strokes until they achieved 85% of age-predicted heart rate max using the Tanaka formula. Subjects performed 10 consecutive serves to deuce and ad courts before and after the fatiguing protocol. A radar gun (Bushnell) was used to measure serve velocity. An independent t-test was used to compare performance between genders, while a dependent t-test was used to determine performance differences within groups. The Pearson-product moment correlation was used to examine relationships among all variables. Significance level was set at p≤0.05.

Figure 1: Fatiguing Protocol

Figure 2: Serve Velocity Measurement

RESULTS

Table 1: Subject Demographics (Mean ± SD)

Demographic Variable	Females (n=6)	Males (n=9)	Total (n=15)
Age (yrs)	19.7 ± 1.4	19.8 ± 1.2	19.7 ± 1.2
Height (cm)	172.5 ± 10.7	182.3 ± 6.9*	178.4 ± 9.6
Weight (kg)	61.8 ± 12.9	78.2 ± 5.2‡	71.6 ± 12.0
BMI	20.6 ± 2.4	23.6 ± 2.1†	22.3 ± 2.6
Absolute PP (W)	542.8 ± 149.0	964.2 ± 88.8‡	795.6 ± 241.1
Relative PP (W/kg)	8.7 ± 0.7	12.4 ± 1.2‡	10.9 ± 2.1
Absolute AC (W)	384.5 ± 82.5	668.8 ± 55.9‡	555.1 ± 158.1
Relative AC (W/kg)	6.2 ± 0.6	8.6 ± 0.7‡	7.6 ± 1.3

*p=0.05, ‡p=0.004, †p=0.02, ‡p<0.001

Table 2: Performance Data by Gender (Mean ± SD)

Performance Variable	Females (n = 6)		Males (n = 9)	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Serve Velo (Deuce court) (mph)	78.8 ± 13.2	71.5 ± 11.3	106.3 ± 10.0*	97.1 ± 9.3*
Serve Velo (Ad court)	82.0 ± 12.8	72.0 ± 12.9	111.3 ± 14.1†	97.9 ± 13.5‡
Serve Accuracy (Deuce) (%)	66.7 ± 27.3	53.3 ± 32.7	57.8 ± 29.1	57.8 ± 23.3
Serve Accuracy (Ad)	60.0 ± 28.3	56.7 ± 19.7	64.4 ± 16.7	57.8 ± 25.4
Serve Accuracy Wide (Deuce)	30.0 ± 21.0	10.0 ± 16.7	22.2 ± 25.4	13.3 ± 20.0
Serve Accuracy Wide (Ad)	13.3 ± 10.3	23.3 ± 19.7	24.4 ± 38.4	26.7 ± 20.0
Serve Accuracy Body (Deuce)	53.3 ± 20.7	80.0 ± 12.6‡	48.9 ± 28.5	62.2 ± 27.3
Serve Accuracy Body (Ad)	63.3 ± 29.4	66.7 ± 16.3	57.8 ± 30.8	53.3 ± 26.5
Serve Accuracy T (Deuce)	16.7 ± 15.1	10.0 ± 11.0	28.9 ± 22.6	24.4 ± 21.9
Serve Accuracy T (Ad)	20.0 ± 17.9	10.0 ± 11.0	17.8 ± 15.6	20.0 ± 20.0

*p<0.001, †pp=0.001, ‡p=0.003, ‡p=0.004

RESULTS (cont.)

➢ Males differed significantly from females in height (182.3±6.9 vs 172.5±10.7cm, p=0.05), weight (78.2±5.2 vs 61.8±12.9kg, p=0.004), BMI (23.6±2.1 vs 20.6±2.4, p=0.02), peak power (PP) (964.2±88.8 vs 542.8±149.0W, p<0.001), relative PP (12.4±1.2 vs 8.7±0.7W/kg, p<0.001), anaerobic capacity (AC) (668.8±55.9 vs 384.5±82.5W, p<0.001), relative AC (8.7±0.6 vs 6.2±0.7W/kg, p<0.001), and serve velocity to deuce (106.3±10.0 vs 78.8±3.2mph, p<0.001; 97.1±9.3 vs 71.5±11.3mph, p=0.001) and ad (111.3±14.1 vs 82.0±12.8mph, p=0.001; 97.9±13.5 vs 72.0±13.8mph, p=0.003) courts before and after induced fatigue (IF).

➢ Mass and height were significantly related to serve velocity regardless of gender and court side before and after IF (r=0.64 to 0.76, p=0.10 to 0.001). Serve accuracy measures did not differ between genders to deuce or ad courts before or after IF.

➢ Serve velocity was slower within male and female genders to deuce (p=0.001, p=0.002) and ad (p=0.004, p=0.003) courts, respectively, after IF.

➢ Serve velocity to both serve sides was significantly correlated to all WT measures before (r=0.70 to 0.86, p=0.003 to <0.001) and after (r=0.75 to 0.87, p<0.001) IF, respectively.

➢ Neither BMI nor serve velocity outcome was related to any serve accuracy measure.

CONCLUSIONS

Biometric, WT, and serve velocity, after IF, differed between genders, while serve accuracy did not. Greater biometric measures (e.g. mass, BMI) were related to higher serve velocity, but not serve accuracy, regardless of gender, demographics, or IF. Women appeared to tolerate IF as well as men for serve accuracy. Future research should include lactate testing to definitively determine anaerobic metabolism status, or at least the "talk test" if lactate testing is unavailable. The effects of other tennis-specific and non-specific IF protocols (e.g. Leuven Tennis Performance test, YOYO Intermittent Recovery Test) should also be examined in this population. The literature indicates that highly fit athletes may possess a greater degree of adaptation that fortifies fatigue resistance[2,3]. Therefore, future investigations should also determine the specific contributions of central and peripheral fatigue to serve velocity and accuracy in recreational and elite amateur and professional male and female tennis players.

PRACTICAL APPLICATION

Tennis-specific anaerobic testing should include protocols that conclusively induce anaerobic metabolism. Strength and conditioning programs should focus on improving anaerobic endurance and aerobic recovery with results demonstrating a rightward anaerobic threshold shift. Strength and Conditioning practitioners should consider sport-specific training regimens (e.g. sprint interval training, combined training, plyometrics) to improve the metabolic profile of D1 tennis players. Such an approach should include a periodization model that also ensures controlled fatigue exposure and adequate recovery time to guard against performance collapse.

Fatigue Protocol Animation

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