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PRE-SEASON CHANGES IN AEROBIC CAPACITY, TRAINING LOAD, SERVE VELOCITY, BURNOUT, AND AGILITY IN COLLEGIATE WOMEN TENNIS PLAYERS

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ABSTRACT

Purpose: The purpose of this investigation was to examine preseason fitness levels and seasonal changes in fitness, serve performance, and perceived burnout in 13 NCAA Division I collegiate women tennis players (n=13, 19.69 $\pm$ 1.32 years, 64.75 $\pm$ 2.89 kg, 168.82 $\pm$ 4.59 cm). ***Methods:*** Every two weeks subjects performed a maximal serve velocity (MSV) test, and an athlete burnout questionnaire (ABQ); the mean score from the ABQ scores gives global burnout index (GBI). Subjects completed the spider agility (SA) test, the 20m shuttle run test at T1 (pre), T4 (mid), and T6 (post). Training load was quantified using the session rating of perceived exertion. ***Results:*** The 20m shuttle test revealed that aerobic capacity increased significantly (34.12 ± 4.50 to 40.15 ± 3.62 ml.kg.min; $p < 0.05$) from pretest to post test. Training load reported a significant fluctuating pattern across the season ($p < 0.05$). No significant differences were observed for serve velocity, burnout, and agility ($p > 0.05$). ***Conclusions:*** The current findings suggest that the participants improved their fitness levels as the season progressed. Therefore, the implementation of a tennis-specific conditioning program during the three month summer break is an appropriate strategy to minimize the effects of detraining.

Keywords: training, aerobic, exercise performance, physical performance, sport

INTRODUCTION

Collegiate tennis players partake in a rather vigorous training schedule throughout their careers. Training for collegiate tennis requires a year-long regimen in all aspects of physical performance. Players will practice 2-3hours/day, and 5-6 days/week, focusing conditioning on flexibility, strength, muscular endurance, anaerobic and aerobic power, speed, and agility. The collegiate tennis season is divided into three distinct periods: fall, spring, and summer. Fall (August–December), is the traditional pre-season where training is designed to improve performance and training volume is high. During the pre-season, players/teams will also compete in various tournaments. Spring

(February–May), is the major competition period during which a wide range of conference matches are played. During the summer (May-July), most programs allow their athletes to leave campus during which time players engage in unsupervised training.

A number of physiological variables are important in tennis play including speed, agility, strength, muscular endurance, anaerobic power, aerobic capacity and joint specific flexibility.[1-3] These are variables that could result in impaired performance if adequate training takes place over the course of the collegiate tennis season. If inadequate training takes place over a prolonged period of time then fitness levels may fall as a consequence of detraining. The magnitude of any decrease in fitness depends upon the length of the detraining period and how highly trained the individual had been.[4,5] Mujika & Padilla[5] showed that short term detraining, less than 4 weeks of insufficient training stimulus, resulted in a 4-14% decrease in aerobic capacity (VO_2 max). Kraemer, et al.[4] has shown reductions in power output following as little as three weeks of strength training cessation. Previous research has identified that short periods of detraining (8 weeks), can result in reduced aerobic fitness,[6] anaerobic power and sprint ability,[7] and increased percent body fat in elite athletes.[8]

Additionally, research by Reilly and Williams[6] suggest that players who start the season in a deconditioned state have to work extremely hard in an effort to try to reach the levels of fitness required for the start of the season in such a short period of time, which may in turn result in mental and physical fatigue during latter stages of the season.[9] For some time, researchers have shown interest in athlete burnout.[10-12] Athlete burnout is a concern in sport for various reasons, including the potential negative consequences for performance and welfare.[12] Burnout is an experiential syndrome with three central characteristics: (a) emotional and physical exhaustion, (b) reduced accomplishment, and (c) devaluation or cynicism.[13-16]

Currently, there is no data available describing tennis athletes' physiological response during a typical pre-season training period. It was hypothesized that the players would return from their three month summer break and experience decreases in their performance and mental variables throughout the fall tennis season as a result of training fatigue. Therefore, the purpose of this investigation was to examine preseason fitness levels and seasonal changes in fitness level, performance level, and perceived levels of burnout in 13 NCAA Division I collegiate women tennis players.

METHODS

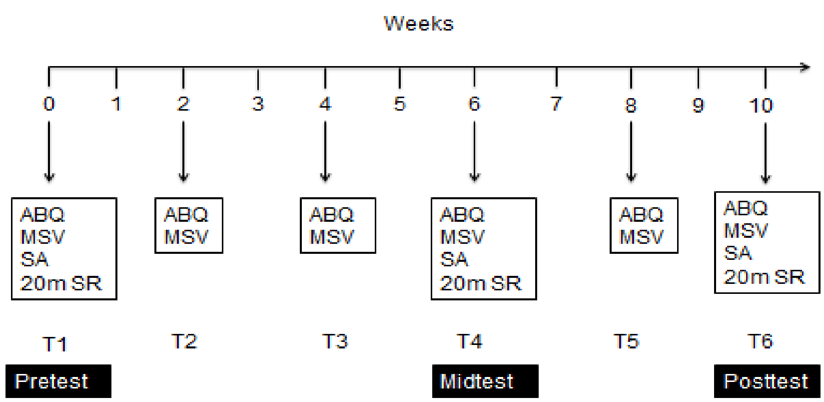
Subjects

Thirteen NCAA Division I collegiate women tennis players volunteered to participate in the current study (age = 19.69 ± 1.32 years, height = 168.82 ± 4.59 cm, weight = 64.75 ± 2.89 kg). The team had practice sessions 5 times a week, 120 min/session. Players had a mean of 10 ± 2.79 years of experience with a minimum of 6 years and a maximum of 14 years. Thirty-nine tennis practice sessions were performed by the players during the study. Each practice session consisted of a dynamic warm-up, tennis specific drills, technical and tactical training, point playing, and practice matches, both singles and doubles. Conditioning sessions were also implemented during practice sessions and would consist mainly of sprints, cone drills, mile repeats, and resistance band exercises. Also, all thirteen of the players on the team played a minimum of two college tennis tournaments while only four players played three tournaments during the fall season. Eighteen weight training sessions were performed by the tennis team during the fall season. The weight training sessions were performed two times per week on nonconsecutive days and focused on upper body exercises one session and lower body exercises the next session. Each training session consisted of three sets of ten to twelve repetitions at 70-85% of 1 repetition maximum (1RM). Before participation in the study, the experimental procedures and potential risks were fully explained to all the subjects. The University Institutional Review Board approved the study, and all participants provided written informed consent before participation.

Methodology

This study was conducted during the fall season and consisted of six testing sessions over a 10 week period during the teams regularly scheduled practice time 15:00-17:00. To test the hypothesis that the players would decrease in their performance throughout the fall tennis season as a result of fatigue, Division I collegiate women tennis players performed a series of both physiological and psychological tests throughout the fall season. Most of the data collection took place on the tennis court, at the beginning of the practice session. All players participated in a familiarization session before beginning any questionnaire or athletic test. Before the start of practice, the 15 item Athlete Burnout Questionnaire (ABQ) was administered in the locker room to the players. Following the ABQ the players performed their usual warm up on the tennis courts. After their warm up, players performed the Maximal Serve Velocity (MSV) test and the Spider Agility (SA) test, which were conducted on the tennis courts. Finally, the 20m Shuttle Run test was administered to all of the players in an indoor training facility. In addition, players reported session rating of perceived exertion (session-RPE) after each training session and training load was calculated by multiplying session-RPE by minutes trained. To assess the changes in the players performance, the ABQ, MSV test, SA test, and 20m Shuttle Run test were administered one week before official tennis practice began (pretest; T1), in the middle (midtest; T4), and end of the fall tennis season (posttest; T6). In addition, the ABQ and the MSV test were conducted every two weeks until the end of the testing period (T1 – T6) (Figure 1).

Figure 1. Study Design: Pretest, midtest, and posttest (T1, T4, and T6) with test procedures during the 10 week period. Testing was conducted every two weeks (T1-T6). T# is the testing session/time point. ABQ=Athlete Burnout Questionnaire; MSV=Maximal Serve Velocity; SA=Spider Agility; 20m SR=20m Shuttle Run

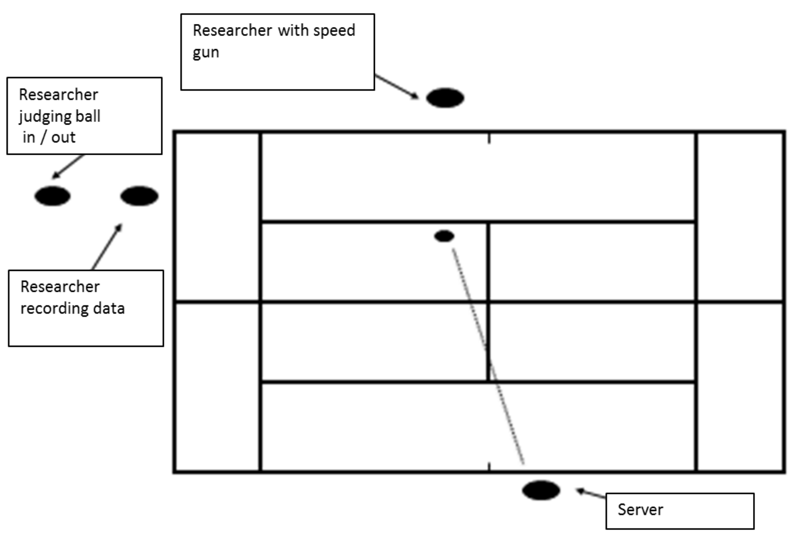


Instrumentation

*The 15 Item Athlete Burnout Questionnaire (ABQ)***.** The 15 item Athlete Burnout Questionnaire[15] consisted of three subscales: emotional/physical exhaustion, reduced sense of accomplishment, and sport devaluation. Internal consistency has been adequate for each of these sub scales: emotional/physical exhaustion (α= .92), reduced sense of accomplishment (α= .86), and sport devaluation (α= .92). Construct validity for this measure was supported by the relationships between the burnout subscales and theoretically related constructs. A global burnout index was computed by calculating the mean score from the three ABQ subscales.[15] The directions to the questionnaire were read out loud before players filled them out and special emphasis was placed on how each player was experiencing each statement listed on the questionnaire at that particular time, regarding tennis. Participants responded to items on a five point Likert- scale ranging from 1 to 5 (almost never to almost always).

Maximal Serve Velocity Test. A speed gun was used to assess the velocity of the tennis players' serve. The speed gun has been shown to be an accurate measuring tool when it comes to measuring an athlete's serve velocity. The speed gun was accurate to within +/- 1.0mph.[17] One week before official tennis practice started, baseline data was collected on all participants. Following baseline data collection, data was collected every two weeks at the start of tennis practice (Figure 1). Players conducted their usual warm-up routine, which included a dynamic warm-up and a 10-15 minute groundstroke, volley, overhead, and serve warm-up. As the players finished their warm-up, they were randomly selected and called in pairs to the testing court. A modified version of the serve velocity test employed by Kraemer et al.[18] was used to analyze serve velocity. At the testing court, each time, players were handed a new unopened can of tennis balls and asked to give their maximal effort to achieve five successful attempts for the serve. The service ball had to land inside the service box in order for it to be counted as a successfully completed attempt. Each attempt for serve velocity was recorded but limited to ten serve attempts, regardless of whether the player reached five maximal successful attempts. Each individual player's fastest serve was used for analysis (Figure 2).

Figure 2. Illustration of the Maximal Serve Velocity Test



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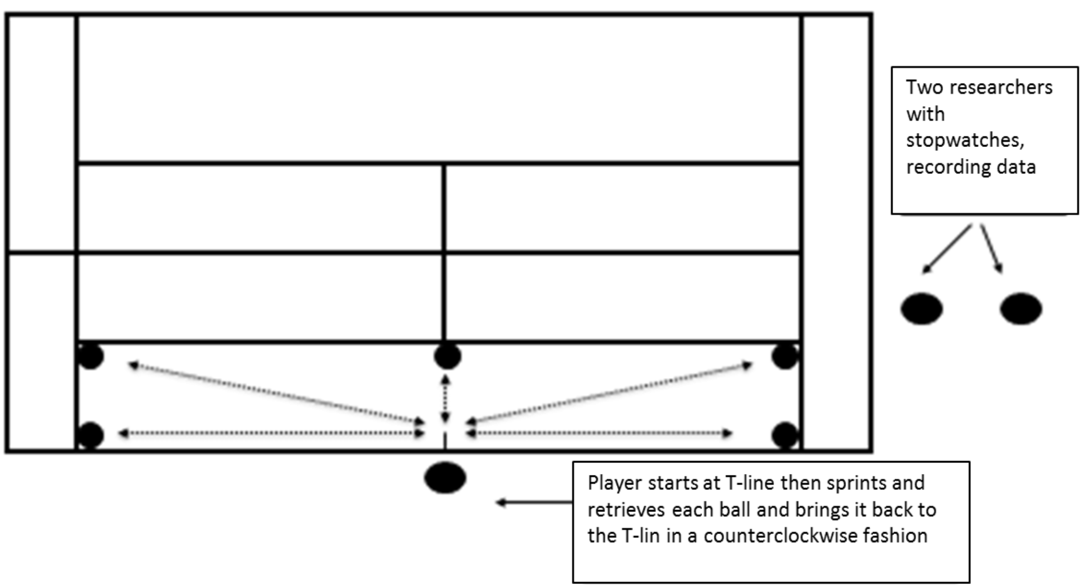
The Spider Agility Test. The SA test was used to assess agility on the tennis court.[1] The spider test is a valid and reliable test of agility for tennis players. The test-retest correlation indicates that the spider test shows a moderate to good reliability with values ranging from 0.70 to 0.83.[19] After the maximal serve velocity test, players were called to the testing court for the SA test. Time was recorded by two stop watches and the average of the two times was used for the player's attempts. The test was performed twice each trial and the best average score was recorded. There was a 3-5 minute recovery period for each player before performing the test for the second time (Figure 3).

The 20m Shuttle Run Test. The 20 meter shuttle run test was used to measure the athletes' aerobic capacity.[20] The correlation between VO2 max and shuttle level completed has been reported to be r= 0.92 and the test-retest reliability of the 20m shuttle run test results in r= 0.975. The 20m shuttle run test is a valid and reliable test for the prediction of the VO2max for male and female adults. This test involved running between two targets that were 20m apart in an indoor training facility. The test was conducted after the spider test was administered. The test started at an initial running velocity of 8.5 km.h-1, which increased by 0.5 km.h-1 each minute. The runs were synchronized with a pre-recorded CD, which released beeps at set intervals. As the test proceeded, the time- interval between each successive beep was reduced, forcing the athletes to increase their running velocity over the course of the test until it was impossible to keep in sync with the recording. The highest level and stage a player completed before twice failing to run the required distance in the required time became the player's score for this test. The final level and stage was then converted to VO2max (ml.kg-1.min-1) which was then analyzed for statistical purposes.

Figure 3. Illustration of the Spider Agility Test



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Internal Training Load.

The training load for each session was calculated using the session-RPE method.[21] Recent research suggests that this method is valid and reliable for quantifying training load during a wide variety of exercise conditions.[21] This method involves multiplying the training duration in minutes by the training intensity. The training intensity was measured using Borg's CR10 scale.[22] The players were asked "How intense was your session?" and were requested to make sure that their RPE referred to the intensity of the whole session rather than to the most recent exercise intensity. Training load was added up for each player at the end of every week for the fall season. The average workload for all the participants was calculated for each week. Throughout the fall tennis season, each tennis player was expected to complete the RPE scale immediately following the end of each tennis practice session, conditioning, and/or weight training session.

Statistical Analysis

Data are reported as: mean ± SD. The dependent variables included: the single maximal effort of the serve (km.h-1), the players best time for their agility (sec), the players maximal cardiovascular capacity (VO2max) (ml.kg-1.min-1), training load (RPE x min), and finally the players psychological fatigue measured throughout the fall season (ABQ GBI score). The statistical power and effect size were calculated using GPOWER version 3.1.[23] For this study a sample size of twelve was recommended to yield a power of 0.80 at a significance of 0.05. A One Way ANOVA with repeated measures was utilized to evaluate differences between the pre-, mid-, and post-tests for the players' maximal cardiovascular capacity/VO2max and SA test time. The same statistical test was used to detect any significant changes across the season for players' GBI score, MSV, average serve velocity, and training load. When appropriate, a Fisher's protected LSD post hoc test was used to determine pairwise differences between means. A dependent t-test was also used to determine statistical differences between the player's baseline MSV values and the last, and the team's first week (week 1) training load and their last (week 10). Finally, trends in performance were interpreted using Cohen's *d* effect sizes. The thresholds for these effects were set at 0.50-0.79 as 'moderate', and 0.80 as 'large'.[24] The SPSS statistical software package version 18.0 was used for statistical calculations. The level of statistical significance was set at p= 0.05.

RESULTS

Maximal Cardiovascular Capacity/VO_2max

The VO_2max of the tennis team showed a significant increase from the beginning of the season to the end (p<0.001, ES: Cohen's d= 1.48). When scrutinized further, the data suggest there is a significant increase in players' VO_2max from the pretest to the mid-test (p<0.001, ES: Cohen's d= 1.09), but there were no further significant changes between the mid-test and post-test (Figure 4; Table 1).

Spider Agility Test

There was not a significant effect across the season for the players' SA Test times (p=0.10) (Table 1).

Global Burnout Index score (GBI)

The athletes' GBI score, which was computed by calculating the mean score from the three ABQ subscales, did not show a significant effect across the season (p=0.21)(Table 1).

Maximal Serve Velocity

There were no significant differences in the athletes' MSV throughout the fall season (p=0.50)(Table 1).

Training Load

There was a significant effect for training load across the fall season (p=0.002). A dependent t-test did show a significant decrease (p<0.001, ES: Cohen's d=1.31) in the players' training load from the first week compared to the last week of official practice (Figure 5).

Table 1. Pre, mid, and post-test values for VO_2max, spider agility test time, global burnout index score, training load, and maximal serve velocity (N=13)

Variable	Pre-test	Mid-test	Post-test	*P-Value*
VO_2max (mL/kg/min)	34.2 ± 4.4	39.1 ± 4.1	40.4 ± 3.5	0.001*
SAT (s)	18.6 ± 0.8	18.2 ± 0.8	18.3 ± 0.9	0.10
GBI	2.4 ± 0.5	2.4 ± 0.6	2.5 ± 0.5	0.21
Training Load	3000.0 ± 670.1	1413.3 ± 521.9	1947.7 ± 920.5	0.002*
MSV (km/hr.)	147.1 ± 8.2	144.7 ± 8.9	141.6 ± 8.2	0.50

Data are Mean ± SD. VO2max = maximal oxygen consumption; SAT = spider agility test; GBI = Global Burnout Index; MSV = Maximal Serve Velocity; * Significance p≤0.05

Figure 4. Change in VO_2max values for the 20m Shuttle Run Test during the study. Data are mean ± SD. *Significant increase in the team's VO_2max from the pre test to the mid test (p<0.001). #Significant increase from the pre test to the post test (p<0.001).

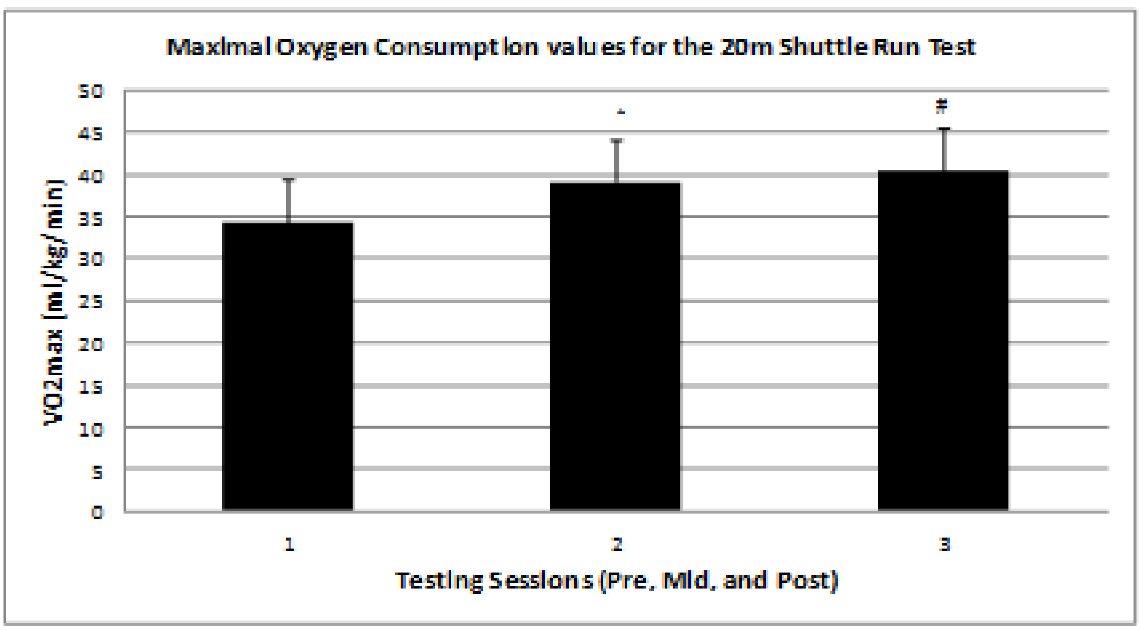

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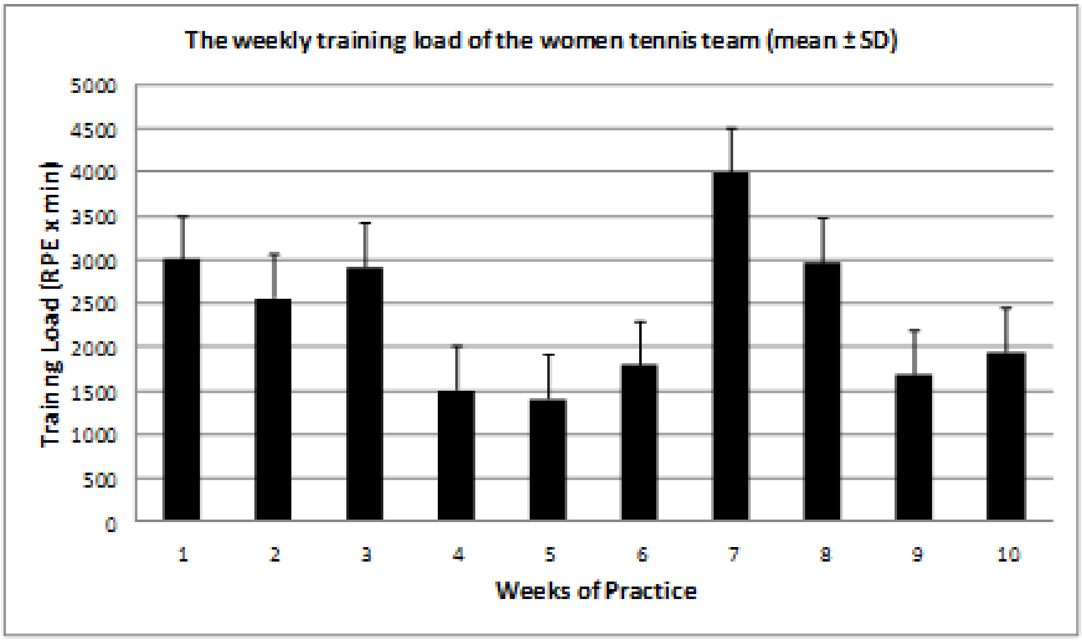
Figure 5. Change in the Weekly Training Load of the Women Tennis Team during the study. Data are mean ± SD. There was a significant decrease in training load from the first week compared to the last week ($p<0.001$).



DISCUSSION

The primary purpose of this investigation was to examine preseason fitness levels and seasonal changes in fitness level, performance level, and perceived levels of burnout in thirteen NCAA Division I collegiate women tennis players. An important finding was that the subjects' aerobic capacity, measured as VO_2Max, which was estimated via performance during the 20m shuttle run, increased significantly across the fall tennis season. Another finding was that the team's training load did show a significant fluctuating effect throughout the ten week experimental period. Lastly there were no significant differences for serve velocity, burnout and agility. Contrary to our initial hypothesis, there were no significant decreases across the season in the player's physiological variables (aerobic capacity and agility), performance variables (serve velocity) and psychological indicators (burnout). The present results indicated that fatigue and under recovery were not significant factors in this investigation. The results showed that there was a significant increase in the player's VO_2Max value across the fall tennis season, indicating that seasonal training improved the subjects' aerobic capacity. There was a significant increase in the player's aerobic capacity from the beginning of the season to the middle of the season and then a non-significant increase from the mid-season to the end of the season. This change may be attributable to the fact that the players returned to pre-season training in a detrained state, due to the summer break of approximately three month duration. During the summer break the players were not involved in a structured aerobic fitness program and training was unsupervised. A significant increase in pre-season aerobic fitness is similar to previous studies,[2] which attribute these increases to high levels of aerobic training performed during the preseason. Preseason aerobic training during practice coupled with the

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preseason matches would have helped to increase their aerobic capacity and VO_2 max. Also, research by Ekblom[25] suggests that increases in VO_2max such as these are the result of continuous aerobic training and match play during this period of the season. Achieving an optimal level of aerobic fitness prior to the competitive season would ensure that more time is spent training other important physical components of performance.

The spider agility test relies heavily on the energy from glycolytic ATP turnover.[26] Due to detraining, the team's slowest spider test times were found in the pre-test. The results showed that the time for the spider agility test improved significantly from pre-test to mid-test. The majority of points during tennis matches last less than 10 seconds, indicating that the times measured during the agility test might have important implications on performance.[3] If athletes' agility times get slower during unsupervised breaks, it would suggest that their on-court performance would be reduced due to the inability to effectively chase down balls and/or set up for shots as quickly as other athletes. On examination of these findings, it is clear that detraining had taken place in two very important physical components for tennis players: aerobic capacity and agility.

There were no significant differences in the athletes' MSV throughout the fall season. However, the highest maximal serve velocity occurred during the first testing session and the slowest occurred at the very last testing session. A possibility as to why the participant's serve velocity decreased across the fall season could be because they did not follow a periodical resistance training program which was suggested by Kraemer et al.[18] to significantly improve serve velocity. Also, the athletes' Global Burnout Index (GBI) score did not show a significant effect across the season. However, there were significant increases in the players' GBI score from the first administration to the last administration of the ABQ. The second time the questionnaire was completed was two weeks into the preseason and was the highest of the six scores. This finding may indicate that the players were struggling with conditioning and tennis practice sessions after returning from their summer break.

One of the limitations of this study was that there was a lack of random sampling in participant selection due to the use of convenience sampling. Also, the interest and motivation to answering questions by the players on the Athlete Burnout Questionnaire and Borg CR10 scale cannot be ensured. Another limitation of this study was the small sample size (n=13). Although this study did find significance in some variables, a larger sample in future studies might find greater significance and provide increased support for these findings and recommendation. Lastly, training load was estimated by perceived exertion and minutes trained. RPE is a volitional scale and is subjective in nature, thus highly variable. Additionally, the time spent in minutes during training sessions, conditioning sessions, or workout sessions are all different ways to train and/or condition, and could therefore have affected training load.

CONCLUSIONS

This study is the first of its kind to investigate changes in fitness variables over a complete fall tennis season in collegiate women tennis players. The results of this study highlight the need for tennis coaches and strength and conditioning specialists to analyze their players' post-break physiological variables to ensure that detraining did not occur during the off-season. More research is warranted in this area, especially to see how these results might change from the end of the Spring season (major competition period) to the beginning of the Fall season (pre-season).

To avoid significant reductions in sport-specific fitness during the off-season players should undertake offseason "maintenance" training that incorporates all of the sport-specific fitness components. Tennis coaches and strength and conditioning specialists could enhance the compliance of athletes to training programs by implementing post break performance standards such as written logs of training during the break and weekly phone calls or emails to players to ensure that the training programs are being followed. These suggestions could decrease the potential for detraining and ensure more time could be spent on other important determinants of tennis performance rather than focusing on each player's aerobic/anaerobic fitness level.

In summary, based on the initial poor levels of aerobic capacity and agility, it is vital that proper programs and protocols be implemented to avoid detraining during the summer break to ensure that the players return from their break ready to train and compete.

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