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Effects of 4-Week QuickBoard Training on Reaction Time, Foot Speed and Sport Specific Agility in Female Collegiate Tennis Players: A Pilot Study.

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EFFECTS OF 4-WEEK QUICKBOARD TRAINING ON REACTION TIME, FOOT SPEED AND SPORT SPECIFIC AGILITY IN FEMALE COLLEGIATE TENNIS PLAYERS: A PILOT STUDY.

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ABSTRACT

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Agility is an important component for successful performance in many sports. The present study aimed to examine the effects of a 4-week QB training on foot speed, reaction time and sport-specific agility performance in elite female tennis players. Eight collegiate female tennis players (*M* = 20.1 years old, *SD* = 1.5) were recruited and randomly assigned to either the training or control group. , The training group participated in a 20-minute QB training session twice a week across 4 weeks, in addition to their routine workload, while the control group continued their routine activities only. The results of the pre- and post-test showed that the training group significantly improved reaction drill performance than the control; however, not for foot speed drill and spider drill performances. These findings suggest that QB training will benefit foot reaction time in female collegiate tennis players, but not on sport-specific agility test performance.

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Introduction

The evolution of tennis has come not only from the ability to design modernized equipment, but also because of the recruitment of bigger, stronger, and faster athletes due to improved training, recovery, and nutrition (Kovacs, 2007). In order to be successful in tennis, players must excel in the tactical, technical, physical, and psychological aspects of the sport (Cannell, 2011). Most importantly, rapid acceleration and deceleration have to be maintained over a long period of time. During game time both the anaerobic and aerobic systems are being utilized, with the anaerobic system making up 70% of the total effort (Cannell, 2011; Lockie, Schults, Callaghan, Jeffriess, & Berry, 2013). Speed and quickness in direction change (i.e., agility) are major components when assessing a player's movement (Kovacs, 2007). According to the literature, agility involves speed and accuracy of movement, technical footwork, and decision-making for an athlete's ability to move quickly and effectively on the court (Cooke, Quinn, & Sibte, 2011). It is also referred to as the ability to maintain or control body position while quickly changing direction during a series of movements in response to an external stimulus (Asadi, 2012; Cooke et al., 2011). It appears clearly that agility is an important quality for any successful tennis players.

The most important aspect of agility is speed, which is critical to tennis players. While genetic traits play a role in an athlete's speed, sport-specific speed training and practice are what help a player reach his highest potential (Galpin, Li, Lohnes, & Schilling, 2008). Moreover, tennis skills are open skill or reaction time sport skills. The importance of training reaction time is to avoid any moments of hesitation, which could lead to chaos during a point. Every shot in tennis is based off where the opponent is standing, where their shot is coming from, where the opponent is on the court, and the speed and spin that has been placed on the ball (Wang, 2009).

There are two well-known training methods when the goal is to improve agility performance, which are plyometric training and the speed, agility, and quickness method (SAQ) (N. Martin & Martin, 2011). Plyometric training involves many of the same characteristics as agilities, including stopping, starting, and changing directions in an explosive manner (Li, McColgin, & Van Oteghan, 1998; Lockie et al., 2013; Maman, Gaurang, & Sandhu, 2011). Because tennis involves constant explosive movements, plyometric training may be beneficial for tennis players looking to maximize their potential. In addition, SAQ training involves training multiple areas (i.e., speed, agility, and quickness) simultaneously. In this method, each area is broken down and then combined in a single drill to allow players to train in an aspect that can be related back to performance (Parson & Jones, 1998). This allows for players to prepare their bodies for the stress it will undergo during competition.

In addition to speed, decision-making and reaction time are also essential for a tennis player to be successful. Playing tennis has been referred to as a visual stress test (Maman et al., 2011). An athlete's ability to react quickly to a moving, visual stimulus not only depends on eyesight but more importantly vision. The difference between the two are that eyesight is measured by looking at a standard eye chart whereas vision is measured by the brain's ability to interpret information picked up by the eyes, especially moving stimuli in a short amount of time (Maman et al., 2011). Therefore, vision training would benefit tennis players to react quicker to a moving tennis ball by improving judgment and response. Anticipation and perception of visual cues are vital areas that, when trained, can be significantly improved. Also, participating in daily competitive practice or play can help maintain reaction time abilities. For example, a study examined National Basketball Association (NBA) players throughout the course of an NBA season (Gonzalez et al., 2013).The players were tested at the beginning and end of the competitive season. It was found the starters were able to maintain their level of reaction time faster than non-starters. Therefore, a competitive practice and match schedule in addition to training on the QuickBoard may lead to an increase in reaction time.

In tennis, both shot selection and the outcome of each point depends on a player's movement skills (Verstegen & Marcello, 2001). The movements in tennis can be broken down into three categories: forward, sideways, and backward. These movements occur approximately 47%, 48%, and 5% of the time during a match, respectfully. In terms of distance, a tennis player moves on average three meters per shot and a total of eight to twelve meters per rally (Lockie et al., 2013). This means the shot is within range of the player, but the player will have to move according to where the ball is bouncing in order to be in ideal position to hit the best shot possible. This requires short, quick, and accurate reactive steps that can be trained and improved through appropriate training strategies.

Coaches and players are eagerly looking for the effective ways of training to gain the best footwork and improve overall agility.

The QuickBoard (QB; The QuickBoard, LLC) is a relatively new developed training tool that can be used for training foot speed and choice reaction speed. Accuracy of movement and technical footwork are important aspects of agility that are necessary for tennis, especially when players have to move to hit a shot close to their body (Cooke et al., 2011). The QB training tool can be used to test and train individuals while being able to monitor progress. Multiple drills can be performed, including count drills (i.e., number of steps in x seconds) and reaction drills (i.e., number of seconds to complete x randomized steps). Not only does the QB possess the ability to assess the processes involving decision-making, action planning, and movement execution, but studies have also shown the QB leads to improvement in agilities (Girard, Lattier, Micallef, & Millet, 2006).

A recent study used the QB to examine the effects of a 4-week choice foot speed and choice reaction training program in 23 active, non-agility trained men and women (Galpin et al., 2008). The participants were randomly assigned to control or training group conditions. . Both groups performed the pre-test and post-test, but only the training group took part in a 4-week training with 12 supervised sessions (three times a week and 20 min each time). During the testing, subjects performed two QB drills. The drills were a foot speed drill and a choice reaction drill, which determined the amount of touches they could obtain during a specific time period and how many seconds it took them to obtain 10 randomized foot touches, respectfully. Each drill was performed three times at maximum effort. All participants also completed a change-of-direction drill during the testing period. This drill consisted of the subject running a maximum-effort sprint of 5 meters with three changes of direction, equaling 20 meters. This was also completed three times with a 150-second break. During the training sessions, subjects only trained on the QB. At the end of the study, significant improvement on each of the test performances was found in the training group; however, the control group did not improve on any of the tests. The results suggest that the QB training may be a useful training tool for activity in young adults attempting to improve agility. It would be interesting to see if the QB training can benefit tennis players because of the necessity of quick feet and reactions during performance on court.

In another study, Parsons and Jones (1998) presented training techniques for each area that are essential to tennis, including speed, agility, and quickness. These sport specific drills were recommended to be used to better train tennis players to move more quickly and efficiently. The previously used change-of-direction drill is beneficial for subjects who are in a sport where sprinting straight is common throughout a competition. For tennis players, however, a drill that involves sprinting, backpedaling, and shuffling would be more appropriate to a match-situation. By replacing the change-of-direction drill as mentioned above with a star drill, which involves sprinting, shuffling, or backpedaling in all directions, subjects are required to move in a way that would normally take place during a tennis competition. This would benefit the athletes because of the ability to apply the test to field performance.

Implications for Future Research

One limitation in the related literature is no previous study has investigated the training benefits of the QB on athlete population. Specifically, the question remains unanswered that if the similar findings would be observed by using elite athletes when examining improvements in agilities on the QB. Another limitation would be the lack of applying these drills to field performance situations (Cooke et al., 2011). Previous studies have used linear speed drills to determine improvements from the QB training. However, it would be valid to incorporate a drill or test that would be sport-specific for tennis players.

Purpose

The purpose of the present study was to examine the effects of a 4-week QB training on foot speed, reaction time and sport specific agility in elite female collegiate tennis players. Based on related research literature demonstrating that training on the QB would lead to an improvement in agility for young active adults, it was hypothesized that the 4-week QB training would improve agility performance in elite female collegiate tennis players. Specifically, 1) the performance of the two QB drills would be significantly improved by the training group; 2) the performance of the spider drill on tennis court would be improved by the training group.

Methods

Participants

The study used eight collegiate female tennis players with at least 10 years of playing experience. They were recruited from the University of Memphis tennis team. The participants completed a physical and filled out a medical history questionnaire. No one had previous experience with the QB. All the participants signed a consent form as well during the study. They were also asked to complete a pre- and post-test self-report survey during the study.

Equipment

The device used for this study was the QuickBoard, developed by The Quick Board, LLC (Figure 1). The board consists of a rubber mat positioned on the ground with sensor pads in five locations (upper right and left, lower right and left, and center). This mat was connected to a power cord and run to a control device that provides visual stimulus (i.e., five bright lights that correspond to the five foot pads) and feedback information about the results of the movement responses (see Figure 1). The control pad also allows for the command of all sequences and drills.

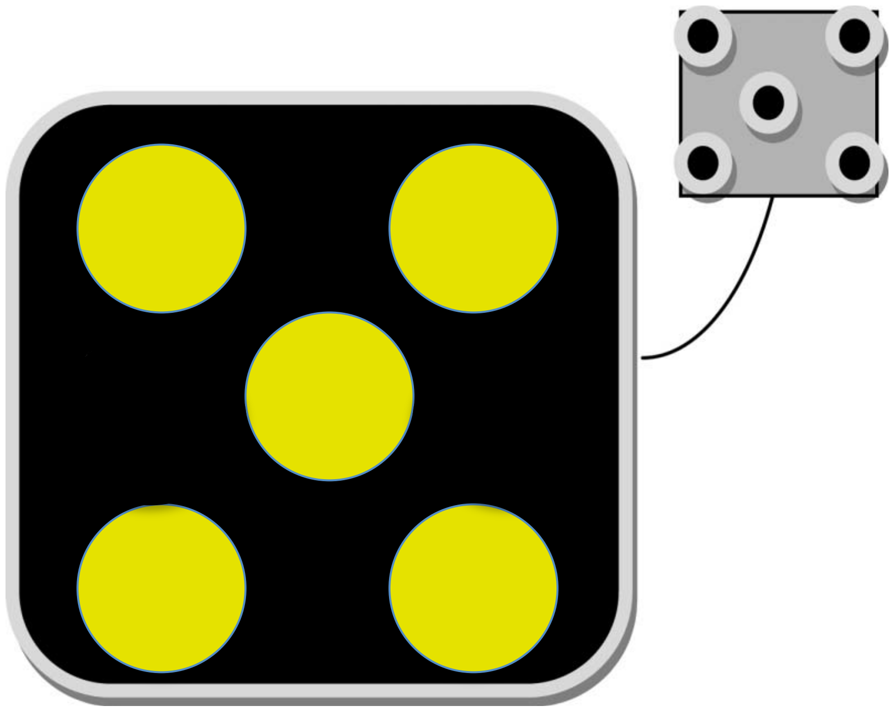

Figure 1. QuickBoard and visual stimulus used to train and test subjects

Experimental Design and Procedure

A pre- and post-test design was used for the study. The players were randomly divided into control and exercise groups (*n* = 4 for both the training and control group). Training length was a total of 4 weeks.

Testing Protocol. There were a total of three drills used in pre- and post-test. These were a Spider drill and two drills on the Quick Feet board (i.e., a foot speed drill and a reaction speed drill).

Spider Drill. This drill required the subjects to sprint, shuffle, and back-peddle in eight different directions. Specifically, the subject started in the middle of a tennis court before sprinting, shuffling, and back peddling in 8 different directions as quickly as possible. The directions were: 1) Sprinting forward, 2) Sprinting to the top right corner, 3) Sprinting/shuffling to the right sideline, 4) Sprinting/shuffling to the back right corner, 5) Backpedaling to the baseline, 6) Sprinting/shuffling to the back left corner, 7) Sprinting/shuffling to the left sideline, and 8) Sprinting to the front left corner (see Figure 2). Each subject performed the Spider drill twice, with the first trial being a fixed sequence in 8 directions. The second trial used a random sequence. In the random sequence test trail, the direction of the movement was based on random order and conveyed through a verbal signal by a tester. Players were then required to make a quick reaction to the signal. Therefore, it not only tested the athletes' good techniques and fast footwork, but also effective decision-making process.

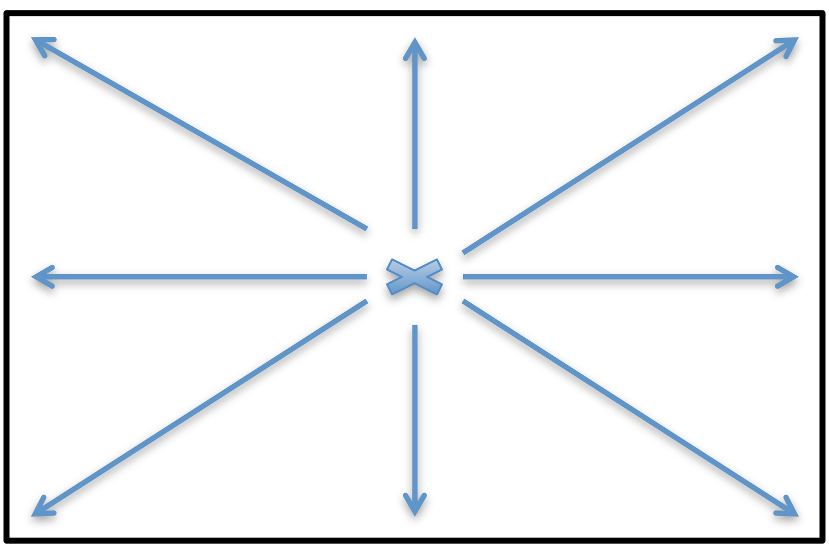

Figure 2: Spider drill used to test subjects. Consists of 8 different directions the subjects must sprint, shuffle, and backpedal toward.

Foot Speed Drill (QF Board). Subjects began with both feet in neutral position (without touching any sensors). A 5-second countdown informed the subject when the test would begin. Once the countdown ended, the subjects touched the right foot to the top corner of the board. Immediately after touching the corner the left foot quickly followed, touching the opposite top corner. Once completed, the right foot returned to neutral position, followed by the left foot. This process was completed as quickly as possible for the duration of the test.

Reaction Speed Drill (QF Board). Subjects stood on the QF board in neutral position. Following a 5-second countdown, subjects watched the control box consisting of 5 separate lights that correspond to the board. This directed the subjects as to where to step during the test. Subjects were asked to react to the stimulus on the panel as fast as possible. When the first light appeared on the panel the subject touched the corresponding mark on the board before returning back to the start position. The subject continued this until 10 touches had been completed. Subjects completed 10 touches in each trial for a total of 3 trials separated by 30 seconds.

Test Schedule

Familiarization. All participants completed a familiarization session in which they practiced all three test drills at their maximum effort for a minimum of three trials each. During this time, all participants also completed necessary paperwork (Galpin et al., 2008).

Pre- and post-test. A pre-test was conducted on all players at the end of week 1 (following familiarization). There was a warm-up consisting of 5 minutes of cycling. Players began with the Spider Drill, having one warm-up trial before beginning the test. The first Spider was fixed, letting the players choose the direction they wanted to run first but having to go in order of the selected spots. The second Spider was random, with the verbal commands being given right before the player made it back to the center of the court. Time was taken using handheld stopwatches and was started on the “begin” command and stopped as soon as the players stepped on the “x” marking the middle of the court at the end of the drill. Following the Spider drill, participants did 2 different QuickFeet Board drills. The first was the foot speed drill. The number of touches completed was recorded by the CAT (computerized agility training) software. Subjects stood on the QuickFeet board in ready position and obtained as many touches as possible in ten seconds for each trial. Three trials were completed separated by 30 seconds rest. The second was a reaction drill, which included 10 foot touches. Subjects stood on the board in ready position and touched ten different spots in the shortest amount of time. This was also performed three times with a 30-second break (Galpin et al., 2008). The same procedure was used in the post-test.

Training Protocol

In the 4-week training, subjects in the exercise group completed 2 training sessions on the Quick Feet board, lasting 20 minutes each session. A warm-up was performed consisting of 5 minutes of cycling.

The first drill was a foot speed drill. Subjects began with both feet in neutral position. This was the same as described above for pre-testing, with the subjects moving forward and backward as quickly as possible in ten seconds. This was performed three times separated by 30 seconds.

The second drill was the reaction drill. This was also the same as described above, with participants touching ten different randomized spots as quickly as possible. This was performed three times separated by 30 seconds.

The third drill was a foot speed drill. This was different than the first foot speed drill. In this drill, subjects stood on the side of the board between the top right and bottom right spots. After the 5-second countdown, subjects moved their right foot to the right onto the spot, followed by their left foot onto the second spot. The right foot then returned back to the start position, followed by the left. This was done as quickly as possible for ten seconds. There were a total of three trials performed separated by a 30-second rest.

The final drill was a reaction drill. It was the same as mentioned above. There were three trials performed separated by 30 seconds (Galpin et al., 2008).

Training Schedule

Week 1: Familiarization, self-report survey and form completion

Week 2-5: The training group completed 2 sessions each week for 20 minutes; The control group continued their normal training with the team, but they did not train on the Quick Feet board.

Week 6: A post-test was conducted on all players.

Statistical Analysis

A descriptive statistical was conducted on all the dependent measures to get the condition means and standard deviation. A 2 (condition: training vs.

control) X 2 (test: pre-test vs. post-test) ANOVA with repeated measures on the second factor was used to test the hypotheses (i.e., the 4-week training on QF board would show a significant improvement on agility test performance compared with the control condition. Specifically, the data analysis would examine if there would be an interaction between the two factors, Condition and Test.

Results

Of the 8 subjects that began the study, 5 successfully completed the study and were included in the data analyses. The 3 subjects who dropped out of the study had ankle or knee injury during the fall season matches. This resulted in 3 subjects in the training group and 2 in the control group. The 2 subjects in the control group also participated in the training group after the post test, leading to the 5 subjects in the training group. The average age of the five participants was 19.2 years (*SD* = .75) with an average of 12.2 years (*SD* = 2.48) of tennis play experience.

Means and standards deviations for the two groups in the pre- and post-test performances are presented in Table 1. The results of the ANOVA showed a significant Test-by-Condition interaction in the foot speed test and the reaction time test ($F_{(1,5)} = 10.848$, $p = 0.022$; $F_{(1,5)} = 7.796$, $p = 0.038$). The follow-up test did not show significant results for the training group in the foot speed test ($p = 0.135$). The follow-up did indicate that there was a significant improvement in the post-test for the reaction time test in the training group ($p = 0.048$); however, there was no such a difference in the control group for either test. The effect size for reaction time was 0.528, suggesting a moderate effect was observed (Figure 1).

For the spider tests, the results showed no significant differences for the main effects and interaction (Figure 1). These results suggest that although the training group had slightly greater improvements in the post-test, the difference did not reach the significance level, with lower effect sizes for the fixed and random tests being 0.301 and 0.280, respectively.

Table 1

Means ± SD, p-values, and effect size for both Control and Training groups. (symbolizes significant effect)*

Drill	Mean ± *SD*	*p* Value	Effect Size
FS (touches)			
Control			
Pre	26.00 ± 2.83		
Post	22.00 ± 0.00		
Training			
Pre	23.20 ± 1.30		
Post	24.60 ± 1.52	0.022*	0.685
RT (seconds)			
Control			
Pre	6.22 ± 0.22		
Post	6.42 ± 0.05		
Training			
Pre	6.10 ± 0.30		
Post	5.85 ± 0.23	0.038*	0.609
Spider (seconds)			
Fixed			
Control			
Pre	23.55 ± 1.13		
Post	23.45 ± 0.42		
Training			
Pre	22.99 ± 0.10		
Post	22.48 ± 0.84	0.641	0.301
Random			
Control			
Pre	24.58 ± 0.95		
Post	24.46 ± 0.52		
Training			
Pre	24.52 ± 1.52		
Post	23.64 ± 1.56	0.356	0.280

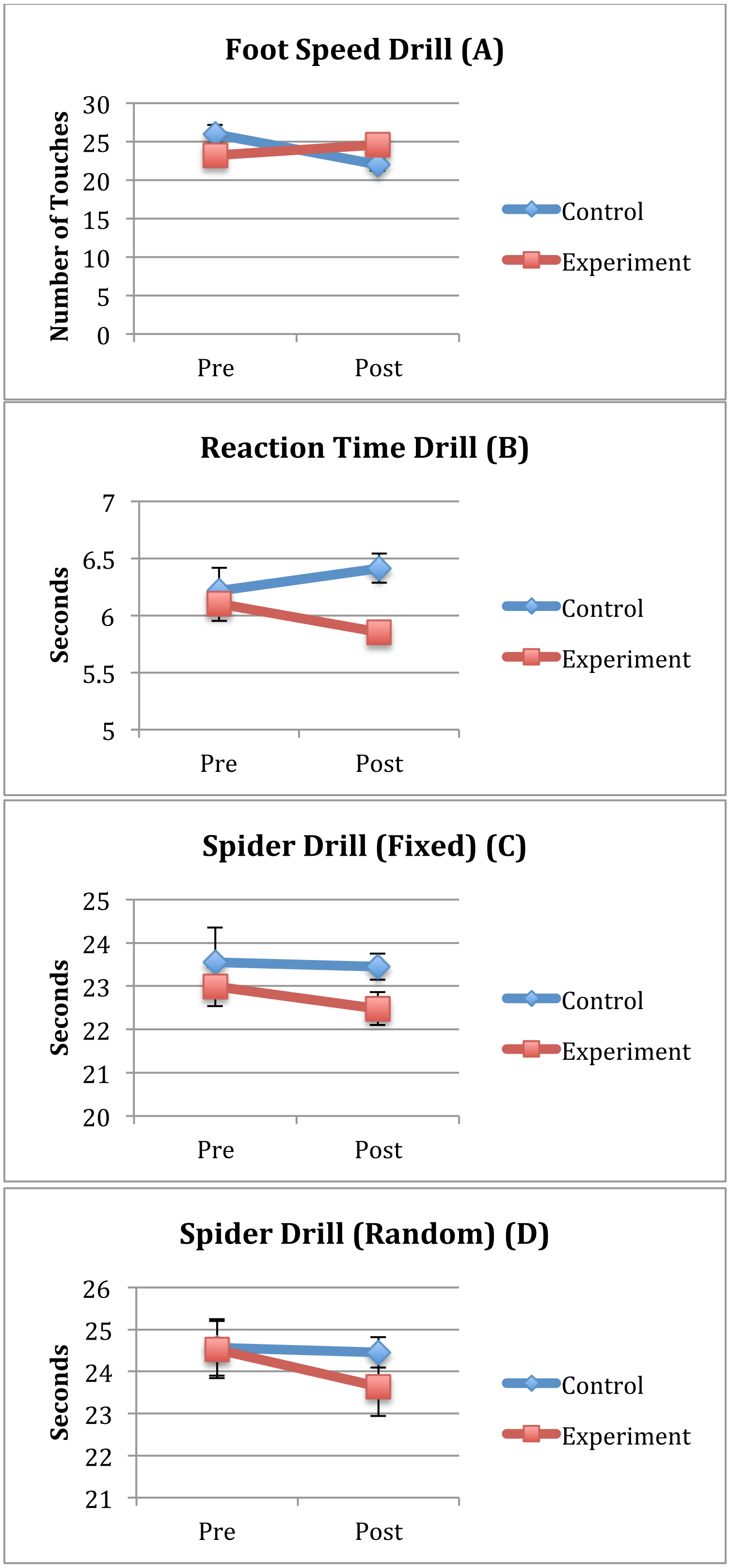

Figure 3. Pre- and post-test performances of the RT (A), FS (B), and spider drill-fixed (C) and spider drill-random (D) for the training and the control groups.

Discussion

Previous research (Galpin et al., 2008) has suggested that training on the QuickBoard could produce significant improvements in reaction time and foot speed as well as in change-of-direction tests, using active non-athlete young adults. The current study aimed to examine the effects of a 4-week QuickBoard agility training on elite female collegiate tennis players. The following two hypotheses were tested: 1) the performances of the RT drill and FS drill on QB would be improved following the 4-week QB training. 2) A positive transfer on spider drill performances would be observed in the post training evaluation.

Reaction Time and Foot Speed

The results revealed a significant decrease in reaction time in the training group following the 4 weeks of training; however, there was no difference for the control condition (i.e., no-training). The findings supported the hypothesis and were consistent with the previous study in which a significant improvement in the reaction time test was found for a group of non-agility trained young adults in a 4-week QuickBoard training study (Galpin et al., 2008). This finding is imperative because testing reaction time on the QuickBoard in an athletic population has not yet been investigated. It suggests that training on a piece of equipment could improve athletes' reaction time. Due to the randomization of the sequence of the reaction drill during both training and testing, the improvement in reaction time is likely related to enhancement of decision-making process and eye-foot coordination.

Previous research has found vision training in male collegiate tennis players led to a significant increase in judgment and response during a match (Maman et al., 2011). Increase in reaction time due to training by a visual stimulus is essential in tennis because of the improvement in vision, which is how well the brain can interpret the information picked up from the eyes of a moving object. Increasing the judgment and response in a match allows the player to have more time to move to the ball, leading to fewer mistakes based off slow reactions. The improvement found in the current study not only trains foot-eye coordination by forcing the subject to step on the correct dot, but it also trains the brain to react quicker to the visual stimulus (Maman et al., 2011).

Previous research also found that participating in competition on a regular basis helps maintain reaction time (Gonzalez et al., 2013). The subjects in the current study were in the middle of the fall season during data collection, which means each player would be competing in five to six individual tournaments over the course of four months. These tournaments included matches against top-ranked national collegiate opponents meaning the match play would be extremely competitive. This would indicate that practice and competitive match play would allow the subjects to maintain their reaction time without the QuickBoard training. Therefore, if 4 weeks of agility training on the QuickBoard is added to the already existing performance, then the subjects' reaction times should show a significant improvement. This explains the significant improvement found in the training group condition following the training period. This is also supported by there being no learning effect in the control group. The subjects in the control group performed training following their 4 weeks of no training and only team practice.

It was noticed that the results showed a significant improvement in foot speed through QB training as well, which was consistent with the previous study (Galpin et al., 2008). However, the follow-up t-test did not show a significant finding. One possible reason could be due to different subject populations used in the studies. The higher athletic level, the less room for the improvement. This is also related to the sensitivity of the measurement. This test measures in steps within 5 seconds. Once the subject reaches a certain level there might be a ceiling effect, making it difficult to show significant improvement. Moreover, this drill requires a player to move quickly in steps while maintaining dynamic balance. There were occasions where subjects were going too fast and ended up sliding or shifting, marking the trial void. This could also affect the accuracy and sensitivity of the measurement. Although there was not a significant finding, the data showed a tendency that an increase in the post-test was observed for the training group only.

Spider Drill

The spider drill was used to test if training on reactive responses and foot speed would transfer to athletes' agility performance using tennis-specific movements. This type of drill simulates a step-rhythm drill, which is shown to be beneficial for tennis players when pairs with specific direction-change movements (Benko & Lindinger, 2007). The results of the current study in both fixed stimulus sequence and random sequence failed to support the hypothesis that QB training would improve the performance of the spider drills. Majority of the previous studies used the pre-planned agility movement in the tests, such as a change-of-direction running (COD), t-test, agility speed ladder, and the Illinois agility run (IAR) (Asadi, 2012; Cressey, West, Tiberio, Kraemer, & Maresh, 2007; Galpin et al., 2008; Hess, Joyce, Arnold, & Gansneder, 2001; Lockie et al., 2013; G.M. Miller, Herniman, Ricard, Cheatham, & Michael, 2006). The shortcoming for the fixed movement directions is that the decision-making aspect of agilities is taken out. The current study added a spider drill with a random stimulus sequence. Specifically, a subject has to react to a random signal for the next movement direction, i.e., either front or back, left or right. The test gives the subject eight possibilities for a direction change whereas the reactive test used in Farrow, Young, and Bruce's study provided options of only right or left for the decision making aspect of the drill.

Galpin et. al,(2008) found that a planned change-of-direction drill in non-agility trained subjects significantly improved after foot speed and reaction time training on the QuickBoard. The current study used both fixed and random spider drills to examine if the significant decrease in reaction time would transfer into the spider drills, ultimately transferring into sport performance. However, the results were not consistent with the report by Galpin et. al, (2008), although a clear tendency was noticed that, in both pre-planned agility movement and reactive test condition, the training group showed greater improvements than the control condition. It is believed the small sample size and short training period were the possible explanations for the non-significant findings in the spider test performances. Further investigations using larger sample sizes and longer training periods would be recommended.

Coach Interview

Following the conclusion of the study, an interview with the coach was conducted to see if any difference was observed during practice and performance. Overall, the coach was pleased with the study and the benefits that resulted. One major improvement included the players' abilities to utilize speed and movement without sacrificing balance. This allowed the players to not only move quicker to the ball, but to also be in a position to successfully execute the shot. However, there was one concern related to reaction time. He found that the players had a problem utilizing the reaction time, resulting in a sense of rush and anxiety during matches. This can be problematic because when a player feels rush they have the tendency to swing the racquet too early resulting in errors. From his professional opinion, he feels it could be from the players being unaccustomed to being able to react quicker. He also noticed once the players recognized this sense of anxiety they were able to perform better.

Practical Application

The ability to apply the previous training and testing performances into tennis competition is imperative for this study due to limited elite athletes being studied. As the dynamic characteristics associated with tennis, each drill has ample benefits to a player's game allowing for application in multiple areas. The reaction drill helps players' decision making ability and eye-foot coordination. In tennis, the first thing a player must do is successfully identify the shot made by the opponent and move efficiently to the ball. This would require eye-foot coordination in order to take the correct and fast first steps or to change directions quickly while maintaining balance. This is also where foot speed is utilized. Once the visual stimulus is registered and the player starts moving, the steps need to be quick and precise. Once the player gets to the ball then quick, accurate adjustment steps may need to be taken in order to place the body in correct position to hit the best shot.

Because of the different directions tennis players move during a point, the spider drill is a drill that can allow the reaction time drill and the foot speed drill to transfer into sport performance. While the current study found no significant improvement in the spider drill, a tendency has been observed that agility performance has been improved through training on the QuickBoard in non-athletes. The use of different drills may allow for an improvement in agility performance to transfer into sport-specific performance.

Conclusion and Future Research

While the reaction time was significantly decreased through the 4-week QB training, the results failed to support the hypothesis that the spider drill performance, which was used as the agility test, would be improved in elite female collegiate tennis players. The small sample size was the major limitation of the study, which used a crossover design, creating low effect sizes and low power. Another limitation could also be measuring the foot speed test in the number of steps taken as opposed to the time it would take to complete a certain number of steps. Time measure may increase the sensitivity of the assessment tool. Nevertheless, the data showed a consistent trend that there were greater improvements following the 4-week QB training and warrant further investigations.

Future studies should use a larger sample size in order to increase the observed statistical power to a reasonable level. In addition, a variety of foot speed drills could be used, such as sideways foot speed drill, which is a natural tennis movement. Simulating this movement as a drill would be beneficial for players by allowing them to incorporate and train all areas of agilities. A follow-up test should also be conducted to examine long-term effects. In addition, measuring foot speed in time as opposed to the number of steps taken may allow for more room for improvement in elite athletes. Moreover, comparisons between male and female collegiate players could be beneficial as well in order to find gender-specific results, which could lead to specific training programs in order to help players reach their greater potentials.

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Appendix A- Racquet Club of Memphis Support Letter

September 24, 2013

Dear Dr. Yuhua Li,

I have been informed of the research Courtney Collins will be doing this semester in relationship to her thesis. We are happy to make our facility available for her to conduct testing throughout the year.

Courtney was a part of our Junior Academy Program here at The Racquet Club before attending the University of Memphis on a tennis scholarship. We are very proud of her accomplishments and look forward to helping her in the future. Please call me if you have any questions.

Peter Lebedevs
Tournament Director
U.S. National Indoor Tennis Championships
The Racquet Club of Memphis
(901) 765-4407

Appendix B**- Pre-Test Questionnaire**

Name: ________________________________ Date: __________________

Gender: Male / Female Telephone #: __________________________

Date of Birth: ________________ Weight (lb): _______ Height (in): _______

Country: ___________________ Year in School: __________________

1. What surface have you trained on the past 3 months?

   (Clay, hard, carpet, grass)

2. How many years have you been playing tennis?

   _______Years

3. What other sports do you or did you play before? ______________________

   How often?

   A. Very frequently B. Moderately C. Occasionally D. A little

4. How do you feel your foot speed is currently?

   1 2 3 4 5
   Fast Moderate Slow

5. How do you feel your reaction speed is currently?

   1 2 3 4 5
   Fast Moderate Slow

6. What foot is your dominant foot?

   RIGHT LEFT

Thanks!

Appendix C- Post-Test Questionnaire

Name: ______________________ Date: ____________________

Please answer the following questions by circling the answer you select.

1. How difficult were the Quick Feet board training sessions in addition to your sport training?

A. Very difficult B. Moderately C. Somewhat D. Slightly
E. Not at all

2. Do you feel you could have done more repetitions during the Quick Feet board training?

YES NO

3. Did you enjoy the training program?

A. Very much B. Moderately C. Somewhat D. Slightly
E. Not at all

4. How comfortable were you using the board?

A. Very much B. Moderately C. Somewhat D. Slightly
E. Not at all

4. How do you feel your foot speed is currently?

1	2	3	4	5
Fast		Moderate		Slow

5. How do you feel your reaction speed is currently?

1	2	3	4	5
Fast		Moderate		Slow

6. How much effect do you think the Quick Feet board training has had on your agility?

A. Very much B. Moderately C. Somewhat D. Slightly
E. Not at all

7. Please list any other comments or concerns?

Thanks!

Appendix D- Coach Interview Questionnaire

1. Researcher: From observation, do you feel the players' movement was more efficient during matches as the training study progressed?

   Coach: Yes. I feel the girls were able to utilize their speed and agility more while being able to control the balance.

2. Researcher: Do you feel the players' footwork speed improved as the training study progressed?

   Coach: Yes. I could definitely tell a difference between who was doing the QB training and who was not. The girls were able to get their feet into better positions during practice and performance, which improved the execution of the shots and points.

3. Researcher: Do you feel the players' reaction improved as the training study progressed?

   Coach: Yes, reaction speed was utilized as well as it could have been. Seemed the only problem was when the girls did not utilize the reaction and quickness ability they became extremely anxious during points. As soon as the players learned to control their emotions with this improvement they were able to calm down and perform better.

4. Researcher: Which reaction-type shot did you notice the most improvement (i.e., return, volley, doubles play, etc)?

   Coach: Yes. The shot that probably improved the most in regards to "reaction-based" shot would be cutting off the angles of the ball. Meaning when the girls noticed the ball was bouncing shorter and off the court, they reacted by moving forward and diagonal as opposed to lateral. Therefore, they were able to take off time and catch their opponents off-guard. They were also able to recognize the depth, spin, and speed of the shot quicker and this lead to being able to take the “first step” quicker.

5. Researcher: Did you feel the training study was beneficial for the players?

   Coach: Yes. It gave the girls an opportunity to improve in their strengths and weaknesses. A major part of both aspects are having the ability to react quickly to an opponent’s shots and take advantage of every situation possible. This allows for momentum shifts in points and, ultimately, individual and team matches.

Appendix E- IRB Approval

Hello,

The University of Memphis Institutional Review Board, FWA00006815, has reviewed and approved your submission in accordance with all applicable statuses and regulations as well as ethical principles.

PI NAME: Courtney Collins

CO-PI:

PROJECT TITLE: Effects of a 4-week Quick Feet Training on Agility in Female Collegiate Tennis Players

FACULTY ADVISOR NAME (if applicable): Yuhua Li

IRB ID: #2826

APPROVAL DATE: 10/18/2013

EXPIRATION DATE: 10/17/2014

LEVEL OF REVIEW: Full Board

RISK LEVEL DETERMINATION: Minimal

Please Note: Modifications do not extend the expiration of the original approval

Approval of this project is given with the following obligations:

1. If this IRB approval has an expiration date, an approved renewal must be in effect to continue the project prior to that date. If approval is not obtained, the human consent form(s) and recruiting material(s) are no longer valid and any research activities involving human subjects must stop.

2. When the project is finished or terminated, a completion form must be completed and sent to the board.

3. No change may be made in the approved protocol without prior board approval, whether the approved protocol was reviewed at the Exempt, Exedited or Full Board level.

4. Exempt approval are considered to have no expiration date and no further review is necessary unless the protocol needs modification.

Approval of this project is given with the following special obligations:

Thank you,

Ronnie Priest, PhD

Institutional Review Board Chair

The University of Memphis.

Note: Review outcomes will be communicated to the email address on file. This email should be considered an official communication from the UM IRB. Consent Forms are no longer being stamped as well. Please contact the IRB at IRB@memphis.edu if a letter on IRB letterhead is required.

Extended Literature Review

Tennis has attracted great research interests due to its evolution from a time of wooden rackets and elegant match play to graphite rackets and 130 mph serves. The evolution of the game has come not only from the ability to design modernized equipment, but also because of the recruitment of bigger, stronger, and faster athletes due to improved training, recovery, and nutrition (Kovacs, 2007). Tennis matches can last anywhere between 90 minutes and 5 hours. The length of the matches will depend on the players' style of play and strategy as well as environmental and surface factors. During these long matches, the cumulative physiological exertion going into each point and each stroke that can create an initial moment of fatigue onset (Girard et al., 2006). In order to be successful in tennis, players must excel in the tactical, technical, physical, and psychological aspects of the sport (Cannell, 2011). Most importantly, rapid acceleration and deceleration have to be maintained over a long period of time. During game time both the anaerobic and aerobic systems are being utilized, with the anaerobic system making up 70% of the total effort (Cannell, 2011; Parson & Jones, 1998).

Speed and quickness in direction change (i.e., agility) are major components when assessing a player's movement (J.M. Miller, Hilbert, & Brown, 2001). According to the literature, agility involves speed and accuracy of movement, technical footwork, and decision-making for an athlete's ability to move quickly and effectively on the court (Galpin et al., 2008). It is also referred to as the ability to maintain or control body position while quickly changing direction during a series of movements in response to an external stimulus (Asadi, 2012; Cannell, 2011; Cooke et al., 2011). While there are many ways for coaches to train tennis players for agility improvement, little scientific evidence is available for the most effective and efficient training strategy that coaches and athletes can adopt into their training programs.

The QuickBoard (QB; The QuickBoard, LLC) is a newly developed training tool that can be used for training foot speed and choice reaction speed. The board is comprised of a rubber mat positioned on the ground with sensor pads in five locations. The board is then connected to a visual stimulus display (Li et al., 1998). The display has lights corresponding with the locations on the board, allowing the subjects to see where they are supposed to be stepping when doing specific drills. While a previous study found that the QB training may improve the agility performance using active young adults, no research evidence is available regarding the training effects for athletes. Moreover, the uniqueness of movement responses on the board relates to the types of movements that are typical during a tennis match. It appears that such types of training using the QB could potentially improve aspects of agilities in tennis players.

This literature review summarizes current research on agility training as it pertains to female college tennis players. Specifically, this review includes 1) an overview of tennis and its techniques; 2) definitions and significance of agility; 3). current training methods designed to improve agility; and 4) current gaps in scientific literature on agility training for tennis players.

Overview of Tennis

Tennis Play Techniques. Tennis is constructed of low-intensity and high-intensity workloads (Girard, Racinais, Micallef, & Millet, 2011). This high-intensity exercise contains repeated sessions of brief, near maximal work matched with rather short, moderate/low intensity recovery periods (Glaister, 2005; Kovacs, 2007; Thompson, Nicholas, & Williams, 1999). Attacking players would be reflected through faster, stronger serves and groundstrokes looking to end the point quickly through swiftness whereas baseline players look to run down every ball, forcing their opponent to play at their pace. When players were told to be aggressive points lasted 4.8 ± 0.4 seconds. This is significantly less compared to 8.2 ± 1.2 seconds for whole-court players and 15.7 ± 3.5 seconds for baseline players. Men are seen more as aggressive players while women are seen more as baseline players (Kovacs, 2007). This leads to the assumption that women play longer points than men even though men may play longer matches due to the majors requiring men to play the best of five sets as opposed to the best of three sets. However, the breaks during matches make up a majority of the match time. The time the players are actually playing is called the effective playing time (EPT). EPT varies between attacking players, whole-court players and baseline players with percentages of 21 ± 5.5%, 28.6 ± 4.2%, and 38.5 ± 4.9%, respectively (Kovacs, 2007). Understanding the duration of points and matches is relevant due to the speed, quick bursts, reaction time, and agility necessary every point for a player to be successful.

Speed Requirements in Tennis. Along with the significance of agility in tennis is the necessity of speed, quickness, and reaction. There may be a moment in a tennis match when a player outworks an opponent and the momentum of the entire match changes. This can be due to a player's speed and their ability to apply that speed to a pressure situation (Gambetta, 1996). Speed can be defined as a motor skill and a biomotor quality. As a motor skill, it is learnable and can be improved through motor-learning principles. As a biomotor quality, it entails having the ability to perform a movement in the quickest possible way. While genetic traits play a role in an athlete's speed, sport-specific speed training and practice are what help a player reach his highest potential (Gambetta, 1996).

Speed is a uniplanar skill that is frequently thought of as being able to move in a linear direction as quickly as possible. Another way to consider speed is sport-specific speed, or change-of-direction speed (Moreno, 1995). This is the ability to accelerate, decelerate, change directions and stop while maintaining control of the body (Benko & Lindinger, 2007; Gambetta, 1996; Lockie et al., 2013). Tennis players must have the ability to move in any direction during a match, all while maintaining control of their bodies so they are able to execute shots. This ability can be characterized by: 1) Fast, short steps in all directions, 2) Fast changes of directions out of different positions on any surface, 3) Appropriate use of a variety of footwork and the ability to execute that footwork, and 4) Ability to combine step-length and frequency variably (Benko & Lindinger, 2007). A player may be fast, but the most essential aspect is the ability to control their movement (Benko & Lindinger, 2007; Gambetta, 1996). As a match goes longer, fatigue starts to set in and the player begins to slow down and lose movement efficiency. The way to improve speed in order to delay the onset of fatigue has been researched in various sports. However, tennis is a sport that requires both the anaerobic and aerobic systems (Parson & Jones, 1998). Therefore, the training that is used on players should be specific to tennis.

Speed training in tennis players has grown as more people are recognizing tennis as being in need of specific speed training. Currently, there has been no research done on time motion analysis of female collegiate tennis players. This leads to the absence of accurate training programs due to not knowing what is occurring in the female body during a prolonged tennis match. Because women are found to have longer points due to being more of baseline players, they need to be able to maintain a level of speed for a longer period of time. On-court drills and specific point drills can do this. For example, 20-meter sprints are beneficial for when a player has to run from behind the baseline to receive a drop shot at the net (Cannell, 2011). A 100-meter sprint is also helpful in improving the mentality to last for extremely long points. Resisted running has also shown improvements in speed. This can be done by performing running exercises in a pool or by having a partner apply pressure to the runner's shoulders (J.M. Miller et al., 2001). Performing these types of drills at least twice a week for 15 minutes has been found to improve linear speed (Parson & Jones, 1998).

There are four major components that affect running speed. These are stride frequency, form, stride length, and speed endurance (Parson & Jones, 1998). In tennis, the most efficient way to move is by taking as few steps as possible when the ball is far away from the body. The player would need an increased stride length, enabling the player to stretch further while taking fewer strides. Stride length is improved by increasing speed-strength. Speed-strength is the ability to produce maximal force during high-speed movements (Parson & Jones, 1998). Pulling sleds is commonly used in this aspect. Lateral speed training is equally important since almost half of the movements in a match are done laterally. Shuffle drills and change-of-direction drills are ideal for improving lateral speed (Parson & Jones, 1998). Incorporating tapping exercises with step-rhythms and tennis-specific movements would also help when trying to translate the drill back into performance. Another type of speed is frequency speed, which is the ability to perform a tapping action while simultaneously performing a tennis swing. This can be improved by having a player sit or stand and perform a specific shot while having to tap their start and stop a tapping motion in various positions. Step-rhythms paired with tennis specific movements are also beneficial for increasing speed. This is done by using various geometric shapes (hexagons and triangles) to train the player to move along a specific pattern in addition to not sacrificing balance. This helps to teach the player to maintain body control while moving as fast as possible in multiple directions (Benko & Lindinger, 2007). The spider drill, which forces a players to start in the middle of the tennis court and sprint, shuffle, and backpedal in eight different directions, is a good example of combining linear and lateral speed. Adding a tennis swing with each change of direction would help improve frequency speed and step speed.

Agility

Agility is sometimes referred to as the ability to maintain or control body position while quickly changing direction during a series of movements in response to an external stimulus (Asadi, 2012; Galpin et al., 2008). It also involves accuracy of movement, technical footwork, movement speed, decision-making, and the ability to efficiently utilize the stretch shortening cycle in ballistic movements (Asadi, 2012; Cooke et al., 2011). When looking at agility, it is important to understand the foundation of agility and coordination. The foundation is made up of balance and base support. Balance is characterized as the ability to maintain control of the body over a base of support. Balance is also seen as the major component in all movement skills (Verstegen & Marcello, 2001). When tennis players are about to get ready to hit the ball, they do a "split-step". This is when the player leads with one foot, jumps into the air off that foot, and lands on both feet at the same time, all while moving forward. The place their feet land on the ground is their normal base of support before they get ready to change directions or move toward a shot. If a player is off-balance, he will be unable to move efficiently around the court. Therefore, it is imperative a player has dynamic balance, or the ability to maintain body mass over the base of support while the body is in motion (Verstegen & Marcello, 2001).

Quickness. Quickness is considered a multiplanar skill that combines acceleration, explosiveness, reactiveness, and flexibility (J.M. Miller et al., 2001; Moreno, 1995; Parson & Jones, 1998). Quickness is a term that is often used incorrectly. It is more than being able to move fast, which is what would be considered speed, as stated above. In terms of tennis, someone who is “quick” is able to change directions quick enough to get to a shot that was hit behind him. A player may be slower than others, but if he has the ability to change directions easier then he may be considered quicker. This is because he has better control of his speed (Moreno, 1995). It is also seen as a player’s ability to control his speed so he can change direction with as little loss of speed and balance as possible (Moreno, 1995). Someone who is “fast” may not be considered “quick” if he is unable to change directions while controlling his speed and body. Quickness also includes starting quickness, which is more related to stance, reaction, and knowledge of where to go (Verstegen & Marcello, 2001).

There are numerous drills that can be used to improve quickness. One drill is an agility box drill. This includes a player starting in a ready position in the corner of the service box. The player will sprint the first side, shuffle the second side, backpedal the third side, and finish with carioca. This allows the player to move in all directions while learning to control his body so the change-of-direction is simpler. Figure 8 drills are also beneficial, because the player knows where they are moving and can focus on footwork (Parson & Jones, 1998). Cone drills can be done either as a planned or randomized exercise, allowing the player to work on footwork and changing directions and then using the improved footwork to test in an unknown sequence (J. M. Miller et al., 2001).

One type of training that has recently been studied in terms of quickness is plyometric training. Plyometric training has been studied previously because of its positive effects on agilities, but few studies have been conducted to see if plyometric training can increase quickness. Numerous sports use plyometric training as a way to improve an athlete's strength and explosiveness. Herodek et al conducted a study on the effects of plyometric training on quickness. They found a positive correlation between subjects' t-test and quickness test performances. This has led to plyometric training not only being used for improvements in agility but also in quickness.

Reaction Time and Decision Making. Sporting events can be decided into two basic categories: reaction time and non-reaction time based sports (Wang, 2009). An athlete's reaction time, especially in tennis, can determine whether the athlete is successful in competition (Wang, 2009). According to the National protocol for the assessment of agility in team-sport athletes, the ability to use these maneuvers successfully in performance will depend on visual processing, timing, reaction time, perception, and anticipation (Farrow, Young, & Bruce, 2005). In tennis, all of these factors work together in one form or another. For example, anticipation is not always a benefit, but it can determine whether one reacts quickly to a shot hit directly at them at the net at a fast pace. Proper timing depends on whether the player reacts in time in order to get in correct positioning for execution. Ultimately, every single shot in tennis is based off where the opponent is standing, where their shot is coming from, where the opponent's location is on the court, and the speed and spin that has been placed on the ball. Therefore, a player's reaction needs to be extremely accurate in order to get his body in the most ideal position before the racket makes contact with the ball. One area of reaction time training that has been focused on is how to quickly encounter an opponent's unpredictable offensive play (Wang, 2009). The importance of training reaction time is to avoid any moments of hesitation, which could lead to chaos during a point.

In addition to the unpredictability of opponents, there is also the fast pace of the game to consider. When comparing lower-level and higher-level competitors, the speed of the game is drastically increased. In tennis there are breaks between each point, allowing for players to control the momentum of matches and slow down the over-all match time. However, once the point starts it is an all-out effort until the point is over. Fitt's law states that if a player wants to increase accuracy, he or she must slow down the action (Wang, 2009). The importance of this is that athletes only have certain ability to process information within a certain time limit (Wang, 2009). As players begin to hit the ball harder they must accept that their accuracy is going to be compromised. Having a limited space to play within is also affected by reaction time. In tennis, there are specific lines the ball has to bounce inside in order to be considered "in play". If reaction time is off, the player may not make accurate contact with the ball, leading to an increase in errors.

A player's reaction is determined by multiple aspects: where the ball is coming from, where the player is, where the opponent is, how fast the ball is coming and what type of spin has been placed on the ball. After considering these points, a player must make a quick decision for what type of shot to hit, where to hit it, what spin to hit on the ball, as well as what is the quickest way to get to the ball and recover (Wang, 2009). One way to help decrease reaction time is to familiarize a player with all types of offense and defense. In tennis, everyone is going to have different playing styles for attacking and defending. When players are exposed to different styles it improves their ability to adapt quickly. Not only should they be able to play against different types of games, but the players themselves should also be able to change their game and play multiple types of offense and defense (Wang, 2009). This will increase the reaction time of their opponents, giving them a slight advantage.

Ways to train reaction time vary. One way that has become popular is vision training. Vision, as opposed to eyesight, is the most important aspect when improving an athlete’s ability to react quickly to a moving, visual stimulus such as a tennis ball. Eyesight is measured by looked at a standard eye chart whereas vision is measured by the brain’s ability to pick up information and transfer it into a reaction. Playing tennis can be equivalent to a visual stress test. Tennis players are constantly being told to “watch the ball”. When players are unable to keep eye-contact on the ball it is often due to visual wandering or lack of visual training (Maman et al., 2011). There are many visual skills to consider when telling a player to watch the ball during a match, including eye-alignment for accurate fixation, eye flexibility in order to shift the player’s focus from far to near during returning or rallying, and depth perception. This, in addition to reaction time and hand-eye coordination, are essential to help players improve judgment and resonse during a match. One study used male university tennis players to test visual training. The study found vision training helped the players have faster judgment and response in the match. When players move around the court, fatigue does not only affect their legs and arms but also their eyes. Therefore, when players are returning a 150 kmh serve, they only have about half a second to decide the direction, speed, and spin of the ball before having to make a decision, leading to extreme stress (Maman et al., 2011). Another study found that participating in competitive play on a daily basis helped maintain reaction time abilities (Gonzalez et al., 2013). This study observed National Basketball Association (NBA) players throughout the course of an NBA season. The players were tested at the beginning and end of the competitive season. They found the starters were able to maintain their level of reaction time greater than non-starters.

Agility Training Methods

Plyometrics and Speed, Agility, Quickness (SAQ) Training Methods. There are two well-known training methods when the goal is to improve agility performance, which are plyometric training and the speed, agility, and quickness (SAQ) method (Verstegen & Marcello, 2001). Plyometric training involves many of the same characteristics as agilities, including stopping, starting, and changing directions in an explosive manner (G. M. Miller et al., 2006; N. Stojanovic, Jovanovic, & Stojanovic, 2012). The explosion in sports is seen to be a function of strength and muscle contraction speed. Tennis is a sport that requires players to constantly move in an explosive manner. This is seen when players are preparing for a groundstroke or serve. The player first recognizes the shot and moves according to where the ball will bounce up into their strike zone. Then, the player sets his feet in an ideal base position and bends the knees, with a majority of weight being on the back foot. As the player bends his knees, the shoulders and torso turn away from the ball, allowing for a tight coil in the body. Right before the player hits the ball, he uncoils and explodes up through his legs and his torso, using all the power he obtained from his lower body and transferring it into his shot. This can be improved by plyometric training because of the stretch-shortening cycle (SSC) that is being performed. The SSC enhances the ability of the muscle-tendon unit to produce maximal force in the shortest amount of time (Chmielewski, Myer, Kauffman, & Tillman, 2006) by first stretching the preactivating muscle and then shortening it (Nicol, Avela, & Komi, 2006). In order to improve the rapid, controlled movements in tennis, SAQ training is beneficial because of its ability to train multiple areas (i.e., speed, agility, and quickness) simultaneously.

The movements in tennis can be broken down into three categories: forward, sideways, and lateral. These movements occur approximately 47%, 48%, and 5% of the time during a match, respectfully. In terms of distance, a tennis player moves on average three meters per shot and a total of eight to twelve meters per rally (Parson & Jones, 1998). This means the shot is within range of the player, but the player will have to move according to where the ball is bouncing in order to be in ideal position to hit the best shot possible. This reiterates the importance of SAQ training, leading players to focus on development of both linear and lateral speed over short distances to reach maximal potential (Parson & Jones, 1998).

In this method, each area is broken down in order to improve in each area. An example of a linear speed drill may be a line drill. Players would run from service line to the net and then backpedal back to the service line. This could also be done to train a player laterally by shuffling from sideline to sideline instead of sprinting forward and backpedaling. When it comes to agility and quickness drills, there are numerous drills that could be done using several different methods. One drill is a cone drill. This can be done by starting at the service line and sprinting, shuffling, and backpedaling in 5 different directions to the net. This helps by forcing the player to change directions multiple times and by utilizing all forms of movement that will be used in a match (Parson & Jones, 1998).

QuickBoard Training. The QB was developed to test and train individuals to enhance their footwork speed and reactive response movements while being able to monitor progress. Multiple drills can be performed, including count drills (i.e., number of steps in x seconds) and reaction drills (i.e., number of seconds to complete x randomized steps). This board has similar characteristics to what is commonly known as “dot drills”. In a dot drill, there are several different flat, rubber-surfaced dots placed on the ground, allowing the subject to step on them without tripping. Drills may vary from jumping among the dots in various patterns to figure 8s, and all of these can be done on one or both legs. However, the benefit with using the QB is the ability to include randomization and decision-making. The board can be used to assess the processes involving decision-making, action planning, and movement execution (Li et al., 1998).

A recent study used the QB to examine the effects of a 4-week choice foot speed and choice reaction training program in 23 active, non-agility trained men and women. All participants were randomly divided into two groups, consisting of a control group and an experiment group. Both groups performed the pre-test and post-test, but only the experiment group took part in a 4-week training with 12 supervised sessions (3 times a week and 20 min each time). During the testing, subjects performed two QB drills. The drills were a foot speed drill and a choice reaction drill, which determined the amount of touches they could obtain during a specific time period and how many seconds it took them to obtain 10 randomized foot touches, respectfully. Each drill was performed three times at maximum effort. Between each foot speed and reaction drill, subjects were given a 90-second break. Subjects also completed a change-of-direction drill during the testing period. This drill consisted of the subject running a maximum-effort sprint of 5 meters with three changes of direction, equaling 20 meters. This was also completed three times with a 150-second break. During the training sessions, subjects only trained on the QB. They would do four different drills, including a 10-second foot speed drill, a 10-touch reaction drill, a 5-second foot speed drill, and a 5-touch reaction drill. Each foot speed drill was separated by 90 seconds and each reaction drill 60 seconds. At the end of the study, significant improvement on each of the test performances was found in the training group; however, the control group did not improve on any of the tests. The results suggest that the QB training may be a useful training tool for activity in young adults attempting to improve agility. It would be interesting to see if the QB training can benefit tennis players because of the necessity of quick feet and reactions during performance on court.

In another article, Parsons and Jones present training techniques for each area that are essential to tennis, including speed, agility, and quickness. These sport specific drills allowed for an understanding of how to better train tennis players to move more quickly and efficiently. The previously used change-of-direction drill is beneficial for subjects who are in a sport where sprinting straight is common throughout a competition. However, for tennis players, a drill that involves sprinting, backpedaling, and shuffling would be more appropriate to a match-situation. By replacing the change-of-direction drill as mentioned above with a star drill, which involves sprinting, shuffling, or backpedaling in all directions, subjects are required to move in a way that would normally take place during a tennis competition. This would benefit the athletes because of the ability to apply the test to field performance.

Current Limitations in the Literature

One limitation in current literature is no previous study has investigated the training benefits of the QB on athlete population. Specifically, the question, which remains unanswered, is that if the similar findings would be observed by using elite teams or athletes when examining improvements in agilities on the QB. Another limitation would be the lack of applying these drills to field performance situations (Cooke et al., 2011). Previous studies have used linear speed drills to determine improvements from the QB training. However, it would be valid to incorporate a drill or test that would be sport-specific for tennis players.

In summary, tennis has become a topic of interest in the eyes of researchers due to its modernization. It is essential to determine the areas that are most important to a player's success. Speed, quickness, reaction time and agility are necessary every point for a player's game. The QB appears to offer a great potential as a useful training tool for the improvement of athletes' agility performance.

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