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Research article

The Effects of Scaling Tennis Equipment on the Forehand Groundstroke Performance of Children

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Abstract
The modifications that have taken place within youth sports have made games, such as basketball, soccer, or tennis, easier for children to play. The purpose of this study was to determine the effects low compression (LC) tennis balls and scaled tennis courts had on the forehand groundstroke performance of children. The forehand groundstroke performances of eight subjects' (8.10 ± 0.74 yrs) using LC tennis balls were measured on a scaled tennis court and standard compression balls (SC) on a standard court. Forehand groundstroke performance was assessed by the ForeGround test which measures Velocity Precision Success Index (VPS) and Velocity Precision Index (VP). Participants attempted three different forehand rally patterns on two successive days, using LC balls on the 18.3m court one day and SC balls on the 23.8m court the other. When using LC balls, participants' recorded higher overall VPS performance scores ($p < 0.001$) for each non-error stroke as well as higher VP scores ($p = 0.01$). The results of this study confirmed that the use of modified balls and modified court size may increase the control, velocity and overall success rate of the tennis forehand groundstroke of children.

Key words: Performance assessment, velocity, precision, success, compression.

Introduction

In recent years, the game of tennis has seen equipment modifications emulate the growth and physical development of children, which is similar to other sports scaling the field, baseball diamond, or gymnasium to the young athlete (Benham, 1988; Martens et al., 1984; Pang and Ha, 2005). However, little research has been conducted to provide evidence of the benefits of using LC tennis balls. Only two experimental studies (Farrow and Reid, 2010; Hammond and Smith, 2006) pertaining directly to the modification of tennis balls and courts could be found during a current review of the literature. Hammond and Smith (2006) assessed the transfer of learning that took place with the use of LC tennis balls compared to standard-compression (SC) balls over the course of 8 weeks, and found no significant impact on skill development due to the use of LC balls. The authors used 14 participants aged 5 to 11 years old. Both the participants' ages as well as the number of participants were factors that may have limited the validity of the researcher's findings.

Whereas Hammond and Smith (2006) produced inconclusive results, Farrow and Reid (2010) observed a significant difference in beginner tennis players' skill acquisition on the standard court with the SC ball when compared to skill acquisition on the scaled court with a LC ball. Throughout the experiment 8-year-old children's skill acquisition was recorded over a 5-week period using a rally design. The combined court modification, along with the use of LC balls, allowed for more opportunities for the children to rally within the lesson. The children studied also hit more LC balls into the court, had more fun – as measured by the Steen Happiness Index – and were more successful with the modified court and balls (Farrow and Reid, 2010). Considering the previous work done, one might argue that Hammond and Smith (2006) initiated the examination of the influence of LC tennis balls on improving skill development, whereas Farrow and Reid (2010) continued that line of research, examining specific effects of modified balls and courts on skill acquisition and physiological responses of children 10 and under.

Despite the previous work which has focused on the influence of equipment modification on skill development (Farrow and Reid, 2010; Hammond and Smith, 2006), such approaches still need to be refined to incorporate a more comprehensive game approach. Our research differs significantly from that conducted previously in that it observes a child's forehand groundstroke performance during two different scenarios: a standard ball and court condition and a modified ball and court condition. Performance testing in the field of tennis appears to be slowly evolving from what was exclusively skill-based testing to what we see now: a more dynamic rally-based performance test.

Thus far, few tennis-specific performance tests have been available and readily used for testing an athlete's performance. Up until the late 1960's the major disadvantage of performance assessments was that skill based tests did not simulate the true environment of a tennis match (Hewitt, 1966; Kemp and Vincent, 1968; Purcell, 1981; Vergauwen et al., 1998). The Kemp-Vincent Rally test was the first of its kind to include a game-based approach through a rally-based design where two people are dynamically exchanging the ball back and forth over the net (Kemp and Vincent, 1968). Speed, or stroke firmness, was an added variable measured along with ball control in an attempt to better simulate real game situations (Purcell, 1981). As technology advanced, so did the capabilities of quantifying ball speed and placement within the dynamic environment of a tennis match. Vergauwen et al. (1998) quantified the precision and velocity of each tennis ball hit, by using video images

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and a radar system in what they dubbed the Leuven Tennis Performance Test.

Follow-up work led Vergauwen et al. (2004) to develop what is now known as the ForeGround test, which has been shown to be both reliable and valid when assessing the performance of young, low-to-intermediate level tennis players. The forehand groundstroke is used in the rally based design of the ForeGround test to assess performance because of its dominance above other strokes in a given rally (Elliott et al., 2009; Vergauwen et al., 2004). Researchers have found that more advanced players scored higher on the ForeGround test in all of the tested variables, including speed, accuracy, and success (Vergauwen et al., 2004). Despite the ForeGround protocol's attempt to quantify the rally-based performance of the forehand groundstroke, the application of the test to tennis as a whole is limited in that it utilizes only one of the fundamental strokes (service, forehand, backhand and volley) used for low-intermediate players (Crespo, 2008). Although previous research has paved the way to performance testing using modified court sizes and ball types, there appears to be little data available that compares performance when using modified balls and court relative to performance using standard balls and court.

The modifications that have been made to equipment have slowed the speed of the game, which has made it easier for children to be successful and learn the skills required to play effectively (Farrow and Reid, 2010; ITF, 2009). Previously conducted research using adults supports the notion that the ball size and type used within tennis influences the speed of play (Cooke and Davey, 2004; Haake et al., 2000; Mehta and Pallis, 2001). When the ball speed is slowed, the player has more time to react to the movement, direction, and spin of the ball. The benefit of having a larger ball to slow the pace of the game has been revealed previously in an adult population (Andrew, 2003). Considering the previous literature indicating the use of larger balls in order to slow down the game of tennis, it seems plausible that similar effects might be seen when children use lighter, LC balls. Intuitively, children should not play with balls that bounce high above their typical groundstroke impact zone or travel too fast, as it may be detrimental to the biomechanical development of their strokes (Barrell, 2008). LC tennis balls thus have great potential for the training of young tennis players, as the rebound height is much less pronounced; however, there is minimal research indicating the specific benefits that LC balls may elicit on tennis performance.

Considering the fact that a child's response time to a particular stimulus is generally greater earlier on in childhood (Haywood and Getchell, 2009; Kiselev et al., 2009) it typically takes them longer to respond. Therefore, it is important that the speed of sports slows down in order to meet the physical limitations of the children playing them. Because of their slow motor response time, children often have difficulties playing the fast-moving game of tennis. The skills necessary to play the game, such as executing a serve, returning a serve, and hitting groundstrokes back and forth over the net in a dynamic rally setting, are difficult for beginning children, especially if ball or court modifications are not made. Most children that are coached in tennis on a standard court using SC balls are limited to learning skills rather than the actual game (Anderson et al., 2009). The 11.0m and 18.3m scaled courts diminish the court area to a size appropriate to capabilities of the children playing. With the modified court there is less area to cover, and correspondingly a child is able to move to more balls and in turn, keep the rally going longer; the modified court theoretically increases the overall opportunity for children's rally success (Farrow and Reid, 2010; ITF, 2009; Newman, 2010). The scaled courts are also proportionate to the height of the child and therefore to the child's physical development. As children develop and their speed and coordination increases, they should be able to make transitions to larger court sizes and higher compression tennis balls. Despite this intuitive transition to modified equipment, there is still a lack of quantitative evidence for the application of LC tennis balls. Therefore, the purpose of this study was to determine the effects of modifying court size and ball type on the forehand groundstroke performance of children. It was hypothesized that children would score higher on the ForeGround test using modified equipment and modified court conditions when compared to the use of standard equipment and standard court conditions, indicating a higher forehand groundstroke performance with the use of modified equipment.

Methods

Participants

Eight tennis players (five girls and three boys) between the ages of 7 and 9 (8.10 ± .74 yrs) were recruited to participate in this study. Each of the participants had tennis playing experience (2.50 ± 1.21yrs) and was enrolled in tennis programming at the time of data collection in order to ensure that each of them was capable of completing the ForeGround test explained in detail below. Participant's tennis programming prior to the research provided them with exposure to both orange and yellow courts. The parents of each participant signed a voluntary consent form and provided demographic data about their child. Approval to conduct this study was granted by the Institutional Review Board of the University of North Dakota. Participants were selected based upon age-specific guidelines from ITF's Tennis 10's manual, which recommends that children between the ages of 5 and 10 play on a scaled court (ITF, 2009). Participants in this study had been exposed to and were assessed on both the yellow and orange courts due to the lack of age-based specificity in tennis programming. As boys and girls differ little in height at that age, (Barrell, 2008) there was no need to be sex exclusive in participant selection.

Performance measures

In order to assess participant forehand groundstroke performance, the ForeGround test was utilized, to calculate both the velocity-precision-success (VPS) score and the velocity-precision (VP) score (Vergauwen et al., 2004). These two dependent variables were the main indicators used for assessing participant performance throughout each of the testing sessions. Four individual performance measures were used to derive VPS scores: success rate, lateral ball placement, longitudinal ball placement, and ball velocity. The combined performance on these individual measures provided each participant with a VP score, ranging between 0-100, with higher scores indicating a better overall forehand groundstroke performance by the player. The VPS score was then calculated by taking the average VP score for a particular test session relative to participant success rate. A VP score was calculated for every ball that successfully landed in the court, as seen here:

$$VP_{LC} = \frac{kph^2}{100}\left(101 - \frac{100 \cdot \Delta lat^2}{\max dev\ (6.40m)^2}\right)\left(101 - \frac{100 \cdot \Delta long^2}{\max dev\ (9.14m)^2}\right) \cdot \frac{1}{10.201}$$

$$VP_{SC} = \frac{kph^2}{100}\left(101 - \frac{100 \cdot \Delta lat^2}{\max dev\ (8.23m)^2}\right)\left(101 - \frac{100 \cdot \Delta long^2}{\max dev\ (11.89m)^2}\right) \cdot \frac{1}{10.201}$$

Success rate was defined as a percentage, calculated by taking the total number of forehand drives hit into the court divided by the total number of attempts made. Lateral and longitudinal ball placement were determined for each shot and measured as the distance from the target at which the participant was aiming. Lateral deviation from the target was measured in a direction parallel to the baseline, while longitudinal deviation from the target was measured in the direction parallel to the singles sideline. Ball velocity was determined by calculating the average lateral and longitudinal speed for each shot.

Instrumentation and implementation

All tests were conducted using Wilson US Open Junior 25 inch racquets. Each of the participants received their racquets as compensation for participating in the study. The orange LC balls used in the study were 6.00-6.86cm in diameter, with a mass between 36.0-46.9g, and a coefficient of restitution ranging between 0.41-0.46 (Wilson, 2010). The SC balls were the standard (Type 2) yellow balls certified by the ITF for international play (ITF, 2011). The SC balls were 6.54-6.86cm in diameter, with a mass between 56.0-59.4g, and a coefficient of restitution ranging between 0.53-0.58 (Wilson, 2010).

The standard court dimensions were 23.8m by 8.2m. The modified orange court dimensions were 18.3m by 5.8m. The net height for both the standard court and the modified court were 1.07m at the net post and 0.91m at the center net strap. On each court, targets were placed on the far corners and on the corners of the service line and the singles sidelines (Figure 1). Three video camcorders, one Sony Handycam Camcorder DCR-HC52 (Sony Corporation of America: New York, NY), and two Canon ZR 960 Camcorders (Canon U.S.A., Inc: Lake Success, NY), all filming at 60 fields per second and at a shutter speed of 1/500 of a second, were triangulated on the court to capture 3D ball placement and the velocity of each tennis ball (for more details on this setup please see reference Vergauwen et al., 2004). Ariel Performance Analysis System was used to digitize ball markings through the process of trimming, digitizing, synchronizing, and transforming data into 3D images; data was filtered at 10Hz. A calibration cube (91.5 cm) was used to ensure accurate transformation of the data to 3D, and to scale the ball landing distances in the computer to corresponding distances on the court.

Procedure

Data was collected on two separate days separated by 24hrs. All participants took part in both days of testing, the completion order being counterbalanced amongst participants. On both days of data collection, participants warmed up with the type of ball they were being tested with that day; half of them using the LC balls on the scaled court while the other half used the SC balls on the standard court. A USPTA certified tennis professional was used for both sessions and was selected based upon his 30 years of experience working with children. The tennis professional was asked to feed the ball to the same location on the court regardless of the testing condition.
Each rally began with a fed ball from the tennis professional. Participants were given six attempts at three different rally patterns. The rally patterns were as follows: Pattern 1: four forehand groundstrokes hit deep crosscourt followed by a fifth forehand hit deep and down-the-line, Pattern 2: one forehand groundstroke hit deep and down-the-line, Pattern 3:one forehand groundstroke hit sharp-angled crosscourt followed by another groundstroke hit deep and down-the-line. Further details can be found as described in the ForeGround protocol (Vergauwen et al.,

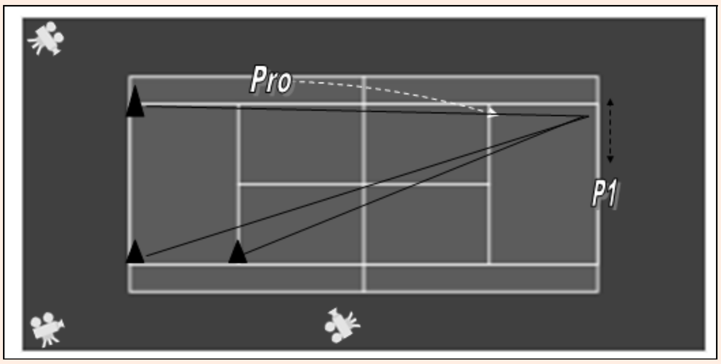

Figure 1. Court Layout. P1 = participant; Pro = tennis professional; white-dashed-line = pro fed ball; black triangle = target; back-dashed-arrowed-line = shot recovery distance; black-line = participant's forehand groundstroke; pictured camera = placement for video camera.

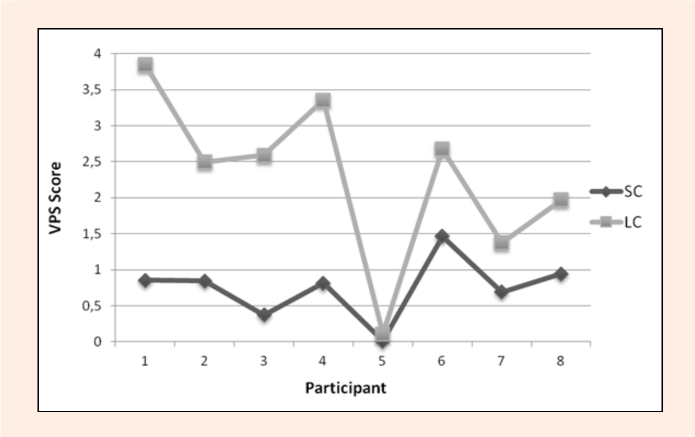

Figure 2. Velocity Precision Success Score. VPS = velocity precision success; SC = standard compression group; LC = low compression group.

2004). The players were instructed to hit as hard as theycould toward a visible target while still maintaining control of the ball. Before each bout of data collection, the test leader gave the participant a verbal explanation followed by physical demonstration to note which cone was the target for each rally pattern of the ForeGround protocol (as done in Vergauwen et al., 2004). The explanation of the pattern was the same regardless of the condition, as the pattern was the same for all conditions.. The rally ended when the player either completed the rally pattern or made an error by hitting the ball into the net or out of bounds.

Data analysis

The forehand groundstrokes performance scores from this study were analyzed using SPSS version 18.0 statistical software. The effect of the independent variable, modified ball and court, on each of the dependent variables (VPS, VP, success rate, ball velocity, and ball placement) was examined using six 2-tailed paired-samples t tests. Confidence intervals were set at 95%.

Results

A 2-tailed paired-samples *t* test was calculated to compare the mean VPS scores for both modified and standard conditions. The mean VPS score for the modified condition was 2.30 (± 1.17) whereas the mean VPS score for standard condition was 0.75 (± 0.43). A significant difference was apparent when using ball and court modifications, $t(7) = 4.47$, $p < 0.001$. Similarly, a 2-tailed paired-samples *t* test was calculated to compare the mean VP scores for both modified and standard conditions. The mean VP score for the modified condition was 6.12 (± 2.69) whereas the mean VP score for the standard condition was 3.22 (± 1.74). A significant difference was also seen in VP scores when using ball and court modifications, $t(7) = 3.34$, $p = 0.01$). These data can be seen in Figures 2 and 3.

Four additional paired-samples *t* tests were calculated to evaluate the effect of ball and court modification scaling on success rate, ball velocity, longitudinal ball placement (X_{long}), and lateral ball placement (Z_{lat}). A significant difference in success rate for the LC condition was found ($t(7) = 8.23$, $p < 0.001$). The ball velocity during standard conditions was also significantly different from ball velocity found under modified conditions: ($t(7) = 2.71$, $p = 0.03$). With regards to precision, the participants hit significantly more LC balls closer, X_{long}, and Z_{lat}, to the targets, relative to their SC forehand groundstroke performance. A significant difference between the two conditions X_{long} was found ($t(7) = 3.83$, $p = 0.01$). In the Z_{lat} direction, a significant difference was evident ($t(7) = 3.30$, $p = 0.01$). These data can be seen in Figures 4-7.

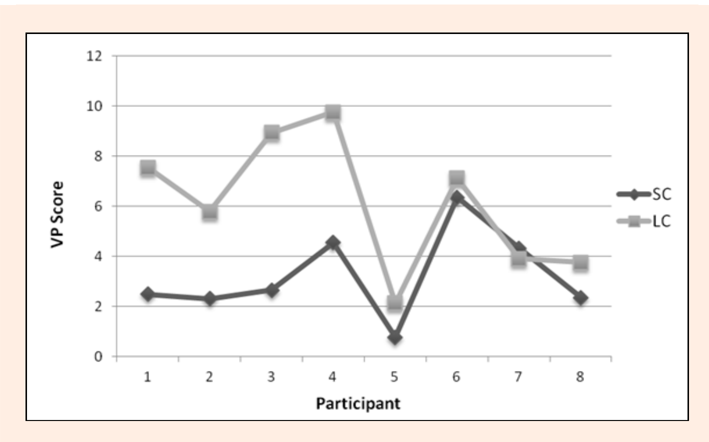

Figure 3. Velocity Precision Score. VP = velocity precision; SC = standard compression group; LC = low compression group.

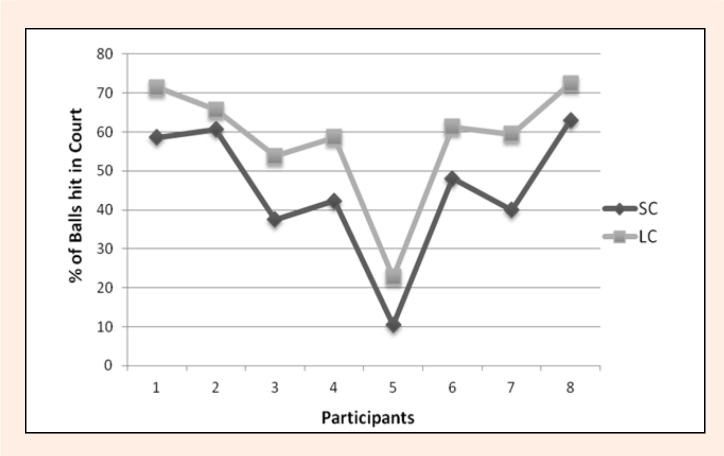

Figure 4. Success Rate. SC = standard compression group; LC = low compression group.

Mean and standard deviation data are displayed in Table 1.

Table 1. Differences in performance between conditions. Data are means (±SD).

Performance Measure	Standard Condition	Modified Condition
VPS Score	0.75 (.43)	2.30 (1.17) *
VP Score	3.22 (1.74)	6.12 (2.69) *
Success Rate (%)	45.0 (17)	58.0 (16.0) *

VP = velocity precision success; VPS = velocity precision success; * denotes significant difference from standard condition

Discussion

Our primary hypothesis was that children would score higher on the ForeGround test using modified ball and modified court conditions when compared to the use of standard ball and standard court conditions, suggesting that the modified game enhanced their forehand groundstroke performance. Evidence for this finding is provided by the significantly greater VPS score under modified conditions (SC = 0.75, LC = 2.3, $p < 0.001$). The results also revealed significant improvements when using ball and court modifications for all of the other performance variables as well: VP scores, success rate, velocity, lateral and longitudinal ball placement.

Several factors may have contributed to the significant enhancement in overall performance for participants playing under modified conditions; the altered pace of the game, a smaller court, and a more proportioned rebound height between the ball and players may have been contributing factors. Research on adults has shown that the type of ball used to play tennis alters the pace of the game, which could logically be extrapolated to children as well (Haake et al., 2000). The LC tennis balls allow children more time to react to the approaching ball, thus providing more time to set up their shot. This increased time to react is particularly important for younger children, as 7 to 8 year olds generally have a difficult time tracking and making solid contact with the ball (Anderson, 2009).

The results from the present study support the notion that with the use of the LC balls, participants may have more time to track and set up, therefore providing a greater window of opportunity to generate solid contact for their forehand stroke. Considering the enhanced performance found when using the LC balls, the results of this study suggest that the slower pace of the game due to the scaling of the ball and court size has an immediate positive effect on the forehand groundstroke performance in these children.

A larger court leads to a greater amount of footwork and movement, making it more difficult for young players to cover the court quickly. A smaller court thus diminishes the distances players have to travel therefore increasing their chance of getting into proper position in

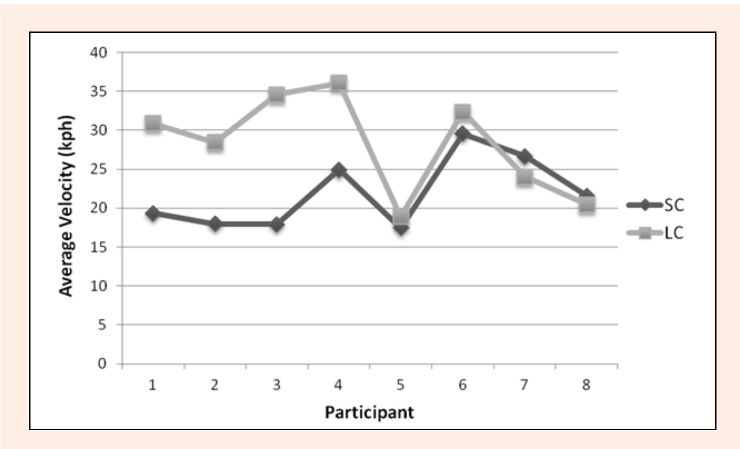

Figure 5. Ball Velocity. SC = standard compression group; LC = low compression group.

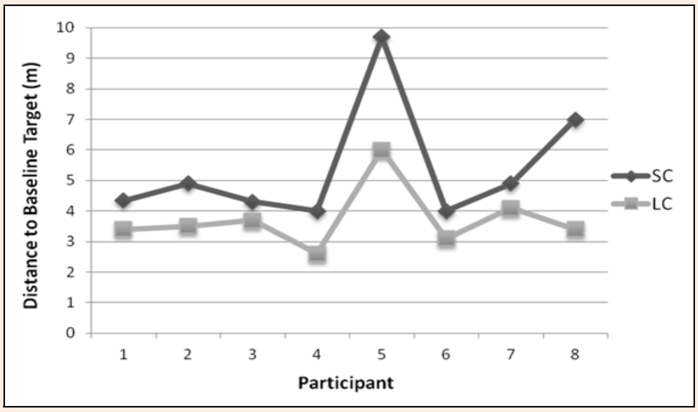

Figure 6. X_{long} Ball Placement. X_{long}= longitudinal direction; SC = standard compression group; LC = low compression group.

order to execute a quality groundstroke. Considering the modification in court size that took place in the current study, it may be that a smaller scaled court is beneficial for the performance of young players in that it may facilitate more time to prepare the ideal mechanics necessary for a quality groundstroke. Furthermore, it is known that proper movement patterns are essential for sound tennis stroke production (Barrell, 2008), and therefore it is important for children to learn and execute these basic locomotive patterns, as footwork and movement on the court are foundational elements of a quality tennis stroke (Elliott et al, 2009). Considering our findings, it is possible that the use of a scaled court was one of several factors that allowed participants more time to set up and prepare for a quality stroke, thus increasing the likelihood of getting to the ball, thereby increasing their performance.

The slower LC balls are manufactured to have a lower coefficient of restitution than SC balls, and consequently they have a lower rebound height (Wilson, 2010). The rebound height of the LC ball is more proportional to the child's height and thus the necessary adjustments to the rebounding LC ball are minimized as it reaches its peak within the child's optimal strike zone. Unlike LC balls, SC balls peak at a much higher height; children are therefore forced to adjust their technique, striking the ball on the rise, or waiting to strike the ball as it descends back beyond the base line, both of which can hinder the quality of the executed shot (Barrell, 2008). The results of our study showed that the use of LC balls enhanced performance, and therefore it is reasonable to assume that the ball rebound height, when proportional to a player's height, may have been a factor contributing to enhanced performance.

The increase in child forehand groundstroke performance due to the LC balls and a scaled court could have substantial effects on the way tennis is taught to developing young players that have yet to reach physical maturity. Considering that success rates were higher for the LC condition in this study, it is probable that the hitting volume for those practicing with LC balls in the future would be substantially higher. These findings are confirmed by the results of Farrow and Reid (2010) who concluded that scaled-court conditions resulted in a significantly higher volume of forehand groundstroke hitting for the participants in their study. Since success rate, and correspondingly hitting volume, typically increases with the use of LC tennis balls, tennis professionals are able to implement the game-based approach earlier on in coaching through the use of modified equipment and scaled courts. In implementing a game-based approach in tennis lessons, students are able to implicitly learn and practice skills in the dynamic environment of the game. The LC balls and scaled court theoretically enable

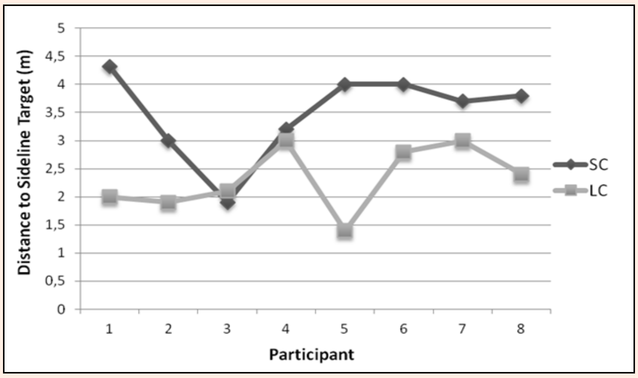

Figure 7. Z_{lat} Ball Placement. Z_{lat}= lateral direction; SC = standard compression group; LC = low compression group.

children to rally more frequently, thus simulating real game-based play earlier on in their training. Furthermore, for children initially learning tennis, practicing with SC balls on the standard court where they are typically less successful, could lead to frustration and avoidance of the sport altogether. Stodden and Goodway (2007) discuss the importance of developing high motor skill competence, whether kicking or ball striking, in children in order to promote physical activity. Utilizing LC balls and a scaled court, children are likely to have more success, which may encourage future participation in physical activities (Fischer et al., 2005; Stodden and Goodway, 2007), including tennis. Therefore, the modification of balls and courts in tennis may contribute to greater tennis participation and potentially enhance involvement in future physical activity in general.

Participants in the current study were on average 1.2 m laterally and 1.7 m longitudinally closer to the target when using LC balls. By the very nature of the ForeGround test, the participant must hit the ball closer to a target relative to the scaled size (6.5m) of the smaller court to get the same score as a ball hit farther away from a target on the standard court (8.2m). Even with the court being smaller for the LC group, forehand groundstroke performance measures were superior with LC balls. These results suggest that children using scaled equipment can not only hit the ball into the smaller court more often, but can also do so with greater accuracy.

Our results revealed that the average velocity for the LC tennis balls was 6.5 km/h faster than the average velocity of the SC tennis balls. This means that children were able to hit the LC balls harder despite the smaller coefficient of restitution of the LC balls. Considering this finding, it was apparent that there was no trade-off between velocity and precision as might have been expected. For example, low-intermediate level tennis players attempting to hit a tennis ball hard, typically lack precision at the expense of speed, or vice versa. In the current study however, performance during the modified conditions was enhanced as a whole, despite the fact that it is more difficult for children to execute accurate forehand groundstrokes with court placement while still maintaining control of the power or speed of the ball (Elliott et al., 2009). Our findings suggest that LC balls not only enhance children's ability to hit with more speed, but they also allow children to execute a more advanced groundstroke, as indicated by enhanced precision and velocity, while simultaneously increasing success rate. As consistency, speed, and accuracy are fundamentals of tennis (Bahamonde and Knudson, 2003; Elliott et al., 2009) one might argue that the enhanced LC performance seen among children practicing with modified equipment could have a greater potential to develop tennis fundamentals at an early age.

The modification system currently evolving in tennis allows for gradual changes within the court size, ball type, and racquet size used by children. Children initially utilizing substantial modifications, starting with 11.0m courts with Stage 3 LC balls, and progress towards more standardized conditions such as an 18.3m court with Stage 2 LC balls and the 23.8m court with Stage 1 LC balls, and finally work their way to the use of a SC ball on the standard 23.8m court (ITF, 2009). The player's height and strength determine the appropriate racquet size, which typically ranges from 58.4 cm to 68.6 cm in length (ITF, 2009). Racquet modifications within the game of tennis ideally enable young children to perform at a higher level than they would be capable of performing using standard equipment, by providing them with equipment that is proportional to their anthropometric measures. Younger children are motivated to continue participation in tennis when skill improvements and playing level progressions are apparent (Crespo and Reid, 2007). It is thus clearly important to modify conditions so that children have success, are intrinsically motivated, and are able to enjoy the game of tennis. Therefore, increasing children's exposure to LC tennis balls should be a central focus of children's programming in the tennis community if it is interested in maximizing the success and growth of young tennis players.

Despite the above findings, the method of assessment for ball velocity may be considered a limitation of this study, as the physical differences (mass and diameter) between the LC ball and the SC ball were not accounted for. For example the SC ball weighs on average 17.5g more than the LC tennis ball, which would likely have had an impact on the resultant mean velocity, which was not accounted for. It would be advisable that future research take into account the physical differences between SC and LC balls, such as mass, diameter, and coefficient of restitution, in order to determine their influence on corresponding performance variables.

When considering participant selection in an experiment similar to that presently conducted, it is pertinent to consider age, skill level, and participant exposure to different ball types. Within this study, age and skill level of the participants were controlled for. Participants were also selected from a level of programming where both LC and SC balls were used regularly. Rather than observing performance, future research focused on the transfer of learning would be beneficial. However, both time and resources are needed to examine the transfer of learning or skill development for both modified and standard equipment; therefore, the practical and logistical constraints of such a study must first be considered prior to commencement of data collection. Future studies may want to consider examining video analysis of the ball leaving the strings of the racquet so that a qualitative assessment of skill acquisition maybe done. Such video analysis may also allow for the quantification of force being generated off the racquet, while at the same time providing a more accurate assessment of ball velocity.

Conclusion

Of the minimal research available pertaining to tennis modifications, results show modest evidence that LC tennis balls, scaled courts, and scaled equipment influence how children progress, perform, and learn the game of tennis (Farrow and Reid, 2010). Of the research available, most appears to utilize adult participants, suggesting the need for additional studies on the modification of tennis equipment and the corresponding influence it may have on the skill development within children. The tennis community knows that when children develop competency through success early on, they are much more likely to continue playing and enjoying physical activity (Ryan et al., 1997). The participants of this study were found to have enhanced forehand groundstroke performance when using modified balls and court versus standard balls and court; considering these finding one might suggest that children may have enjoyed the game to a greater extent due to their enhanced success. As stated in the literature, modified equipment can have a significant impact on the performance and enjoyment of young tennis players. Therefore, modifying the game of tennis may play a vital role in future tennis instruction and the continued enjoyment of young tennis enthusiasts around the world.

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Key points

- This study observed the effects of modified tennis balls and court had on the forehand groundstroke performance in children.
- Modified ball compression and modified court size can increase control, velocity and overall success of tennis performance.
- Children will have more success learning the game of tennis using modified equipment than using standard equipment.

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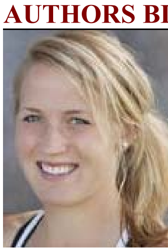

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