

**Title: The effect of equipment scaling on the skill acquisition of beginning tennis players.****Abstract**

This study examined the effectiveness of equipment scaling (tennis ball compression and court size) on beginner tennis player skill acquisition and associated psychological responses within a structured competitive development/participation program. The participants' ability to rally and their stroke proficiency was recorded pre and post a five week acquisition phase. Coupled to these dependent measures were within practice session recording of hitting opportunities, resultant success and the affective measure of session happiness. The group who practised using a standard ball and standard court (adult constraints) were afforded a significantly poorer learning experience relative to the other ball-court scaling combinations. In particular, the adult standardised intervention group recorded significantly less hitting opportunities on the forehand and backhand side than the scaled-court intervention conditions. The decreased hitting opportunities experienced within the standardised adult condition then flowed into significantly poorer hitting success relative to the scaled-court groups. The decompressed ball/scaled-court intervention group rated their experience significantly happier than the standardised adult group. Discussion centres on the stronger learning effect generated by court scaling relative to the influence of ball type and the broader application of these findings to skill acquisition theory and practice.

## Introduction

A common recommendation within the junior sports coaching field is the need to scale the equipment to the needs of the children ([http://www.ausport.gov.au/participating/coaches/tools/factsheets/coachin\\_children/Modified](http://www.ausport.gov.au/participating/coaches/tools/factsheets/coachin_children/Modified)). The reasons for modification are usually twofold: first to enhance the skill acquisition of the learner; and second to increase the fun/motivation of the learner and in turn maximise the chance of continued participation in the sport. The majority of sports now have junior or modified programs for children entering and progressing through a sport. Some examples from Australia include: 'Auskick' Australian football, 'Kanga Cricket' and 'Netta Netball'. Interestingly, while commonsense would recommend the scaling of the equipment and playing conditions presented to children when first learning a sport, there is a lack of empirical evidence to guide the degree of initial scaling and/or progression required as skill develops.

A useful paradigm for examining the issue of task and/or equipment scaling is borne out of constraints lead framework (Davids, Button & Bennett, 2008). Based upon Newell's (1986) model of learning, three inter-related but different constraints (task, environment and performer) can be manipulated to influence the outcome of skill production. Scaled equipment can be used to constrain a learner's movement pattern to promote skill acquisition (Davids et al., 2008). For instance, specific task constraints can be used to enable learners to cope with restrictive time demands and to allow learners to focus on the emergence of specific information-movement couplings. This is nicely illustrated through tennis which has introduced three ball types for use in tournaments played under the Rules of Tennis. That is, in addition to a regulation or medium paced ball (type 2), faster (type 1) and slower (type 3) balls have been recommended for different conditions. Specifically, the type 3 ball is 6% bigger than the type 1 and 2 balls, increasing its drag and subsequent flight time, slowing the game of tennis down accordingly (Metha & Pallis, 2001). As a result, researchers have demonstrated and recommended that the type 3 ball may be beneficial for beginning players (Cooke & Davey, 2005).

Indeed, in tennis, the selection and advance of equipment (i.e. racquets) represents another important task constraint (Davids, Bennett & Beak, 2002; Pellet & Cox, 1997; Gruetter & Davis, 1985; Blanksby, Elliott & Ellis, 1979), particularly when considered in the context of the varying ages and skill levels that play the sport. Previous work has in fact investigated the effects of ball compression (Hammond & Smith, 2006) and court size (Coldwells & Hare, 1985; Lee, Edwards & Smith, 1984) on skill development. Unfortunately, this body of extant research is limited and its findings inconclusive; largely constrained by research designs that failed to match the control and experimental groups for age and skill and lacked sufficient control over the influence of coaching process (Coldwells & Hare, 1994; Hammond & Smith, 2006). This lack of a firm evidence base to guide the use and interaction of scaled racquet sizes and court dimensions/ fixtures (i.e. net height) in tennis is topical as the sport's governing body, the International Tennis Federation (ITF), has recently set out to launch a worldwide coaching/participation initiative - the 'Play and Stay' program - based on task/equipment scaling. The broad aim of the program is to encourage coaches to get players to 'play' the game rather than to simply teach technique. This emphasis is consistent with recent critiques of sport pedagogy that have underlined the benefits of less prescriptive coaching approaches (Davids et al., 2008). The program variously recommends the use of three different racquets and modified balls on three different sized courts within a variety of competition formats. Yet guidelines as to the most appropriate ball type and court size for players of different ages and/or skill levels appear arbitrary. By way of example, in embracing the initiative, the United States Tennis Association (USTA) suggest that players aged 8 years and under use the combination of 48-58cm racquets, 'very low compression' balls and a 10.97m x 5.49m court with a net height of 0.84m, while advocating a graduated increase in racquet size (58-64cm), court size (18.3m x 8.23m), net height and ball compression (to 'low compression balls') for 10 and under players. The Lawn Tennis Association (LTA), on the other hand, suggest red balls (mass: 32-42g; rebound height: 95-110cm), an 11x5.5m court with a 0.8m net height, and 43-58cm racquets as being appropriate for starter adults or children aged up to 8; orange balls (mass: 36-47g; rebound height: 100-115cm), an 18x6.5m court with a 0.8m net height, and 58-63cm racquets to match starter adults and children aged 8-9; and green balls (mass: 47-52g; rebound height: 118-132cm), a full court and 63-66cm racquets for starter adults and children aged 10 years old. Given the number of modifiable equipment constraints, it's clear that significant investment in a well controlled course of research is required to corroborate any of the above recommendations.

This study therefore represents a first effort to determine the effect of equipment and task scaling (one type of modified/decompressed tennis ball and one modified/reduced court size) on the skill acquisition and associated psychological responses of beginner tennis players in a structured coaching program similar to the 'Play and Stay' approach.

## Methods

### Participants

A total of 23 primary school children with limited to no previous tennis playing experience participated voluntarily in this study after ethics approval was granted by the University and parental consent obtained. The age of the participants was  $8 \pm 0.4$  years.

### Experimental design

The experimental design consisted of a rally performance pre-test used to record the number of balls the participants could hit back to a coach and to allow a qualitative assessment of stroke production by three qualified tennis coaches. This tennis skill assessment was used to ensure the homogeneity of baseline data and the skill-matching of intervention groups. This was followed by a five week training period, where participants were assigned to one of four practice conditions that involved the manipulation of ball compression and court size. One week after the final practice session a post-test identical to the pre-test was completed. In addition to the pre-post testing, within practice session data such as the volume of strokes hit by each participant were recorded. Furthermore, at the completion of each practice session, participants completed a positive psychology scale that assessed their affective responses to each practice session.

### Apparatus and testing procedures

All testing sessions were conducted on a regulation outdoor (synthetic grass) tennis court. The rally performance assessment was performed with two balls of varying compression on both a full-sized and a scaled tennis court. The two balls used for the assessment, and throughout the research design, were a standard Slazenger tennis ball (standard ball) and a Wilson 'red' decompressed ball (<50% of standard ball compression, or, 56% lighter, 10% bigger and 37% less bouncy than standard balls, ITF, 2008). Ecological validity was assured through the use of "used" or "worn" balls, reflecting those generally employed in most tennis coaching practices. As assessed by a ball rebound test on the synthetic grass court, the ball rebound heights of the standard ball and the modified ball were 1.26 and 0.88 respectively. Interpreted alongside the ITF's minimum specifications for the rebound heights of new standard and decompressed balls, this reflects a consistent 7% decrease in ball rebound height across ball type (ITF, 2008). The courts selected for the assessment, and throughout the study, were a full sized court 23.77m x 10.97m (standard court) and a 11m x 5.5m court (scaled-court). All players used 53cm aluminium Wilson tennis racquets. The modifications utilised were in accordance with the ITF's recommendations for the age and skill level of the participants (<http://www.tennisplayandstay.com/#Progression>).

**Rally performance test.** Through pace and direction controlled live ball feeds by a qualified tennis coach, participants were challenged to rally as many forehands and backhands over the net as possible in standardised sequence (i.e., forehand, backhand, forehand and so on). If a participant failed to return more than one shot on their first rally attempt, a second chance was provided. The total number of strokes hit consecutively was recorded as their rally performance score. During the rally performance assessment, two digital video cameras were set up (on forehand and backhand sides) perpendicular to the direction of ball flight to record the participants' full groundstroke swings. Through video replay in the sagittal plane and a qualitative assessment scale (Table 1), three qualified tennis coaches - with experience in coaching young beginner players - rated each player's forehand and backhand technique. All participants completed this test under each combination of court size and ball type with one stroke selected (i.e. the first shot) and analysed per participant. The four phases (preparation including movement to the ball, backswing, forwardswing including impact, and follow-through) of each player's forehand and backhand stroke were rated using a 7 point scale with a summed, maximum achievable score of 28 per stroke. These total values for the stroke were included in subsequent data analysis. Intraclass (forehand: 0.82; backhand: 0.80) and interclass (forehand: 0.92; backhand: 0.87) correlations on summed scores were calculated as the coaches performed a test-retest assessment on the strokes played in the standard ball-standard court condition.

**Within session measurement.** During and at the completion of each practice session participants were required to complete two forms of ongoing assessment. First, the number of balls hit (per stroke) per session for each participant was recorded. This measure was obtained by a research assistant filming each practice session from an elevated, behind the court position and then using video replay to count each participant's hitting volume for the session. Each participant wore a specific coloured hat to assist with player identification. At the conclusion of each session, participants completed a modified version of the *SHI (Steen Happiness Index)*. This is a 20 item measure that examines people's responses on the following scales: *Meaning* - participating in meaningful activities; *Engagement* - losing the self in engaging activities; and *Pleasure* - experiencing and savouring pleasures. Response choices range from a negative (1) to an extreme positive (5). In the current study, six questions were selected and adapted to suit the comprehension level of the participants.

### *Training Procedures*

All groups completed one 30 minute practice session per week for five weeks. Each practice group used the same tennis racquet and completed identical activities within each practice session consistent with the Tennis Australia (TA) "Hot Shots" training program. The "Hot Shots" is based on the principles of the ITF's Play and Stay initiative, and its activities largely comprise of game play, where players are presented with a combination of cooperative rally situations and competitive playing opportunities, both with a partner. The same TA qualified coach administered all practice sessions, hence the only difference between each practice group was the combination of ball type and court utilised. Beyond the practice intervention, participants were asked to refrain from participation in tennis activities. The four practice conditions are detailed below:

*Standard ball-scaled court.* This group ( $n = 6$ ) completed their practice on a mini-sized tennis court (12m x 6m) with the net height set at 0.8m and hit a standard tennis ball.

*Decompressed ball-scaled court.* This group ( $n = 5$ ) completed their practice on a mini-sized tennis court (12m x 6m) with the net height set at 0.8m and hit a decompressed tennis ball.

*Standard ball-standard court.* This group ( $n = 6$ ) completed their practice on a full sized singles tennis court and hit a standard tennis ball.

*Decompressed ball-standard court.* This group ( $n = 6$ ) completed their practice on a full-sized singles tennis court and hit a decompressed tennis ball .

### *Analysis of Data*

The pre-post test rally performance variables of hitting volume and stroke proficiency for each court and ball combination were separately analysed using a 4 x 2 (group x test occasion) factorial analysis of variance (ANOVA) with repeated measures on the second factor. The practice session measures were categorised under the themes of opportunities, success and happiness (see below) and were analysed separately using a 4 x 5 (group x practice session) ANOVA with repeated measures on the second factor. For all ANOVA's, the Greenhouse-Geisser correction was applied to any violations of sphericity. Significant interactions as a result of these analyses were investigated through the use of t-tests with Bonferroni correction where appropriate. The alpha level was set a priori at  $P < 0.05$ .

### *Practice Session Analysis Categories*

*Opportunities.* Total hitting volume of all forehand and backhand strokes (recorded separately) irrespective of whether the ball was considered to be hit in or out of the court.

*Success.* This measure separately analysed the number of forehand and backhand strokes that were successful (hit into the court).

*Happiness.* The participants' responses to the SHI were analysed, first by considering an overall happiness response (all six questions collapsed together) and then through individual analyses of each index factor (Meaning, Pleasure, and Engagement).

## **Results**

### *Pre-Post Testing Rally Hitting Volume.*

Analyses revealed a significant group x time interaction ( $F_{3,19} = 11.16, P < 0.05$ ) for hitting volume within the standard ball/scaled-court test condition. Specifically, the groups that practised under the standard ball/scaled-court and decompressed ball/standard court practice conditions improved significantly from the pre to post-test occasion (Figure 1). There were no other significant main effects or interactions for any of the groups on the standard ball/standard court or decompressed ball/scaled-court testing conditions.

INSERT FIGURE 1 NEAR HERE

### *Pre-Post Testing Technical Proficiency.*

*Forehand.* One-way ANOVA demonstrated that there were no significant differences between the groups' forehand technical proficiency before the intervention commenced for any of the court size/ball type testing combinations. There was a general pre-post test improvement in technical proficiency of the forehand stroke under the decompressed ball/standard court (Pre  $M = 18.86$ , Post  $M = 24.79$ ) ( $F_{1,19} = 25.06, P < 0.05$ ) and standard ball/scaled-court test conditions (Pre  $M = 20.34$ , Post  $M = 24.85$ ) ( $F_{1,19} = 11.99, P < 0.05$ ) but this was not mediated by group. There were no other significant main effects or interactions within any of the other testing conditions.

*Backhand.* One-way ANOVA demonstrated that there were no significant differences between the groups' backhand technical proficiency before the intervention commenced for any of the court size/ball type testing combinations. Similar to the forehand proficiency analyses, there was a general pre-post test improvement in technical proficiency under the decompressed ball/standard court (Pre  $M = 19.44$ , Post  $M = 24.52$ ) ( $F_{1,19} = 19.26, P < 0.05$ ) and standard ball/scaled-court test conditions (Pre  $M = 17.88$ , Post  $M = 25.83$ ) ( $F_{1,19} = 49.69, P < 0.05$ ). Additionally, the decompressed ball/scaled-court test condition also demonstrated a

general proficiency improvement over time (Pre  $M = 23.38$ , Post  $M = 27.00$ ) ( $F_{1,15} = 5.00$ ,  $P < 0.05$ ). However, none of these improvements were mediated by group. There were no other significant main effects or interactions within any of the other testing conditions.

*Opportunities (Hitting Volume During Practice).*

*Forehands.* Analyses revealed a significant group main effect ( $F_{3,19} = 10.88$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.63$ ) and group x time interaction ( $F_{12,76} = 3.68$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.37$ ) for forehand hitting volume across the five practice sessions (Table 2). In this case, interpretation of the significant group effect is more instructive than the interaction. The standard ball/standard court group experienced a significantly reduced number of forehand opportunities than the both the scaled-court groups ( $P < 0.05$ ) and trended in a similar direction relative to the decompressed ball/standard-court group ( $P = 0.06$ ) (Figure 2). Despite these specific between group differences, visual inspection of the data demonstrated that the key derivative in performance was the type of court more so than the influence of ball type. This was confirmed by analysis of the data collapsed by court type. A group main effect showed greater forehand opportunities when playing on a scaled-court ( $M = 32.41$ ) than a standard court ( $M = 22.58$ ) ( $F_{1,21} = 22.66$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.52$ ), while an interaction effect ( $F_{4,84} = 4.19$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.17$ ) showed more forehand opportunities being provided on a scaled-court throughout the intervention with the exception of week 3 relative to a standard court (Figure 3).

INSERT TABLE 2 & FIGURES 2 & 3 NEAR HERE

*Backhands.* A significant group main effect ( $F_{3,19} = 9.49$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.60$ ) and group x time interaction ( $F_{12,76} = 2.47$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.28$ ) was recorded for backhand hitting volume throughout the five practice sessions (Table 3). The significant group effect is again more instructive. The standard ball/scaled-court group experienced significantly more backhand hitting opportunities than both standard court conditions ( $P < 0.05$ ) and similar to the forehand side, the number of backhands hit by players in the decompressed ball/scaled-court group trended higher ( $P = 0.06$ ) than with the same ball on a full court (Figure 4). Backhand hitting volume, when investigated by court type, revealed a significant group main effect, with greater backhand opportunities provided on a scaled-court ( $M = 4.87$ ) than a standard court ( $M = 1.46$ ) irrespective of ball type ( $F_{1,21} = 23.40$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.53$ ). There was no significant group x time interaction ( $F_{4,84} = 0.51$ ,  $P > 0.05$ ,  $\eta_p^2 = 0.02$ ).

INSERT TABLE 3 & FIGURE 4 NEAR HERE

*Success (Shots In).*

*Forehands.* Analyses revealed a significant group main effect ( $F_{3,19} = 4.21$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.40$ ) and group x time interaction ( $F_{12,76} = 3.41$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.35$ ) for the absolute number of forehands hit successfully across the five practice sessions. The significant group effect demonstrated that the decompressed ball/scaled-court group hit more forehands into court than the standard ball/standard court group ( $P < 0.05$ ) (Figure 5). The significant interaction was primarily driven by the variable performance of the decompressed ball/standard court group and again is not instructive (Figure 6).

Similar to the opportunities measure, a secondary analysis that did shed further light on the hitting success of the participants was when the practice groups were collapsed by court type (irrespective of ball type). Participants playing on a scaled-court hit a significantly higher number of forehands in the court (except in session 3) than those that played on a standard court ( $F_{4,84} = 5.47$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.20$ ) (Figure 7). The group main effect ( $F_{1,21} = 12.48$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.37$ ) confirmed the higher number of forehands hit into the court by the players participating on a scaled-court ( $M = 22.1$ ) relative to the standard court ( $M = 12.1$ ). Finally, when the success of the participants is considered as a relative percentage of the total number of hits rather than absolute hits, a similar story emerges to the data reported here, hence these additional analyses are not reported.

INSERT FIGURES 5, 6 & 7 NEAR HERE

*Backhands.* A significant group main effect ( $F_{3,19} = 4.72$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.43$ ) revealed that the standard ball/scaled-court group hit more backhands into court than the standard ball/standard court group ( $P < 0.05$ ) (Figure 8). There was no significant group x time interaction ( $F_{12,76} = 1.79$ ,  $P > 0.05$ ,  $\eta_p^2 = 0.22$ ).

When the practice groups were collapsed by court type (irrespective of ball type), participants playing on a scaled-court ( $M = 2.40$ ) hit a significantly higher number of backhands in the court than those that played on a standard court ( $M = 0.47$ ) ( $F_{1,21} = 14.75$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.41$ ). There was no significant

interaction ( $F_{4,84} = 0.26, P > 0.05, \eta_p^2 = 0.01$ ). Similar to the forehand analysis, when the success of the participants is considered as a relative percentage of the total number of hits rather than absolute hits, a similar story emerged and hence not reported.

INSERT FIGURE 8 NEAR HERE

#### *Happiness.*

The participants' responses to the SHI revealed a significant group effect ( $F_{3,19} = 3.60, P < 0.05, \eta_p^2 = 0.36$ ). The decompressed ball/scaled-court group ( $M = 3.87$ ) rated practice a happier experience than the standard ball/standard court group ( $M = 3.28$ ), while the other two groups did not significantly differ from any other group (standard ball/scaled-court  $M = 3.70$ , decompressed ball/standard court  $M = 3.72$ ). There was no significant group x time interaction ( $F_{12,76} = 1.37, P > 0.05, \eta_p^2 = 0.17$ ) nor any significant main effects or interactions when each sub-scale was analysed separately.

#### **Discussion**

The aim of this paper was to examine the effectiveness of equipment scaling (tennis ball compression and court size) on beginner tennis player skill acquisition. The participants' ability to rally and their stroke proficiency was recorded pre and post a five week acquisition phase. Coupled to these dependent measures were within practice session recording of hitting opportunities, resultant success and the affective measure of session happiness.

The primary conclusion that can be drawn from the results is that the standard ball/standard court practice condition (or the group that practised under adult game constraints) affected a negative learning experience for the participants relative to the other ball-court scaling combinations. In particular, the standard/standard intervention group recorded significantly less hitting opportunities on the forehand side than both the scaled-court conditions (Figure 2). On the backhand side, they hit fewer balls than the standard ball/scaled-court condition (Figure 4). The decreased hitting opportunities experienced within the standardised adult conditions then flowed into the hitting success measures where fewer forehands were successfully hit into court relative to the decompressed ball/scaled-court group (Figures 5) and fewer successful backhands (Figure 8) were struck relative to the standard ball/scaled-court condition. The final piece of corroborating evidence that the adult standardised practice conditions were inappropriate for the children's skill acquisition was that the children rated the decompressed ball/scaled-court intervention a significantly happier experience than the standard ball/standard court condition.

It is clear from the results obtained that a cyclical pattern developed across of the practice intervention. The greater hitting opportunities created in the scaled-court conditions relative to the standard ball and court conditions led to greater hitting success and participant happiness. While the exact nature of this relationship was not investigated such findings are consistent with motor learning theory highlighting the importance of creating practice conditions that set an optimal challenge for the learner so that learning is maximised and motivation and success are optimised (Schmidt & Wrisberg, 2000).

The interaction between ball and court scaling was obviously a key feature of this study. While the between group results were not entirely clear, other than the relatively poorer performance of participants within the standard/standard condition, visual inspection of the data highlighted the strong influence of court scaling relative to that of the ball. Resultant analyses that considered the specific influence of the court scaling (irrespective of ball type) demonstrated an obvious advantage for the participants practising on a scaled-court relative to the standard court. This learning advantage might be explained by examining the relative degree of scaling applied to the various conditions. Using the balls' rebound heights, the decompressed ball had a scaling ratio of .70 relative to the standard ball whereas the length of the scaled-court conditions was scaled to  $\approx .50$  of the full court. In other words, the extent to which the court scaling may have influenced the acquisition conditions was more significant than those of the ball. It's important to mention that while these scaling ratios meet with current ITF recommendations, consideration of only ball rebound height oversimplifies ball behaviour and playability. That is, ball properties such as its size directly influence ball aerodynamics (and therefore velocity), contributing to a relative change in ball rebound height during typical tennis rallies. Nonetheless, the notion of scaling ratios is relevant as coaches have historically scaled court size (and more particularly, length) before ball type. In these instances, players often modify swing shapes and speeds to combat a scaled, smaller court but a non-scaled, standard ball. Therein lies the theoretical rationale for advocating the use of a lower compression ball, where players can develop more complete technical and tactical repertoires uninhibited by courts that are too large, racquets that are too big and heavy and/or balls that are too bouncy.

Interestingly though, the pre-post measures of rally volume and technical proficiency did not reveal strong learning effects for any particular practice intervention. The only findings of note were that the standard ball/scaled-court and decompressed ball/standard court groups significantly increased their rally

length (as measured by balls hit) on the standard ball/scaled-court test condition. In regards to technical proficiency and the above rationale, there were no significant between group differences in any of the test conditions. However there were significant improvements over time (irrespective of group membership) on the various scaled court-ball combinations but not the standard ball/standard court test condition. A number of issues may help explain these findings. First, the poor test performance may have been somewhat mediated by the rally test protocol that required players to alternate between forehand and backhand strokes. As was evident across the within session measures of hitting opportunity and success, all participants were significantly weaker on their backhand relative to forehand side. If participants were permitted to play any stroke they liked (or allowed to 'run around their backhand' to play a forehand), their rally performance scores may have been higher. Nevertheless, it may not be unsurprising that participants failed to make significant changes in the space of the five week intervention as they were likely still attempting to assemble a coordinated movement pattern while experiencing a wide range of necessary movement variability. Finally, the absence of conclusive pre-post testing effects also highlights the importance of collecting within session measures of performance, without which many of the learning characteristics of each practice intervention would have been concealed.

Another obvious trend in the results was the greater number of forehands hit by the participants, both in terms of overall volume and success, relative to the backhand side. This effect is most likely due to a combination of constraints such as the participants' self-selection of a forehand grip and the heightened relative strength demands to hit a backhand stroke (Krishnan, 2006). It is also important to note the context in which this study was completed. There was no direct coaching of the participants on stroke production, or tactical awareness, rather participants were engaged in a series of organised hitting games/activities based upon Tennis Australia's 'Hot Shots' development program. Hence the coaches did not intervene to assist learners to solve the perceptual-motor issues surrounding the generation of an appropriate backhand stroke. Coupled to this, is the earlier finding of the cyclical relationship between opportunity, success and challenge which would have reinforced the participants' keenness to hit a forehand relative to a backhand.

The current study also highlights a number of critical issues to be addressed in future research. Firstly, while the current study was ecologically sound, this came at the expense of a small participant sample and a relatively short practice intervention (albeit reflective of real world constraints). Furthermore, the sensitivity of technical proficiency measurements able to be implemented were, necessarily, qualitative and may have obscured some of the perceptual-motor learning being made by participants. While the scaling of ball compression was not as influential as court scaling in the current study, the influence of the ball should not be discounted. In particular the size of the ball coupled with its relative decompression requires further systematic examination. It is recommended that research similar in design to laboratory-based approaches used to measure differently skilled performers' sensitivities to haptic information when wielding a tennis racquet (Davids, Bennett & Beak, 2002) or the approaches used to examine the relative properties of the type 3 ball (Cooke & Davey, 2005; Metha & Pallis, 2001) be adopted to examine the optimal degree of scaling for participants at particular developmental progressions.

In conclusion, the current study highlighted the negative influence of providing adult constraints to children learning tennis skills. Furthermore, the mixed results found for hitting opportunities, success and participant happiness across the differently scaled ball type and court size combinations make it difficult to support the various tennis organisations mandating of the progression of skill development on the basis on specific ball and court combinations. Put simply, skill learning is not that linear!

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**Table 1.** Stroke proficiency assessment in tennis (SPAT), where coaches were instructed to consider the median to represent the average level of competence per phase for an 8 year old beginning tennis player.

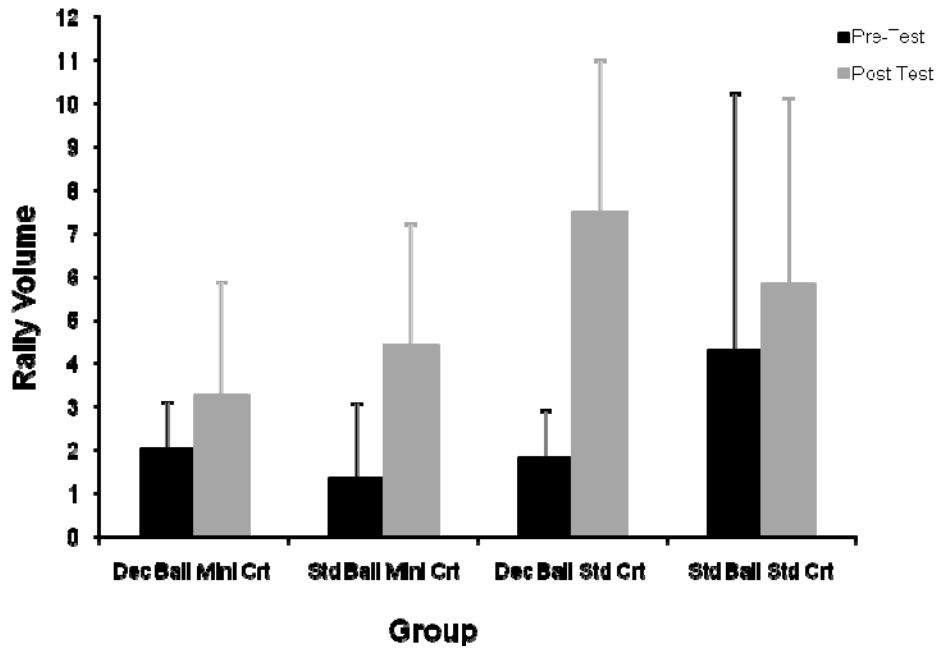
	<b>Scale</b>						
<b>Phases</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
	<b>Very poor</b>	<b>Poor</b>	<b>Slightly below average</b>	<b>Average</b>	<b>Slightly above average</b>	<b>Good</b>	<b>Very good</b>
<b>Preparation</b>							
<b>Backswing</b>							
<b>Forwardswing and impact</b>							
<b>Follow-through</b>							

**Table 2.** Total mean forehand hitting volumes (standard deviation) for each group across each practice session.

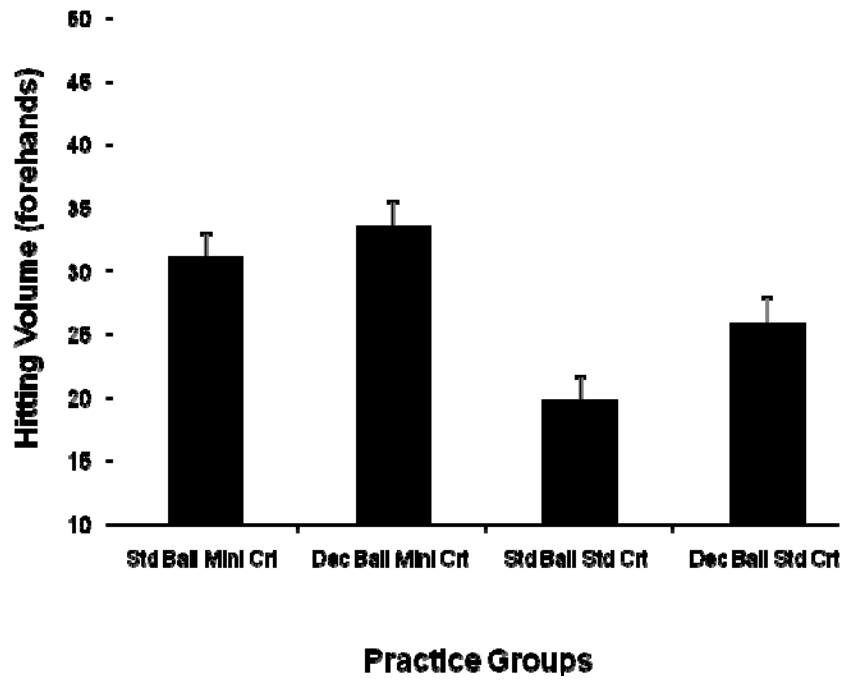
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Dec Ball Mini-Crt	35.00 ± 6.44	33.75 ± 4.30	29.40 ± 8.23	34.00 ± 14.08	36.16 ± 9.32
Std Ball Mini- Crt	39.60 ± 9.41	29.00 ± 10.05	27.16 ± 9.41	34.83 ± 15.09	25.20 ± 8.42
Dec Ball Std-Crt	27.80 ± 7.69	26.20 ± 6.68	36.60 ± 6.30	10.75 ± 1.08	28.25 ± 2.86
Std Ball Std-Crt	18.50 ± 8.45	15.83 ± 3.97	23.00 ± 4.04	21.66 ± 5.20	20.00 ± 7.77

**Table 3.** Total mean backhand hitting volumes (standard deviation) for each group across each practice session.

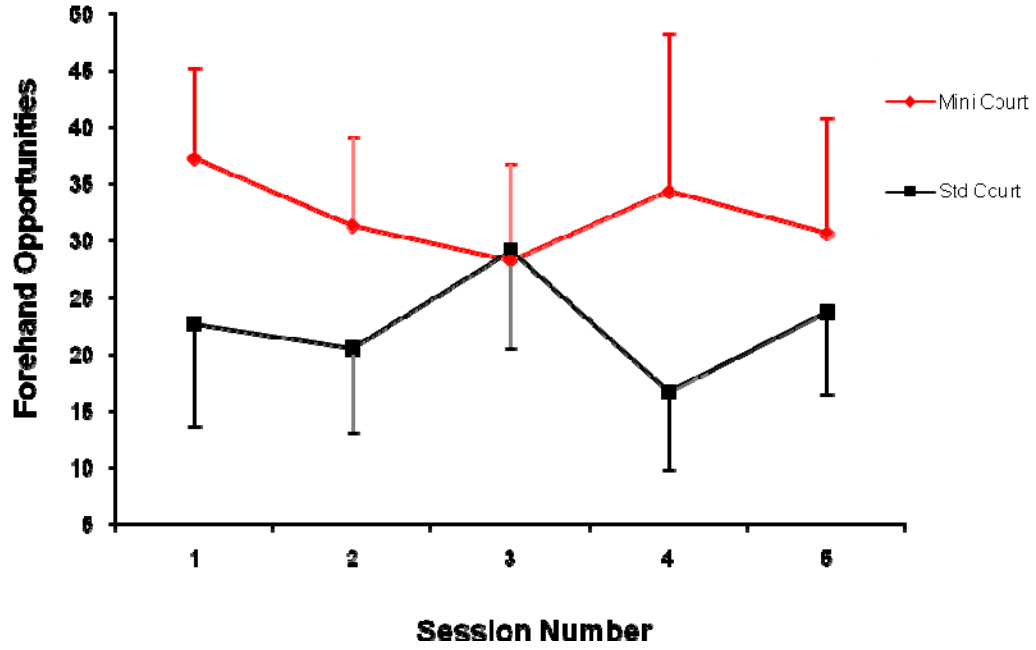
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Dec Ball Mini-Crt	3.16 ± 2.31	4.80 ± 2.76	3.20 ± 2.33	2.83 ± 2.63	6.16 ± 3.76
Std Ball Mini- Crt	10.88 ± 6.07	4.83 ± 1.94	5.50 ± 3.01	4.16 ± 4.30	3.22 ± 1.86
Dec Ball Std-Crt	0.80 ± 0.44	1.00 ± 0.70	1.20 ± 1.30	0.40 ± 0.54	2.53 ± 2.63
Std Ball Std-Crt	3.00 ± 4.51	2.50 ± 5.16	1.50 ± 1.76	1.16 ± 1.16	0.33 ± 0.51



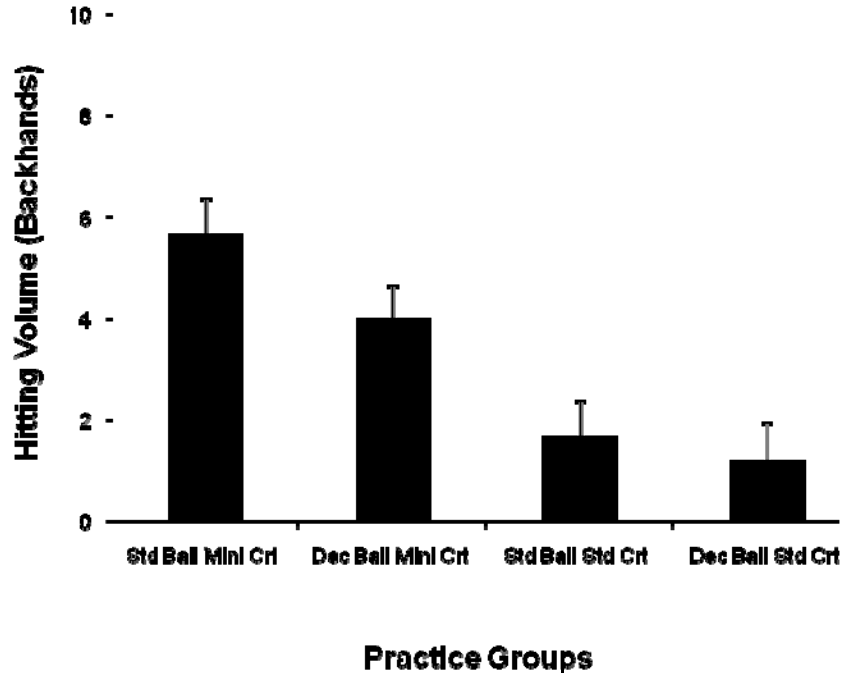
**Fig 1.** The mean rally length of each group pre-post the acquisition phase in the standard ball/scaled-court test condition. Errors bars represent standard deviation.



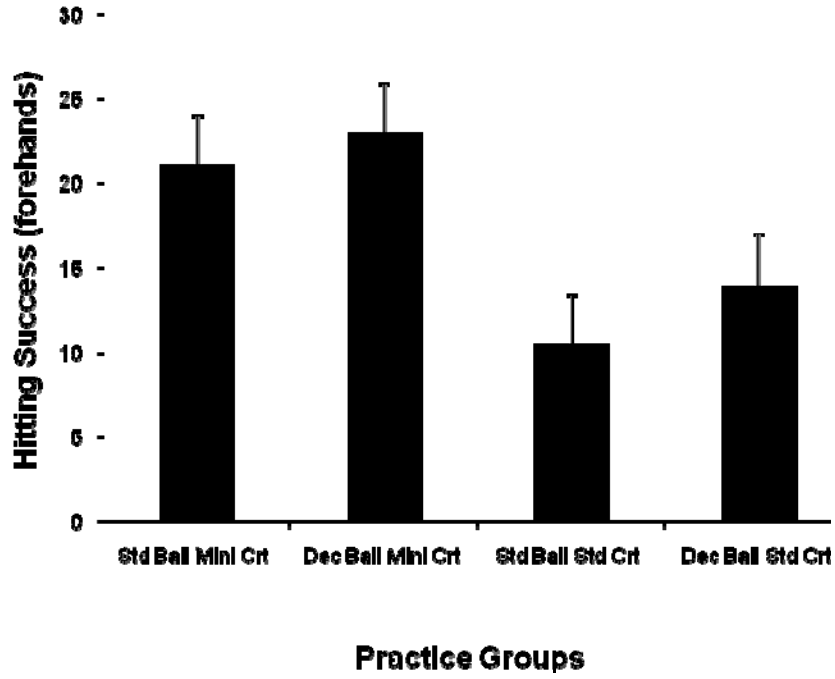
**Fig 2.** The mean number of forehand opportunities for each practice group. Errors bars represent standard error.



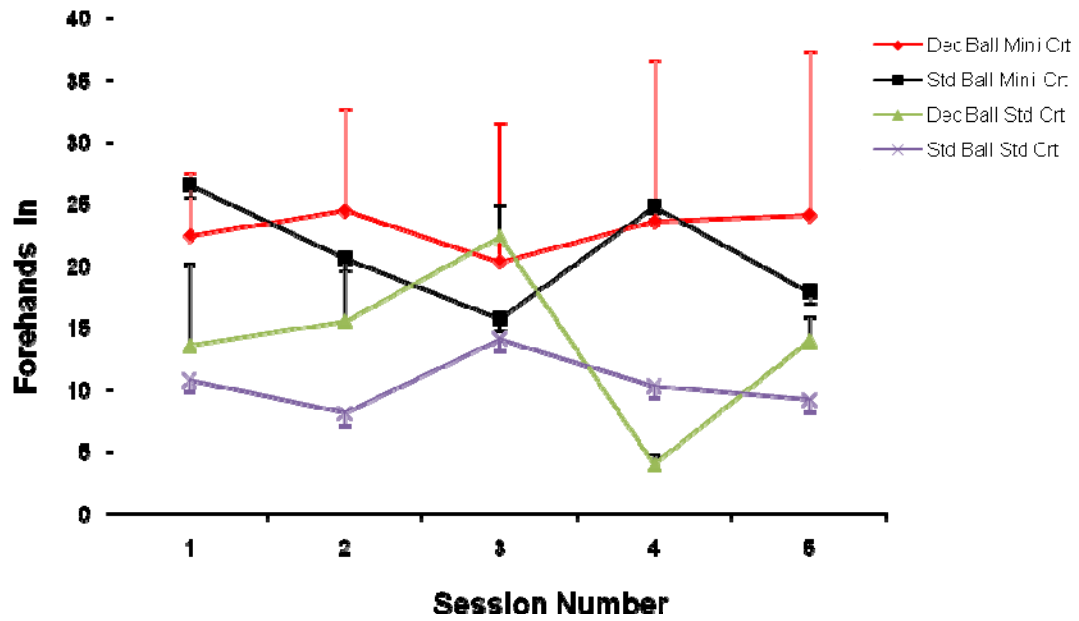
**Fig 3.** The mean number of forehand opportunities collapsed across court type (irrespective of ball type) across each practice session. Errors bars represent standard deviation.



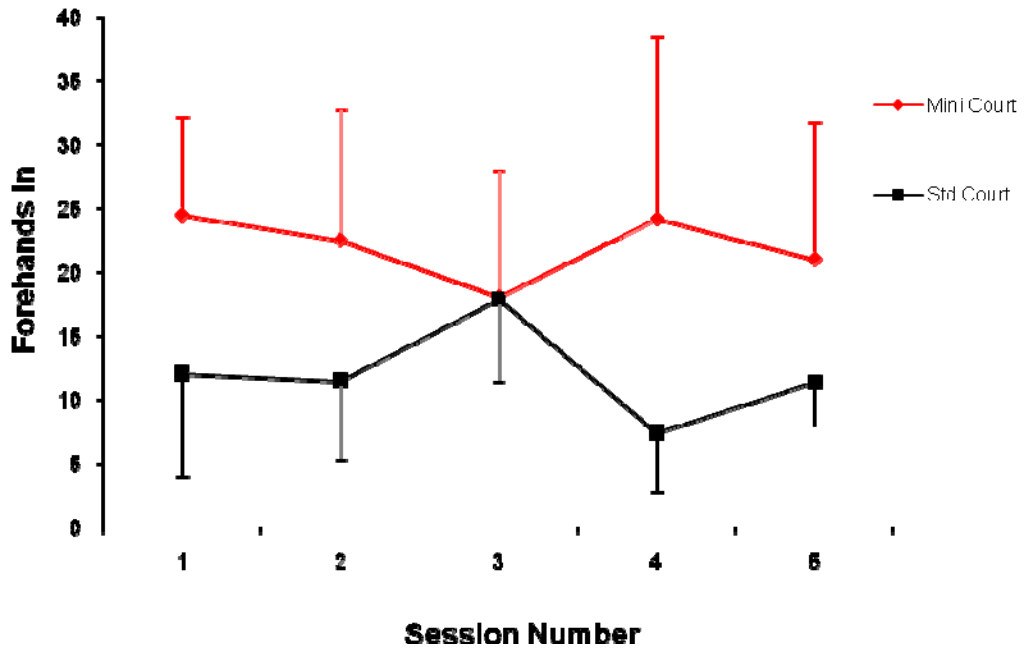
**Fig 4.** The mean number of backhand opportunities for each practice group. Errors bars represent standard error.



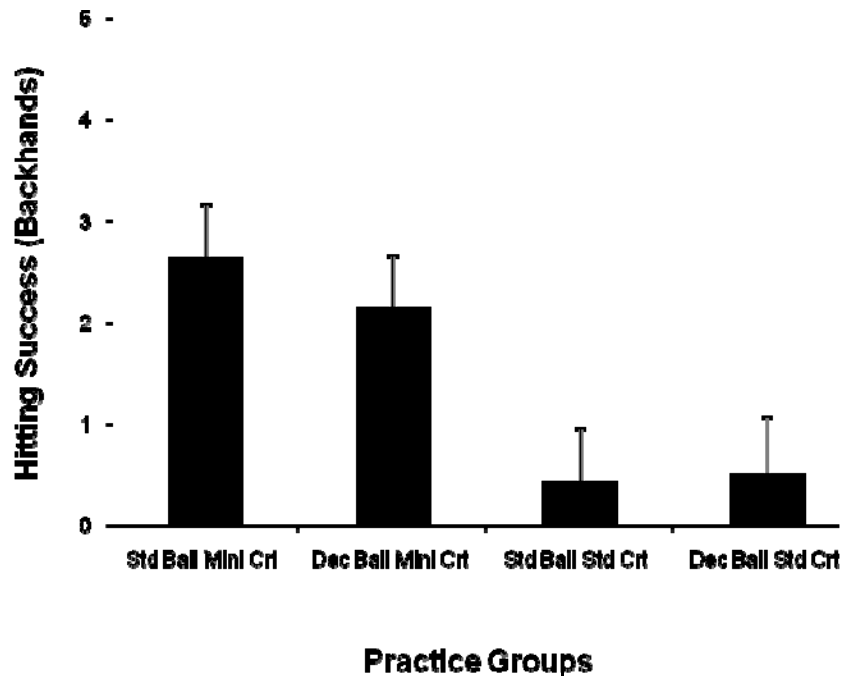
**Fig 5.** The mean number of forehands hit successfully for each practice group. Errors bars represent standard error.



**Fig 6.** The mean number of successful forehands for each group across each practice session. Errors bars represent standard deviation.



**Fig 7.** The mean number of successful forehands collapsed across court type (irrespective of ball type) across each practice session. Errors bars represent standard deviation.



**Fig 8.** The mean number of backhands hit successfully for each practice group. Errors bars represent standard error.