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ORIGINAL SCIENTIFIC PAPER

Effect of Scaling Racquet Using a Body-Scaling Approach on Badminton Match Performance

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Abstract

This research aimed to determine the ideal racquet size by modifying racquets based on a body-scaling approach employing arm-to-racquet length ratios. Twelve boys aged between 13 to 14 years (13.17±0.83) with one to two years of badminton experience volunteered to participate in the study. To calculate arm-to-racquet length ratios, participants' arm lengths for both hands were recorded. Participants were divided into six pairs and played a badminton match using three types of racquets which were racquets A (1.1:1.0), B (1.0:1.0), and C (0.9:1.0). Participants' hitting opportunities, successful strokes, winning strokes, rally length, and unforced errors were notated manually via video replay. Based on the one-way ANOVA with repeated measures, the results showed that the use of racquet B which had a pi ratio of 1.0:1.0 for arm length-to-racquet length ratios during badminton matches, recorded the highest mean scores in hitting opportunities, successful strokes, and winning strokes than racquets A (1.1:1.0) and C (0.9:1.0), p<.05. The results also demonstrated that the use of racquet B reduces the unforced errors during matches compared to racquets A and C, p<.05. It is suggested that giving children equipment that suits their physical characteristics (e.g., racquet length with arm length) might improve their performance and allow them to play badminton more efficiently.

Keywords: *affordances, badminton, body-scaling, constraints-led approach, scaling equipment*

Introduction

According to the dynamic system theory, practitioners can aid the learning of complicated tasks by modifying the tasks' demands or the practice environment (Woods et al., 2020). This theory suggests that changing one or more task, environmental, or performer constraints will probably affect the performer's information (perceptions) and movement options (action) (Broadbent, Buszard, Farrow, & Reid, 2021). The changes in the constraint (e.g., task constraints) have prompted the performer to explore new or more stable movement coordination patterns (Brocken, van der Kamp, Lenior, & Savelsbergh, 2021). There is a need for task modifications that considerably aid in the development of young talent while retaining the true nature of the individual movement coordination patterns displayed in adult games (Buszard, Reid, Masters, & Farrow, 2016; Buszard, Farrow, & Reid, 2020; Gorman, Headrick, Renshaw, McCormack & Topp, 2021). The court size and net height (Ortega-Toro, Blanca-Torres, Giménez-Egido, & Torres-Luq, 2020), the size of the ball (Afrouzeh, Musa, Suppiah, & Abdullah, 2020), and the size of the equipment (Azmi, Suppiah, Low, Noordin, & Samsir, 2020; Azmi, Low, & Nadzalan, 2023) being used are just a few examples of how junior sports are frequently modified.

Changing the practice environment through sports equipment modification is a crucial strategy for encouraging performers to seek functional movement patterns (Renshaw & Chow, 2019; Chow, Davids, Button, & Renshaw, 2021) and would increase participants' enjoyment during the games (Farrow & Reid, 2010). These sport equipment modifications have utilized the concept of affordances. Gibson (1986) de-

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fined affordance as the environment (i.e., the game's equipment) in terms of what it "offers" or "affords" the person. In other words, Gibson (1986) opted to explain the characteristics of the environment in terms of how they are related to individuals' attributes. As a result, affordances are body-scaled as people attempt to harness their abilities to excel in goal-directed tasks like competitive sports (Fajen, Riley & Turvey, 2009; Silva et al., 2013). Tennis researchers have used the racquet-to-racquet time (technical) (Timmerman et al., 2015) and height (physical maturity) (Limpens et al., 2018) measures to evaluate the effects of scaling in junior sports. Basketball researchers recently evaluated the relative difference between basketball players' hand span and ball size using this technique (Gorman et al., 2021). These situations created the opportunity to create a more cohesive plan for junior sports modification.

Pi-ratios, a body-scaling approach, have been designed to create methodical guidelines for junior sports modifications (Broadbent et al., 2021). The affordances theoretical idea from dynamic system theory was used to optimize modifying constraints in junior sports (Gorman, Renshaw, Headrick & McCormack, 2020). Pi ratios were calculated for the age group relative to the size of adult competition constraints (Broadbent et al., 2021). Given that youth rugby league games last half as long as adult games (40 minutes as opposed to 80 minutes), the task constraint ratio for match time (calculated based on action capabilities) in those games is 0.50. By comparing the average value of each group to the average adult, physical maturation ratios (calculations based on body/physical maturation) for each physical size measurement were established. If the children were half as tall as adults, the physical maturation ratio would be 0.50. To determine pi ratios, the task constraint was divided by the physical maturation ratio (Broadbent et al., 2021). Children's learning abilities are aided by giving them basketballs that fit their hands, which enables them to manage the ball in ways that adults do (Arias, 2012; Arias, Argudo & Alonso, 2012a,b; Gorman et al., 2020).

When designing talent development routes, the effectiveness of game modification is crucial to take into account (Buszard et al., 2020). For example, children had more opportunities to hit the shuttle and execute more successful strokes with a smaller court and racquet size in badminton (Suppiah, Low, Azmi, Noordin & Samsir, 2019; Azmi et al., 2020). However, the most crucial aspect is how the playing field, rules, and equipment have been altered in children's sports. The ability of the performer to attain motor competence may be significantly impacted by the scaling circumstances made available to them (Broadbent et al., 2021). Therefore, the study aimed to demonstrate the application of a body-scaling approach by modifying the racquet length based on children's physical characteristics (e.g., arm length) to identify the most appropriate badminton racquet size (from a selection of three racquet sizes; racquet A, B, and C). The study hypothesized that children might improve their match-play performance during badminton matches by utilizing a scaled racquet that employs a body-scaling approach. Children may be able to handle the racquet similarly to adult players, which could help them develop abilities appropriate for the adult game if the child's arm length and racquet size are matched.

Methods

Participants

A minimum sample size of 12 participants was recommended by an a priori power analysis for ANOVA repeated measures (α=0.05, 1-β=0.95, f=0.60). Therefore, the study included a total of 12 boys (13.17±0.83 years) who had played badminton for one to two years. The consent form was given to the parents of the research participants so that their children may participate in the study. The study was approved by Sultan Idris Education University's Ethics Committee for Human Research (2022-0498-02).

Experimental procedure

Participants' hands (right and left) were measured before the study started. The distance from the most distal crease of the wrist to the tip of the middle finger was measured using a segmometer to calculate the length of the hand (Fallahi & Jadidian 2011; Alahmari et al., 2017; Gorman et al., 2021). Hand length was measured twice on the right and left hands of each participant, and the mean values for hand length were calculated from the average of these measurements. The intra-rater and inter-rater reliability values were calculated using intra-class correlations, and they revealed incredibly high levels of reliability with scores between 0.97 and 0.99.

Participants completed badminton matches using three different types of racquets (racquet A, racquet B, and racquet C) (see Table 1) on a standard court. Racquet A is a standard racquet size used for official badminton tournaments. The length for racquet B was 100% of the participants' average arm length. The length for racquet C was 92% of the participants' average arm length. Based on the prior study, they manipulated the net height of badminton using 92% of the average height of children (Pirak, Nazarudin, & Suppiah, 2020). Pi ratios were calculated by dividing the task constraint by the physical maturation ratio (Broadbent et al., 2021). Table 1 displays the measurements for three different types of racquets. The following equation was used to get each racquet's pi ratio:

Pi ratio = task constraint ratio: physical maturation ratio

Table 1. The measurements for three different racquet types.

Type of racquet	Racquet length (cm)	Pi ratios	Description
Racquet A	68.0	1.1:1.0	Adult size – Standard racquet used to play in official badminton tournaments.
Racquet B	61.0	1.0:1.0	100% of the average arm length of participants.
Racquet C	56.1	0.9:1.0	92% of the average arm length of the participants.

Participants played using one type of racquet in a day to avoid exhaustion. Participants were unaware of which racquet they were using during the game. The order of the three types of racquets was counterbalanced across participants (Limpens et al., 2018). Before the match, participants were ranked based on their performance during the tasks performance (i.e., short serve, clear, and drop) to determine the pair. Participants played against the same opponent who was equally skilled at using all different kinds of racquets.

Participants completed 10 minutes of warm-up before starting their match. Participants played the best three sets of 21 points. All matches in all three types of racquets were recorded. One digital video camera brand Sony HDR-CX115 (Sony Tech, UK), has been set up 5 meters behind the baseline on each side to enable an analysis of the matches via video replay. The parameters (see Table 2) that were measured during match-play were as follows:

Table 2. Parameters in match-play.

Parameters	Description
Hitting opportunities	The total number of hits, regardless of the result.
Successful strokes	The number of successful hits that fall in the desired playing area and pass the net.
Rally length	The total number of shots exchanged between the two players, beginning with the service and ending when the point is won (total shots regardless of the outcome).
Winning strokes	A point is awarded to the player who made the shot when it successfully penetrates the court and denies the opponent the chance to defend.
Unforced errors	A misjudgment in a serve or return shot cannot be traced to anything other than the player's bad judgment and is not the result of the opponent's ability or effort (Paserman, 2007).

Data analysis

A Shapiro-Wilk test was used to determine if the data were normally distributed. The findings confirmed that the data were normally distributed, p>.05. The mean and standard deviation of the results of each skill test were calculated using descriptive statistics. A one-way repeated measures ANOVA was used to compare the parameters during the match-play between racquet A, racquet B, and racquet C. To compare the means of the three different types of racquets on the parameters measured, a Tukey post hoc test was performed. Cohens'd been employed to calculate effect sizes (ES). A modified scale with ES values of 0.25 trivial, 0.25-0.5 small, 0.5-1.0 medium, and >1.0 large was proposed by Rhea (2004). All statistical tests were run using the statistics package SPSS version 22.0. The statistical significance level was set at p<.05.

Results

Physical characteristics

Table 3 shows the participants' physical characteristics in this study.

Table 4 depicts the overall descriptive statistics in the parameters of match-play performance of three types of racquets.

Table 3. Participants' physical characteristics

Variables	N	Mean	Std. Deviation
Age (years)	12	13.17	0.83
Height (cm)	12	155.42	2.40
Weight (kg)	12	47.00	3.46
Arm length (Right) (cm)	12	61.38	0.71
Arm length (Left) (cm)	12	61.29	0.79

Table 4. Descriptive analysis for match play performance

Parameters		Mean	Std. Deviation	Sig.	η2
Hitting opportunities	Racquet A	36.83	5.87	.000	.573
	Racquet B	47.17	6.05		
	Racquet C	43.00	2.49		
Successful strokes	Racquet A	25.66	5.45	.000	.615
	Racquet B	37.89	6.24		
	Racquet C	32.14	2.62		
Rally length	Racquet A	72.17	5.98	.005	.383
	Racquet B	79.00	8.07		
	Racquet C	81.33	2.06		
Winning strokes	Racquet A	8.00	0.74	.000	.696
	Racquet B	11.08	1.00		
	Racquet C	9.58	1.31		
Unforced errors	Racquet A	6.08	1.24	.001	.455
	Racquet B	4.25	0.97		
	Racquet C	4.67	1.15		

*Significant, p<.05.

Hitting opportunities

One-way ANOVA repeated measures demonstrated that there was a significant difference between racquets A, B, and C in hitting opportunities, F(2, 22)=14.786, p<.001, η2=.573. Participants recorded the greatest means score in hitting opportunities when using racquet B(47.17±6.05) compared to racquet C(43.00±2.49) and A(36.83±5.87). The pairwise comparisons showed that there were significant differences between racquet A and racquet B; and racquet A and racquet C in hitting opportunities, p<.05. The hitting opportunities between racquets B and C, did not differ significantly (p>.05).

Successful strokes

One-way ANOVA repeated measures showed that there was a significant difference between racquets A, B, and C in successful strokes, F(2, 22)=17.606, p<.001, η2=.615. Based on the result in Table 4, demonstrated that participants produced higher successful strokes in racquet B(37.89±6.24) than in racquet C(32.14±2.62) and A(25.66±5.45). The pairwise comparisons found that there were significant differences between racquets B and A; and A and C in successful strokes, p<.05. There were no significant differences between racquets B and C in successful strokes, p>.05.

Rally length

One-way ANOVA repeated measures showed that there was a significant difference between racquets A, B, and C in rally length, F(2, 22)=6.824, p<.005, η2=.383. In the match-play, participants created longer rallies when utilizing racquet C(81.33±2.06) compared to racquet B(79.00±8.07) and A(72.17±5.98). The pairwise comparisons revealed that there were significant differences between A and racquet B; and racquet A and racquet C, p<.05. However, there was no significant difference in rally length between racquet B and C, p>.05.

Winning strokes

One-way ANOVA repeated measures revealed that there was a significant difference between racquets A, B, and C in winning strokes, F(2, 22)=25.160, p<.001, η2=.696. Participants generated more winning strokes when using racquet B(11.08±1.00) during the match-play performance compared to racquet C(9.58±1.31) and A(8.00±0.74). The pairwise comparisons showed that there were significant differences between racquets B and A; B and C; and racquets A and C in winning strokes, p<.005.

Unforced errors

One-way ANOVA repeated measures demonstrated that there was a significant difference between racquets A, B, and C, F(2, 22)=9.201, p<.001, η2=.455. Using racquet B(4.25±0.97) during match play resulted in fewer unforced errors, which is the opposite of what happened while using racquet C(4.67±1.15) and A(6.08±1.24). The pairwise comparison demonstrated that there was a significant difference between racquets A and B, and between racquets A and C in unforced errors, p<.005. However, there was no significant difference between racquets B and C in unforced errors, p>.05.

Discussion

The study aimed to examine the effect of modifying racquet length based on a body-scaling approach on children's badminton match performance. The study hypothesized that children would perform well during match play because the technique maximizes affordances, making it smoother for children to play badminton than with a standard racquet. The results support our hypothesis, children produced more hitting opportunities, successful and winning strokes, and generated lower unforced errors during badminton matches when using racquet B which used 1.0:1.0 for arm length-to-racquet length ratios compared to racquets A (1.1:1.0) and C (0.9:1.0) (see Table 4). The use of a racquet scaled with 100% of participants' arm length-to-racquet length ratios led to better stroke performance and minimized unintentional fouls during the matches. The findings of this study are consistent with prior studies that equipment modification using a body-scaling approach increased motor skills proficiency in basketball (Gorman, Headrick, Renshaw, McCormack, & Topp, 2021), badminton (Azmi, Low & Nadzalan, 2023), and tennis (Limpens, Buszard, Shoemaker, Savelsbergh, & Reid, 2018). Therefore, simplifying the task by modifying the constraints based on children's physical capabilities allowed children to accomplish skills while maintaining information movement coupling that was unique to the sport (Fitzpatrick, Davids, & Stone, 2018; Buszard, Farrow, & Reid, 2020).

From the findings, racquet A is most likely too long for the participants to utilize during the matches. This racquet makes it harder for youngsters to create a better strokes leading to fewer opportunities for good hits, successful strokes, and winning strokes. A longer racquet may cause participants to commit more unforced errors, such as shots to the net (heavy to control) or shuttles hitting outside the court's boundaries (more power required to generate the strokes). According to the perception-action coupling theory, such a larger racquet is likely to limit the skills youngsters can learn and show off since it makes different kinds of information available to guide behavior than it would with scaled equipment (Broadbent, Buszard, Farrow, & Reid, 2021). Their reduced capacity to explore and develop novel movement solutions may also have an impact on the learning opportunities available to enhance their motor competence (Renshaw, Davids, & Savelsbergh, 2010; Azmi et al., 2023). Thus, it is conceivable that when using racquet A, participants were more reliant on conscious resources to manage their motions. When using difficult equipment, participants altered their technique more frequently, which shows a higher level of conscious involvement in the activity, decreasing the opportunity for participants to learn the skills implicitly (Buszard, Farrow, Reid, & Masters, 2014a).

The findings also indicated that racquet C, which utilizes 92% of the average arm length, performed better than racquet A. However, racquet B, which employs 100% of the participants' average arm length, performed better in match play than racquets A and C. It demonstrates that more desirable movement patterns may emerge if task constraints are scaled appropriately. The research suggested that children should employ racquets that used roughly 100% of their arm's length to obtain the same body-scaled affordances (Azmi et al., 2023). It was found that using racquets that were shorter and closer to the participants' arm lengths (racquet B, for example) made them easier to control, which in turn helped them enhance their stroke-making skills. In order to promote coordinated movement patterns, the application of scaled racquets may encourage participants to concentrate more on important perceptual aspects (Davids, Button, & Bennett, 2008; Buszard, Farrow, Reid, & Masters, 2014b). Modifying the task encourages children to look for novel solutions by examining the practice environment, which eventually supports unconscious learning processes - implicit learning (Renshaw, 2010). Therefore, using scaled equipment that has been modified depending on children's physical characteristics tends to encourage less cognitive processing to execute skills during the game (Buszard et al., 2014a).

Some previous studies also support the benefits of scaling equipment based on children's physical capabilities. When children are given basketballs that match their hands, it's simpler for them to handle the ball as adults do, which enhances their ability to learn (Farrow, Buszard, Reid, & Masters, 2016; Gorman, Renshaw, Headrick, & McCormack, 2020). Employing badminton racquets that match their physical abilities has been linked to positive effects, such as making it smoother for children to learn the game's basics (Suppiah et al., 2019; Azmi et al., 2020). This study has a few limitations, despite the fact that it offers strong results. The participants were limited to 13-year-olds with prior badminton expertise. A follow-up investigation with varied player traits and abilities would be intriguing. Other age groups must be taken into consideration in order to provide recommendations for the development of racquet sizes in junior badminton competitions. In addition, future studies should focus on how modifying equipment affects learning and determine if implicit or explicit learning is more common. The idea that the junior game ought to imitate the adult game in terms of match-play features and behaviors is one of the implicit assumptions of the scaling sport argument (Buszard et al., 2020).

Conclusion

In conclusion, the findings of this study provide crucial practical application for coaches and teachers where scaling the task constraints based on physical attributes contribute to optimal learning experience for children to execute the skills effectively. The application of a racquet scaled at 100% of the participants' arm length-to-racquet length ratios improved stroke performance in terms of winning strokes and successful strokes and reduced unintentional fouls in terms of unforced mistakes throughout the matches. It would be feasible to build activities that take participants' constraints into account, which could be a useful tool for skill development.

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Conflict of interests
The authors declare no conflicts of interest.

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