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Effects of sport imagery training and imagery ability on badminton service return in a secondary-school physical education setting

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The effects of sport imagery training and imagery ability on badminton service return performance (hitting speed, hitting accuracy, and swing posture) were investigated in a school-based physical education (PE) setting. Two groups of 30 and 29 Grade-11 schoolboys, respectively, were trained using conventional and imagery teaching methods in four 70-min weekly PE lessons. The students' imagery ability was classified (as low or high) using a questionnaire. Three-way mixed analysis of variance was employed to determine the effects of teaching method, imagery ability, and performance test (before and after the PE lessons) on the performance. This study discovered significant effects of imagery ability on hitting speed; performance test and the teaching method–performance test interaction on hitting accuracy; and imagery ability and performance test on swing posture. In conclusion, badminton imagery training was discovered to positively exert different effects on students with differing imagery ability in a school-based PE setting.

KEY WORDS: Imagery intervention, Sport psychology, Sports education, Teaching pedagogy.

Use of imagery is a popular and well-established strategy for improving sport performance (Cumming & Ramsey, 2008). Mental imagery is defined as recreation or creation of an experience in mind with the use of all senses but the absence of external stimuli (Vealey & Greenleaf, 2001). In the sport context, imagery literally means to mentally rehearse or visualize the kind of sports in mind. There are two distinct modalities of imagery that athletes might experience during practice or sports competition, namely external and internal imagery (Mahoney & Avener, 1977; Hall, 2001). The former is to visually imagine oneself performing a motor task as an observer in a third-

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person perspective (Mahoney & Avener, 1977; Ridderinkhof & Brass, 2015), whereas the latter is to imagine himself/herself performing the action with sensations in a first-person aspect (Mahoney & Avener, 1977; Ridderinkhof & Brass, 2015). Compared with novices in one study, elite athletes were discovered to practice more frequently with sport imagery even though they had never been introduced to or had experience of using sports imagery (Cumming & Ramsey, 2008). Imagery practice has been demonstrated to positively influence sports performance (Arvinen-Barrow, Weigand, Thomas, Hemmings, & Walley, 2007). Moreover, differential implementation of imagery practice throughout a competition season was discovered to enhance athletes' performance (Munroe, Hall, Simms, & Weinberg, 1998).

One study reported that elite athletes possessed higher imagery ability than nonelite athletes (Hall, Rogers, & Barr, 1990). Moreover, some studies have revealed that participants in different sports are benefited by sports imagery to differing extents (Callow & Hardy, 2001; Martin, Moritz, & Hall, 1999; Robin et al., 2007). Most research has focused on comparison between elite and nonelite athletes or those with high versus low sport imagery ability, and elitism in sports has been promoted to enhance the performance of talented athletes (Arvinen-Barrow et al., 2007; Gregg, Hall, McGowan, & Hall, 2011). The popularity and applicability of sports imagery in a school-based physical education (PE) context have been rarely discussed.

Imagery is an effective teaching and learning method in PE and can foster students' skill development (Anderson, 1997). The school-based context provides an environment in which imagery intervention can be integrated into the PE curriculum and the effectiveness of imagery evaluated for a large group of students (Tobin, Nadalin, Munroe-Chandler, & Hall, 2013). Incorporating imagery into PE lessons is crucial to the development of children's physical activity behaviours (Stewart, Divine, Jenny, & Law, 2015). To improve the quality of teaching of sports in PE, educators should consider the use of sports imagery to be a skill that can be taught or introduced during PE lessons. Ultimately, it is critical to strengthen the motivation of students in PE by helping them achieve success and simultaneously obtain positive insights into sports culture.

Whether imagery benefits the learning outcomes of school students with differing imagery ability in sports performance during PE lessons is an essential research question, as is whether sport imagery could help school students with differing imagery ability to learn more effectively during sports activities. The applicability of sport imagery when teaching sports in the school-based PE setting should be determined. One study on sport imagery development in primary school children aged 7-12 years revealed that the relationship between mental imagery and sports skill was stronger among older children, with the 12-years olds discovered to have well-established imagery ability (Caeyenberghs, Tsoupas, Wilson, & Smits-Engelsman, 2009). This finding implies that secondary-school students, who are 12 years or older and have well-established imagery ability, may be a more reliable population for a sport imagery study conducted in a school-based PE setting. Badminton is one of the most popular sports for recreational players. It demands muscle strength, hand-eye coordination, and motor coordination and is a suitable sport to be implemented in imagery research. Mental imagery training intervention was not a newly-emerging concept that it has been discovered to be effective in improving athletes' skill performance in swimming (Post, Muncie & Simpson, 2012), rugby (Yahya, Ismail & Amer, 2016) and volleyball (Radhakrishnan, 2008; Sharma, 2017). Besides, numerous studies have substantiated that imagery training was beneficial to improving tennis service (Dana & Gozalzadeh, 2017; Fortes et al., 2019; Guillot, Desliens, Rouyer & Rogowski, 2013) and service return (Robin et al., 2007). However, there were only limited studies on relationship between mental imagery training and badminton performance. A study revealed that internal mental imagery training (first-person perspective) had more significant effects on short service backhand in badminton than external mental imagery training method (third-person perspective) (Manurung & Dimyati, 2018). There was no study particularly focusing on the effects of imagery training on badminton service return performance. For the sake of filling the gap, this study investigated the effects of imagery training and imagery ability on the badminton sport performance in a secondary-school PE setting. The hypothesis was that both imagery training and students' imagery ability positively affect badminton performance.

Method

Design

A mixed-methods approach was adopted in this study to evaluate the effects of incorporating imagery in conventional teaching method in a PE setting and students' imagery ability on badminton sport performance. The main factors considered in this study were the teaching method, imagery ability, and performance test before and after a school-based PE programme (pretraining and posttraining test). The outcome measurements were the service return performance, as reflected by hitting speed, hitting accuracy, and swing posture.

Participants

Fifty-nine boys aged 16-17 studying in Form 5 (Grade 11) at a local secondary school were recruited to participate in this study. They are recreational players with no formal regular training on badminton. Ethical approval was obtained from the Human Research Ethics Committee of XXX, and written informed consent from all students was obtained prior to the commencement of the 4-week school-based PE programme.

Equipment And Questionnaire

Thirty regular badminton rackets (YONEX Co., Ltd., Tokyo, Japan), 200 badminton shuttlecocks, and a 240-badminton feeding machine (S3025, Siboasi, Billi Edge Manufacturing Company, Coimbatore, India) were used in the pretraining performance test, physical practice during PE lessons, and the posttraining performance test. A badminton racket intelligent smart sensor (Coollang Xiaoyu 2.0, Z-Wave Lifestyle Enterprise, Singapore) was used to record the hitting speed of the service return during the pre- and posttraining performance tests. A sports imagery ability questionnaire (SIAQ) was employed to classify the imagery ability of the students. The SIAQ, was good in both internal reliability and temporal stability, was selected from 'The Sport Imagery Ability Questionnaire Manual' published by Williams and Cumming (2014). The SIAQ comprised 15 questions and evaluated the students' sport imagery ability, including abilities at skill, strategy, goal, affect, and mastery imagery. Each question was answered using a 7-point Likert scale (1 = very hard to imagine to 7 = very easy to imagine). In this study, only the skill and strategy imagery abilities, covering 6 out of the 15 SIAQ questions, were considered in order to simplify the imagery focus during the PE lessons. The 6 SIAQ questions employed were as follows: making up new plans and strategies in my head, refining a particular skill, alternative plans and strategies, improving a particular skill, making corrections to physical skills, and creating a new event or game plan.

Procedure And Data Collection

The badminton training programme consisted of four weekly PE lessons conducted separately with two classes of students. The duration of each lesson was 70 min. All PE lessons (for both groups) were conducted by an experienced and trained PE teacher highly familiar with the training in badminton sport. Active play imagery practice over four weeks was previously discovered to positively influence physical activity in children (Stewart et al., 2015). Through random class allocation, 30 and 29 students were allocated to the conventional teaching (CON) group and conventional teaching also incorporating imagery learning and practice (IMG) group, respectively. In the CON group, direct teaching was conducted through speech and demonstration, physical practice, and feedback. In the IMG group, both direct and imagery teaching were performed, which involved imagery teaching, direct teaching through speech and demonstration, imagery practice, physical practice, and feedback. Since imagery teaching and practice were included for the IMG group, they had relatively less time for physical practice than the CON group. All lessons were conducted on an indoor badminton court at a secondary school.

All students in the CON group and IMG group were required to complete the SIAQ prior to participating in the pretraining service return performance test during the first lesson. A badminton racket intelligent smart sensor was affixed at the end of the badminton racket handle. A 240-badminton feeding machine was positioned on the badminton court so that shuttlecocks were served appropriately and consistently for the pretraining performance test. It was a test of students' forehand high clear performance in which the hitting speed, hitting accuracy, and swing posture were measured. Each student had 10 opportunities to hit a shuttlecock served by the feeding machine. In each trial, hitting speed was recorded by the sensor and saved on an iPad. The total number of successful hits was recorded. The whole test for each student was video-recorded using a digital camera for further analysis of swing posture. After the pretraining performance test, students in both groups were subjected to training regarding the forehand high clear technique. For the IMG group, internal imagery (also known as first-person imagery) was adopted and introduced in addition to the conventional training provided. The content included informing the students that imagery was the visual and mental rehearsal of a skill (going through the whole process in the mind) before putting that skill into practice. More specifically, students in the IMG group were required to close their eyes and mentally visualize themselves performing the entire actions in a first-person perspective on how they would approach when facing different types of oncoming shuttlecocks, for instance, preparation, backswing, swing, the instant and sound of impact, follow-through and recovery. Since the idea of sport imagery was a new concept to the students in the IMG group, in order to refresh their memories and improve the learning outcome, the procedure and key points of internal imagery were revisited at the beginning of every lesson. Eventually, posttraining performance test was conducted for both groups of students in lesson 4 in accordance with the procedure used in the pretraining performance test.

Data Reduction And Analysis

The total scores for the six SIAQ questions employed in this study were used to classify the imagery ability of the students. The students with total scores lower than 24 were classified as having low imagery ability, whereas those with scores equal to or higher than 24 were classified as having high imagery ability.

The hitting speeds in the 10 trials performed by each student were downloaded from the iPad. The average speed (in km/h) of the 10 trials for each student was used as an input for statistical analysis. Additionally, the total number of successful returns in 10 trials for each student was used as an input for statistical analysis.

Swing posture was qualitatively assessed by reviewing the videos recorded during the performance tests. Quantitative scores (maximum of 10) were given on the basis of whether the following requirements were met: (i) the racket was being gripped correctly (yes = 1, no = 0); (ii) the shuttlecock was hit when the racket was at its highest point with the elbow fully extended (yes = 1, no = 0); (iii) the student shifted their centre of gravity effectively (yes = 2, partially = 1, no = 0); (iv) the student followed through in their swing, as indicated by a right (left) hand racket holder finishing their swing towards the medial position of the left (right) leg (yes = 2, partially = 1, no = 0); (v) the prehitting posture was correct, as indicated by a right (left) hand racket holder placing their right (left) arm and right (left) leg to the rear and their left (right) arm and left (right) leg to the front before hitting the ball (yes = 2, partially = 1, no = 0); and (vi) swinging the racket in a semicircular path (yes = 2, partially = 1, no = 0). The average score (in terms of % of the maximum score) of the 10 trials for each student was used as an input for statistical analysis. The reliability of the trained PE teacher in rating swing posture was shown to be high with intra-class correlation coefficient = 0.96.

Statistical Analysis

Three-way mixed analysis of variance (ANOVA) was used to investigate the effects of teaching method, imagery ability, and performance test on service return performance. Teaching method was a between-subject factor in the two groups (CON and IMG). Imagery ability was a between-subject factor and had two levels (low and high). Performance test was a within-subject factor in two repeated measures and was obtained before and after the school-based PE programme (pretest and posttest). Three univariate ANOVA tests were conducted to determine the effects on service return performance of the three response variables, namely hitting speed, hitting accuracy, and swing posture. SPSS version 24.0 (IMB Inc., Chicago, IL, USA) was used to perform all statistical tests. The significance level was set at $p = 0.05$ for all tests.

Results

Marginal means and standard deviations (SDs) in the variables of teaching method, imagery ability, and performance test in the three outcome measures (hitting speed, hitting accuracy, and swing posture) as well as the results of three-way mixed ANOVA [including reports of the effect size (ES) in partial eta squared] are presented in Table I.

Hitting Speed

Three-way mixed ANOVA revealed no significant effects on hitting speed of teaching method ($p = 0.548$, ES = 0.007) or performance test ($p = 0.138$, ES = 0.040), second-order interactions (teaching method–imagery ability: $p = 0.666$, ES = 0.003; teaching method–performance test: $p = 0.578$, ES = 006; and imagery ability–performance test: $p = 0.880$, ES < 0.001), or the third-order interaction ($p = 0.922$, ES < 0.001) (Table 1a). However, a significant effect of imagery ability on hitting speed was discovered ($p < 0.001$, ES = 0.344) (Table 1a). The hitting speed of the students with high imagery ability (mean = 131 km/h, SD = 21 km/h) was significantly higher than that of the students with low imagery ability (mean = 106 km/h, SD = 16 km/h) (Figure 1).

TABLE I

Marginal Means (Sds) In Teaching Method, Imagery Ability, And Performance Test; And The Results Of Three-Way Mixed ANOVA Tests: (A) Hitting Speed, (B) Hitting Accuracy, And (C) Swing Posture Based On The 59 Students.

				Performance Test (PT) (within subject factor)	
	Teaching Method (TM) (between subject factor)	**Imagery Ability (IA) (between subject factor)**	**Group Size (pre-test)**	**Before the physical education program (post-test)**	**After the physical education program**
(a) Hitting Speed (km/h)	convention (CON)	low	16	106 (14)	107 (15)
		high	14	133 (27)	134 (27)
	convention plus imagery (IMG)	low	14	104 (17)	107 (18)
		high	15	128 (12)	130 (17)
Statistical Test Results	**Main effects**	TM: *p*=0.540, ES=0.007; IA: *p*<0.001*, ES=0.343; PT: *p*=0.126, ES=0.042			
	2nd order interactions	TM^IA: *p*=0.674, ES=0.003; TM^PT: *p*=0.609, ES=0.005; IA^PT: *p*=0.845, ES<0.001			
	3rd order interaction	TM^IA^PT: *p*=0.957, ES<0.001			
(b) Hitting Accuracy (total number of success in 10 trials)	convention (CON)	low	16	7.1 (2.6)	7.4 (2.4)
		high	14	7.9 (1.3)	8.6 (1.4)
	convention plus imagery (IMG)	low	14	6.1 (2.2)	7.9 (2.6)
		high	15	7.4 (2.7)	8.5 (2.0)
Statistical Test Results	**Main effects**	TM: *p*=0.588, ES=0.005; IA: *p*=0.072, ES=0.058; PT: *p*<0.001*, ES=0.394			
	2nd order interactions	TM^IA: *p*=0.976, ES<0.001; TM^PT: *p*=0.008*, ES=0.119; IA^PT: *p*=0.642, ES=0.004			
	3rd order interaction	TM^IA^PT: *p*=0.144, ES=0.038			
(c) Swing Posture (% of maximum scores)	convention (CON)	low	16	46 (17)	48 (16)
		high	14	59 (18)	64 (16)
	convention plus imagery (IMG)	low	14	46 (16)	51 (16)
		high	15	61 (13)	67 (15)
Statistical Test Results	**Main effects**	TM: *p*=0.603, ES=0.005; IA: *p*=0.001*, ES=0.188; PT: *p*<0.001*, ES=0.331			
	2nd order interactions	TM^IA: *p*=0.913, ES<0.001; TM^PT: *p*=0.208, ES=0.029; IA^PT: *p*=0.090, ES=0.051			
	3rd order interaction	TM^IA^PT: *p*=0.523, ES=0.007			

* significant effect with p-value < 0.05

HITTING ACCURACY

Three-way mixed ANOVA revealed no significant effects on hitting accuracy of teaching method ($p = 0.588$, ES = 0.005), imagery ability ($p = 0.072$, ES = 0.058), the teaching method–imagery ability interaction ($p = 0.976$, ES < 0.001), the imagery ability–performance test interaction ($p = 0.642$, ES = 0.004) or the third-order interaction ($p = 0.144$, ES = 0.038) (Table 1b). However, this study discovered significant effects on hitting accuracy of performance test ($p < 0.001$, ES = 0.394) and the teaching

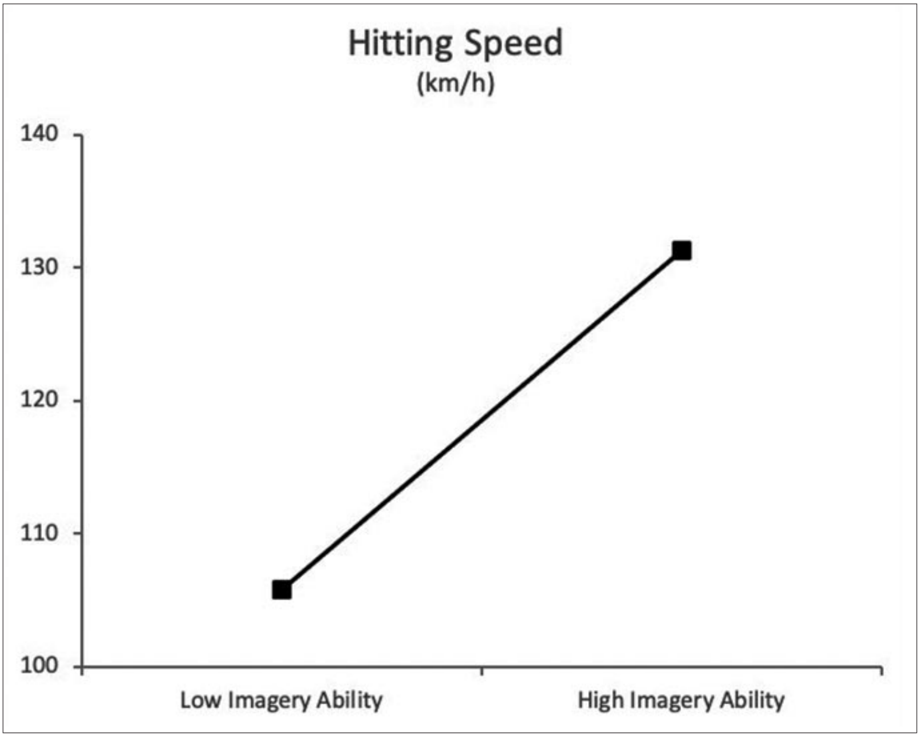

Fig. 1. - Pooled means of the hitting speed of 10 service return trials in low and high imagery ability groups for all 59 students.

method–performance test interaction (p = 0.008, ES = 0.119) (Table 1b). The hitting accuracies of the CON and IMG teaching groups were 0.5 higher (increasing from 7.5 to 8.0) and 1.4 higher (increasing from 6.8 to 8.2), respectively, after the 4 weeks of lessons (Figure 2). Significant difference (p = 0.026, ES = 0.193) was found in terms of the gain in hitting accuracy for the CON and IMG group with lower imagery ability with mean (SD) of 0.38 (0.72) and 1.79 (2.04), respectively. On the other hand, there was no significant effect (p = 0.283, ES = 0.043) for the gain in hitting accuracy for the CON and IMG group with higher imagery ability with respective mean (SD) of 0.71 (0.91) and 1.13 (1.13). The IMG teaching group thus achieved greater improvement in hitting accuracy than the CON teaching group.

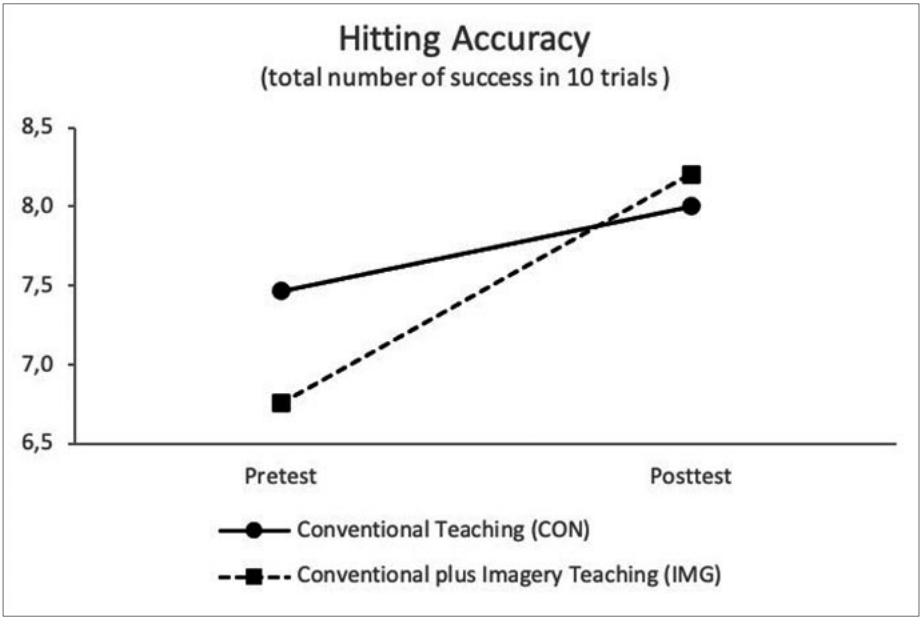

Fig. 2. - Pooled means of the hitting accuracy of CON and IMG groups in pretest and posttest for all 59 students.

SWING POSTURE

Three-way mixed ANOVA revealed no significant effects on swing posture of teaching method (p = 0.603, ES = 0.005), the second-order interactions (teaching method–imagery ability: p = 0.913, ES < 0.001; teaching method–performance test: p = 0.208, ES = 0.029; and imagery ability–performance test: p = 0.090, ES = 0.051), or the third-order interaction (p = 0.523, ES = 0.007) (Table 1c). However, the effects of imagery ability (p = 0.001, ES = 0.188) and performance test (p < 0.001, ES = 0.331) were significant (Table 1c). The students with high imagery ability demonstrated significantly better swing posture than those having low imagery ability (62 vs. 48) (Figure 3). The students' swing posture was significantly improved after the 4 weeks of lessons (pretest score of 53 vs. posttest score of 57) (Figure 4).

Discussion

The effects of sport imagery training and imagery ability on service return performance in badminton were investigated in the context of a sec-

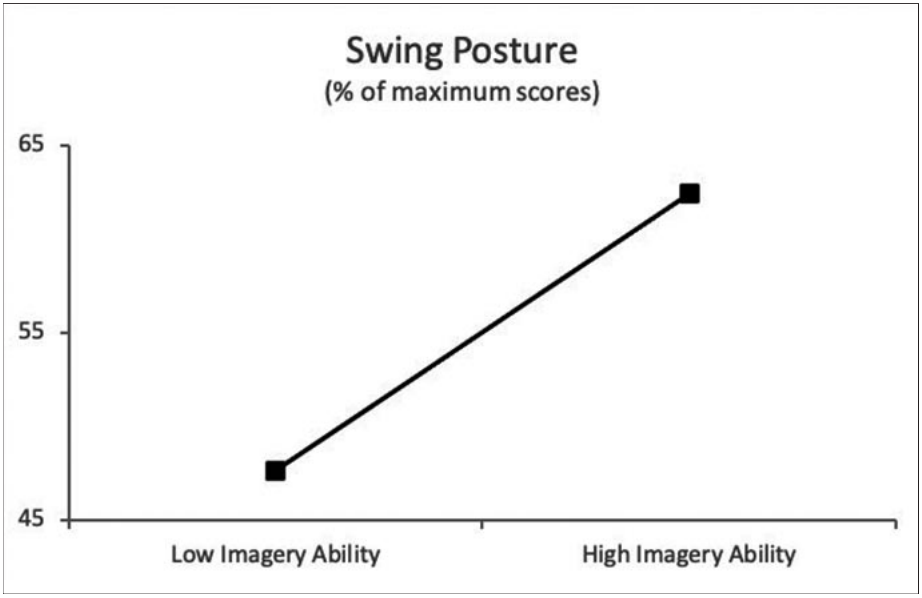

Fig. 3. - Pooled means of the swing posture over 10 service return trials in low and high imagery ability groups.

ondary-school PE setting. The performance (before and after the PE lessons)—judged in terms of hitting speed, hitting accuracy, and swing posture—was compared between the groups that did and did not receive imagery training and the groups of students with high and low imagery ability. The results demonstrated that imagery training improved hitting accuracy, and the students with high imagery ability had a higher hitting speed and superior swing posture compared with those with low imagery ability.

A previous study reviewed the considerations for conducting imagery interventions in PE settings (Stewart et al., 2015). Such considerations cover the aspects of a specific school context, the appropriate methodology, and individual imagery prompts. The contribution of the present study was to incorporate such novel considerations into a specifically designed teaching pedagogy capable of assessing the potential impact of sports imagery in a school-based PE setting. Another study (Robin et al., 2007) investigated the effects of motor imagery training and ability on service return speed and accuracy in tennis among experienced tennis players (those playing for >7 years) and concluded that motor imagery improved service returns, with the improvement greater in participants with high imagery ability than those

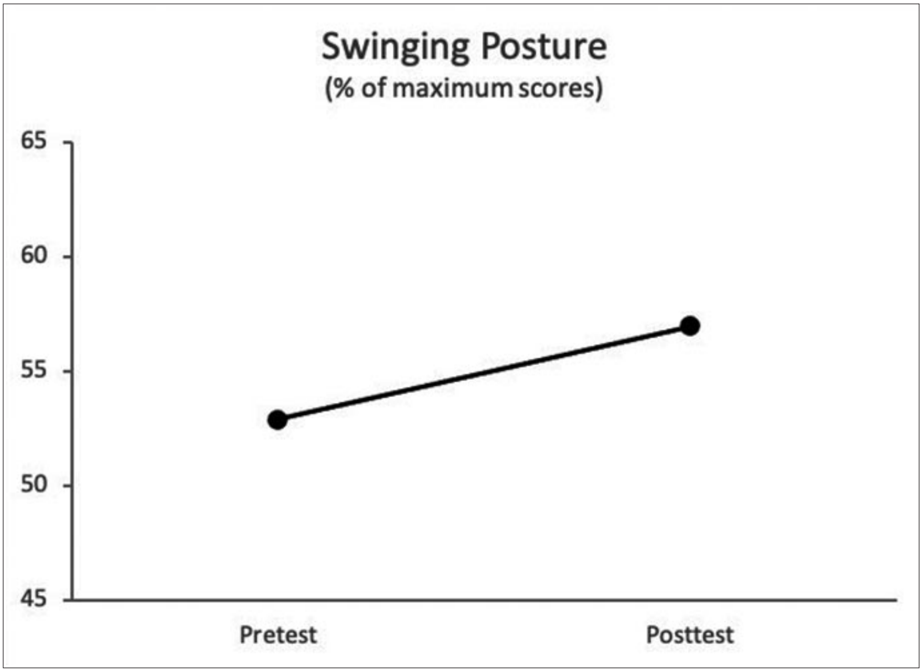

Fig. 4. - Pooled means of the swing posture over 10 service return trials in pretest and posttest for all 59 students.

with low imagery ability. The experimental design of the present study was similar to this, except the participants were secondary schoolboys and the imagery training was incorporated into school-based PE lessons in which badminton was taught. Additionally, swing posture was measured as well as speed and accuracy in the service return. The results of this study validate comparable findings regarding higher performance in badminton after imagery training and greater advantage of students with high imagery ability.

The impacts of imagery training on hitting speed and swing posture were discovered to be nonsignificant. However, students with high imagery ability had significantly higher hitting speed and superior swing posture compared with those with low imagery ability. During a badminton swing, the strength of muscles including the flexor carpi ulnaris, extensor carpi radialis, lateral head of the triceps brachii, biceps brachii, and upper trapezius (Sakurai & Ohtsuki, 2000) is positively related to hitting speed and postural control. However, the imagery learning and practice implemented in the present study did not focus on the training of these muscles; this could be the reason for the nonsignificant change in hitting speed and swing posture after the PE lessons. In two studies of athletes, the difference in physiological response between those with high and low imagery ability was evaluated, and those with high imagery ability were discovered to make more accurate movements than those with low imagery ability (Guillot, Collet, & Dittmar, 2004; Roure, 1999). This finding may provide a scientific explanation of the higher performance in hitting speed and swing posture of the students with high imagery ability in the present study.

The experimental data showed that the hitting accuracy of both the CON and IMG groups was improved after the PE lessons. However, no significant difference was discovered in hitting accuracy between the students with high and low imagery ability. Hitting a shuttlecock accurately requires a skill related to hand–eye coordination. Eggleston (1936) claimed that physical and mental practice are both efficient when acquiring the skill of performing hand–eye coordination tasks, and most crucially, physical practice is more efficient than mental practice. Physical practice was conducted throughout the entire teaching period; thus, both groups benefited from the teaching. The IMG group exhibited significantly greater improvement than the CON group. Similar finding was reported in a study conducted by Trussell (1952)—that different combinations of physical and mental practice can enhance performance. The result of greater improvements in combined practice than physical practice alone can be explained by the differential influences of mental and physical practice (Frank, Land, Popp & Schack, 2014; Frank, Land & Schack, 2016; Guillot, Moschberger & Collet, 2013). This echoes the present result—that the hitting accuracy of the IMG group improved significantly more. In view of the imagery ability, particularly for students with lower imagery ability, the IMG group yielded significantly higher gain in hitting accuracy than the CON group, suggesting that the imagery training could improve the hitting accuracy of those with lower imagery ability. For those with higher imagery ability, the IMG group also had higher gain in hitting accuracy than the CON group, despite no significance. However, this was not unanimous with the findings of the greater performance improvement for athletes in tennis with good imagery ability than those having poor imagery ability (Robin et al., 2007). This could be explained by the different intensity of regular training and experience in sports of the recreational players in comparison with players of national levels. In general, our findings agreed with previous studies that the gains of mental plus physical practice are higher than those of either physical or mental practice alone (Jackson, Doyon, Richards & Malouin, 2004; Malouin, Richards, Durand & Doyon, 2009). The present study demonstrated that teaching using imagery has a positive effect on hitting accuracy. Differential teaching methods that fit in the learning outcome between students with high and low imagery ability can benefit from the imagery training and ultimately get a better improvement. Swing posture is a type of motor manipulation. The present results may increase awareness of using imagery as a teaching tool to better improve the motor manipulation ability of students with low imagery ability in different sports performance skills.

This study had several limitations. First, only Grade 11 schoolboys were recruited in this study, and the findings may thus be inapplicable to other age groups and girls. Second, owing to the limited time frame available to complete the school-based PE programme, the imagery ability of the students after the teaching period was not measured. Imagery ability has been found to be partly related to badminton performance, especially regarding swing power and posture; therefore, discovering whether the imagery ability of students is higher after imagery training is worthwhile. Third, the applicability of the present results is limited; this study focused on the teaching of badminton in PE lessons, which is only a small part of PE. The work can be repeated for different sports in PE lessons to determine the generality of the findings and can ultimately be applied to the whole of PE.

In conclusion, in a school-based PE setting, using sport imagery was demonstrated to improve badminton performance more than conventional teaching when students' imagery ability was taken into consideration. The different effects of badminton sport imagery training for students with differing imagery ability were validated. Individual motor imagery and motor learning abilities are crucial performance indicators for the design of PE lessons in further studies. Sport imagery could be applied to sports other than badminton and to physical activities in secondary-school PE lessons for superior teaching pedagogy.

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