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THE EFFECT OF MOTOR IMAGERY WITH SPECIFIC IMPLEMENT IN EXPERT BADMINTON PLAYER

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Abstract—Motor skill can be improved with mental simulation. Implements are widely used in daily life and in various sports. However, it is unclear whether the utilization of implements enhances the effect of mental simulation. The present study was designed to investigate the different effects of motor imagery in athletes and novices when they handled a specific implement. We hypothesize that athletes have better motor imagery ability than novices when they hold a specific implement for the sport. This is manifested as higher motor cortical excitability in athletes than novices during motor imagery with the specific implement. Sixteen expert badminton players and 16 novices were compared when they held a specific implement such as a badminton racket and a non-specific implement such as a a plastic bar. Motor imagery ability was measured with a self-evaluation questionnaire. Transcranial magnetic stimulation was used to test the motor cortical excitability during motor imagery. Motor-evoked potentials (MEPs) in the first dorsal interosseous (FDI) and extensor carpi radialis muscles were recorded. Athletes reported better motor imagery than novices when they held a specific implement. Athletes exhibited more MEP facilitation than novices in the FDI muscle with the specific implement applied during motor imagery. The MEP facilitation is correlated with motor imagery ability in athletes. We conclude that the effects of motor imagery with a specific implement are enhanced in athletes compared to novices and the difference between two groups is caused by long-term physical training of athletes with the specific implement.

Key words: implement, motor-evoked potential, motor imagery, training, transcranial magnetic stimulation.

INTRODUCTION

Physical training improves motor skills in sports (Nakata et al., 2010). In particular, previous studies have demonstrated that long-term physical training with specific implements leads to functional and structural alterations in multiple brain areas in expert players of racket sports (Lees, 2003; Maravita and Iriki, 2004), such as soft tennis (Ohguni et al., 2009), badminton (Di et al., 2012), table tennis (Jafarzadehpur and Yarigholi, 2004) and tennis (Fourkas et al., 2008).

The effects of physical training may be enhanced with mental simulation both in athletes and novices (Driskell et al., 1994; Gregg et al., 2011). Motor imagery is the mental process of a motor task in the absence of movement and muscle activity (Hanakawa et al., 2003). The effects of motor imagery are modulated by the interactions between various physiological and psychological factors in a complex manner (Decety et al., 1989; Lafleur et al., 2002; Jackson et al., 2003; Bakker et al., 2008; Saimpont et al., 2012). It is widely accepted that motor imagery and real motor execution share similar neuronal elements at cortical and subcortical levels in the motor pathways (Grezes and Decety, 2001). If a transcranial magnetic stimulation (TMS) is delivered to the primary motor cortex during motor imagery, motor-evoked potential (MEP) in the target muscle is facilitated compared to that at rest condition (Fadiga et al., 1998; Hashimoto and Rothwell, 1999). The degree of MEP facilitation depends on the excitability of the motor pathway at the time of motor imagery. Using TMS, it has been reported that expert tennis players show increased corticospinal excitability during motor imagery of a tennis forehand but not during motor imagery of a table tennis forehand or the golf drive (Fourkas et al., 2008). This study suggests that the motor cortical network is altered by long-term training with specific implements. The results further support the notion that utilization of specific implements leads to functional or structural changes in the brain (Elbert et al., 1995; Draganski et al., 2004; May et al., 2007). However, it is not clear whether the application of a specific implement during the motor imagery enhances the effect of this mental process.

Badminton is a racket sport involving intermittent movements with high intensity in short periods. The high-level performance in handling the racket requires a

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Abbreviations: ANOVA, analysis of variance; ECR, extensor carpi radialis; EMG, electromyogram; FDI, first dorsal interosseous; MEP, motor-evoked potential; MIQ, movement imagery questionnaire; RMT, resting motor threshold; TMS, transcranial magnetic stimulation.

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fine combination of perception and action which is related to high cortical functions with activity in different brain regions (Lees, 2003; Maravita and Iriki, 2004). Therefore, expert badminton player provides a good model for investigating how the long-term utilization and application of a specific implement may affect the brain functions. In the present study, we investigated the effect of motor imagery with a specific implement (badminton racket) in athletes (expert badminton players) and novices. We hypothesize that the effects of motor imagery are enhanced in athletes compared to novices when they handle the specific implement. This can be tested by measuring the different motor outputs with different degrees of MEP facilitation during motor imagery in the two subject groups.

Long-term training with implements leads to better performance in athletes (Maravita and Iriki, 2004; Nakata et al., 2010). However, it is not known whether the performance of motor imagery with a specific implement is also affected by the long-term physical training. We tested the motor imagery ability with kinesthetic and visual items in athletes and novices (Hall and Martin, 1997). Our second hypothesis is that athletes will show better motor imagery ability than novices when they handle the implement. In addition, the better motor imagery ability will be correlated with larger MEP facilitation during motor imagery in athletes.

EXPERIMENTAL PROCEDURES

Subjects

Sixteen expert badminton players (athletes, eight women, mean age 20.0 ± 1.4 years) and 16 age- and gender-matched healthy subjects (novices, eight women, mean age 20.8 ± 1.9 years) participated in the study. All subjects were right-handed, confirmed using the Oldfield Handedness Inventory (Oldfield 1971). Expert badminton players were Chinese national first-class or second-class athletes who had experience in competition at national or international tournaments. The average training time for athletes was 14.1 ± 1.9 h per week for 11.1 ± 1.2 years. Novices were university students with no formal badminton training experience. All subjects provided written informed consent in accordance with the Declaration of Helsinki. The experimental protocol was approved by the Human Research Ethics committee of the Shanghai University of Sport.

Behavioral measures for motor imagery

Behavioral measures and TMS measures were performed on two separate days at least two weeks apart in a random order. For the behavioral measures, we measured the time course of motor imagery in athletes and novices. First, subject performed the motor task physically. The motor task was a badminton serving task. A short period of training was performed before recording. A brief instruction with basic rules of badminton was provided for novices. The motor task was performed 20 times. An acoustic cue was given as the start signal for serving. The time at the delivery of cue was defined as time 0. The time course 1 s before the cue to the time when the shuttlecock landed on the floor was video-recorded (Fig. 1A). For the motor imagery task, the subjects were seated comfortably in a chair and wore an eye mask. The present study was designed to investigate the different effects of motor imagery with different implements (specific vs. non-specific) in athletes and novices. To this end, the effects of motor imagery with a badminton racket (specific implement) were compared to that with a plastic bar (non-specific implement) in the two subject groups (Fig. 1B). A commercial plastic bar was used for a non-specific implement because it had a similar weight and shape as the badminton racket. We assumed that

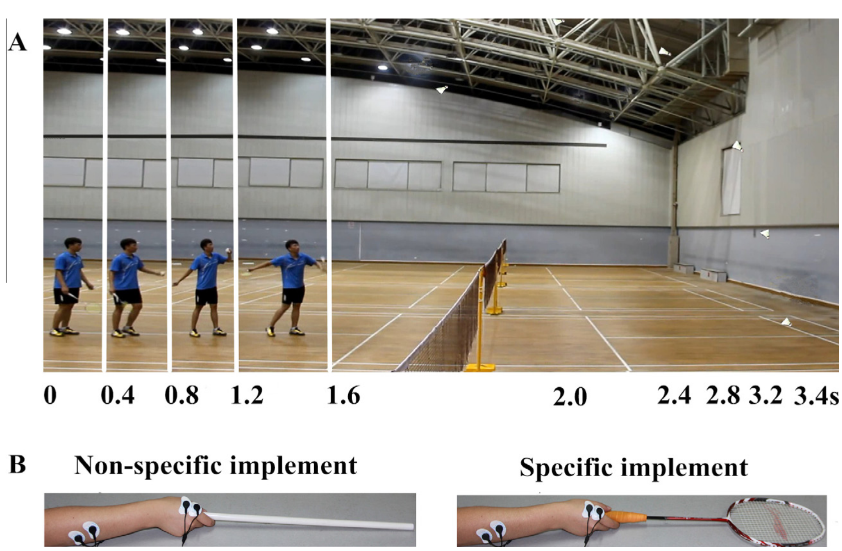

Fig. 1. Motor task and experimental setup. (A) Badminton serving performed by a representative expert player. The time course of the badminton serving was recorded. For the motor imagery task, subject was instructed to perform the task in the same way mentally. (B) Motor imagery was performed when the subject held a non-specific implement such as plastic bar (left) or when they held a specific implement such as badminton racket (right).