

Original Article

Soleus H-reflex modulation during receive stance in badminton players in the receive stance

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Abstract. [Purpose] This study aimed to clarify the characteristics of motor neuron excitability by examining the soleus H-reflex in the ready position adopted immediately before making a return during badminton games. [Subjects] Sixteen individuals with (badminton group) and 16 without (control group) experience of playing badminton were studied. [Methods] Each subject was instructed to take up various stances for returning a shuttlecock to measure the H- and M-waves in the soleus. [Results] The H-wave was significantly decreased when gripping a racket was held in the dominant hand than compared to just standing in the badminton group. In contrast, in the control group, no significant differences were observed between when standing and the other stances. [Conclusion] Based on these results, the excitability of spinal motor neurons may have been reduced (H-wave suppression) by badminton training to increase the instantaneous force (power training).

Key words: Badminton, H-reflex, Receive stance

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INTRODUCTION

During badminton games, it is necessary for players to use high-level stroke skills in various situations¹⁾. Players need to be able to select and execute a large number of stroke, in different situations, after selecting highly strategic shots to disrupt their opponent's readiness, rather than simply returning the shuttlecock²⁾. For example, when an opponent takes up the ready position in front of the net, it is appropriate to return the shuttlecock by placing a clear shot behind the opponent, and an opponent takes up the ready position in the back section of the court, a drop shot falling near the net is appropriate. During a rally, a player needs to select the most appropriate shot to disrupt an opponent's readiness, and as soon the opponent's readiness disrupted, deliver the most offensive shot to earn a point^{3, 4)}.

Reports about strokes have been made in some previous studies of badminton games, which focused on the development of skills for delivering effective services and overhead strokes^{5, 6)}, or the characteristics of upper-limb muscle activities of skilled badminton players when hitting a smash⁷⁾. Furthermore, in badminton rallies, quick movements are essential for returning the shuttlecocks at various speeds in all directions. To win a rally, increased leg strength enabling rapidly movement to the spots where the shuttlecock falls⁸⁾, and endurance to continue moving without decreas-

ing the speed of movement^{9, 10)}, are crucial. In addition, in order to effectively return a shuttlecock (to disrupt an opponent's readiness), it is necessary to deliver a stroke in a stable stance. In these situations, players need to instantaneously predict the spot where the shuttlecock will fall, and immediately begin to move to it. However, no studies have examined the mechanisms by which badminton players instantaneously react to shuttlecocks, and move. In which demands, instantaneous lower-limb muscle movements are particularly needed. If badminton players have the ability to instantaneously activate their own lower-limb muscles, the excitability of their spinal motor neurons controlling the fibers of such muscles may be characteristic. The soleus H-reflex has frequently been the focus of previous studies^{11–13)}, as it is considered to represent the excitability of spinal motor neurons. Accordingly, in line with this, the present study aimed to clarify the characteristics of badminton players' motor neuron excitability by examining the soleus H-reflex in the ready position immediately before making a return.

SUBJECTS AND METHODS

Sixteen individuals with experience of playing badminton (mean age: 20.9±2.1; years of experience: 8.3±3.0) and 16 without such experience (20.1±1.2) were studied. All subjects were provided with explanations regarding the study objectives and its safety before obtaining their consent to voluntarily participate in this. This study, which was conducted with the approval of the Research Ethics Committee of the Health Science University (approval number: 13).

Neuropack (NIHON KOHDEN) was used for the measurement of the M- and H-waves. Before measurement, it was confirmed that cutaneous resistance was 2 kΩ or less.

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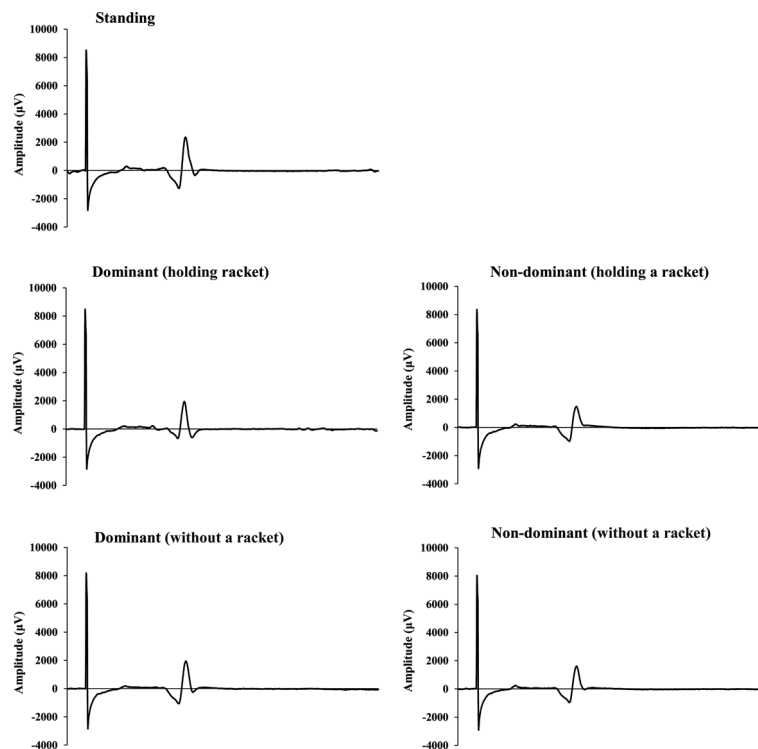


Fig. 1. H-wave after tibial nerve stimulation of stance in a representative badminton subject

Silver plated electrodes for recording were placed on the skin of the medial part of the soleus on both sides, while bipolar stimulating electrodes were attached to the popliteal fossa of the dominant and non-dominant legs. Subsequently, electrical stimulation was intracutaneously applied to the tibial nerves to measure the M- and H-waves in the medial part of the soleus; and their thresholds and maximum values were recorded by gradually increasing stimulation. For H-wave measurement, the stimulation level was set to obtain H-wave amplitudes of approximately 30% of the maximum M-wave value (Mmax), as well as the M-wave of 4 to 8% Mmax, at a frequency of 0.2 Hz¹⁴). When recording the H-reflex, it was confirmed that the M-wave remained unchanged. When changes were observed, the recorded values were discarded due to considering the possibility of changes in the stimulation level. The H-reflex was measured in the ready position before receiving a shuttlecock with or without a racket held in the dominant or non-dominant hand, in addition to a static upright stance. The subjects were instructed to maintain these 5 stances, and the H-wave was recorded 10 times, and the mean was calculated (Fig. 1). Individual subjects' stances were measured in a random order.

Among the amplitudes obtained for each stance, the difference between the minimum and maximum H-wave values was calculated. Subsequently, the difference between the minimum and maximum M-wave values (Mmax) as a response to maximum stimulation in the supine position was calculated to normalize the H-wave value as a percentage of the Mmax.

Table 1. H-wave in the badminton and control groups in each stance

		Badminton	Control	Significant
Holding	Dominant (%)	86.5±10.5	108.6±15.6	*
	Non-dominant (%)	91.0±14.7	113.5±27.8	
Without a racket	Dominant (%)	94.9±15.2	103.3±16.4	
	Non-dominant (%)	90.8±13.3	97.8±15.8	

*: $p < 0.05$

For statistics, the statistical software Stat View was used. Significant differences were examined by performing one-way analysis of variance, followed by multiple comparisons, adopting the Tukey-Kramer method with a significance level of 5%.

RESULTS

The H-wave rate of each stance was calculated, using the values when just standing as 100% (Table 1). In the badminton group, the H-wave significantly decreased when holding a racket in the dominant hand compared to when standing. In contrast, in the control group, no significant differences were observed between when standing and the other stances. Furthermore, the H-wave was suppressed in all stances compared to when standing in the badminton group, while it was promoted in the control group.

DISCUSSION

Muscle stimulation excites type Ia afferent fibers, and consequently activates spinal alpha motor neurons, leading to the contraction of stimulated muscles (stretch reflex). The H-wave obtained with electrical stimulation has been used as an index for evaluating the spinal control of muscle contraction during the stretch reflex, as it represents the excitability of spinal motor neurons. In previous studies, the soleus H-wave obtained by eliciting stimuli was shown to be greater when standing compared to walking¹⁵⁾, and this may be explained by the mechanism in which the stretch reflex stabilizes the ankle joint when standing (increased H-wave), while it interferes with the swing phase when walking (decreased H-wave). In short, a greater amplitude of the H-wave amplitude contributes to ankle fixation and stability. The H-wave also varies between different exercise tasks, such as walking and running, and stances, such as prone and standing positions^{16, 17)}. Furthermore, the soleus H-wave has been reported to be greater in swimmers than in non-swimmers¹⁸⁾. On the other hand, the H-reflex level is lower in professional ballet dancers than in athletes in general¹⁹⁾. Based on these findings, long-term physical training may specifically influence the excitability of spinal motor neurons. In the present study, on comparison of the soleus H-wave of those with and without experience of playing badminton were compared, and its values was significantly lower in the former when experienced players held in the dominant hand, while those with no experience of playing badminton showed a markedly different tendency. Some previous studies reported that the H-wave amplitude is greater in athletes mainly engaged in endurance training than in those mainly engaged in power training^{20–22)}. Such training-dependent (endurance/power) variation in the H-wave may be associated with differences in the lower-limb loading level. For example, the H-wave decreases in the prone position compared to when standing under the influence of gravity¹⁷⁾, and increases in a microgravity environment or underwater^{11, 23)}. In this respect, continuous badminton training suppresses the soleus H-wave, presumably due to being power-focused. In badminton games, it is necessary for players to deal with shots at various speeds, such as drop shots near the net and high-speed smashes, and appropriately the return shuttlecocks. Therefore, badminton players need to increase the instantaneous force of their legs to execute rapid movements. In fact, their leg strength levels have been reported to be high⁸⁾. The results of the present study suggest that the excitability of badminton players' spinal motor neurons may be suppressed by training to increase the instantaneous force (power training). Furthermore, the reduced excitability of spinal motor neurons when playing badminton may be associated with an increased ability to move to feet rapidly. Considering that badminton is regarded as a lifelong sport for a wide range of age groups, regardless of the sex, and that it increases the stepping ability (by suppressing the excitability of spinal motor neurons), this sport is also likely to be an effective fall-preventing on approach.

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