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Dynamic Control of Upper Limb Stretch Reflex in Wrestlers

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[1]Graduate School of Sport Sciences, Waseda University, Tokorozawa, Saitama, JAPAN; [2]Faculty of Sports and Health Science, Fukuoka University, Fukuoka, Fukuoka, JAPAN; [3]Faculty of Sport Sciences, Waseda University, Tokorozawa, Saitama, JAPAN; [4]Department of Integrative Physiology, Kyorin University School of Medicine, Mitaka, Tokyo, JAPAN; and [5]Department of Biology, Portland State University, Portland, OR

ABSTRACT

ITO, S., K. NAKAGAWA, T. NAKAJIMA, M. ITEYA, L. CRAWSHAW, and K. KANOSUE. Dynamic Control of Upper Limb Stretch Reflex in Wrestlers. *Med. Sci. Sports Exerc.*, Vol. 54, No. 2, pp. 313–320, 2022. **Purpose:** The objective of this study was to clarify the characteristics of the upper limb stretch reflex in wrestlers. **Methods:** Ten wrestlers and 11 control subjects participated in the study. The experiment was divided into two sessions. In the extension perturbation session, participants either relaxed or flexed the elbow when they felt a perturbation (abrupt elbow extension induced by a dynamometer). This was done 30 times by each subject for both sessions. In the flexion perturbation session, participants also relaxed or extended the elbow when they felt a perturbation (abrupt elbow flexion). During the tasks, the stretch reflex was monitored by recording the surface EMG activities of the right biceps and triceps brachii. The EMG reflex components were divided into three periods based on the time after the perturbation (M1, 20–50 ms; M2, 50–80 ms; and M3, 80–100 ms). The averaged background EMG activity just before the disturbance was subtracted from the EMG activity in each period. The resultant value was integrated to obtain reflex magnitudes of M1 to M3. **Results:** For the triceps brachii, in the relaxation task, the wrestler group showed a significantly smaller value for M2 than did the control group. In the extension task, the wrestler group showed a significantly larger value for M3 than did the control group. There was no difference in M1 between the two groups. For the biceps brachii, there was no significant difference between any reflex components. **Conclusions:** Our results suggest that high-level wrestlers have specific characteristics of the long-latency stretch reflex in the triceps brachii that are modulated in a situation-specific manner. **Key Words:** STRETCH REFLEX, WRESTLING, UPPER LIMB, MOTOR CONTROL

The main aim of combat sports, such as wrestling and judo, is to take down a standing opponent. Combat sport athletes have an excellent balance ability as compared with control subjects (1). Leg attack is an important and frequently used move. To be successful against experienced wrestlers, the balance of the opponent first needs to be disrupted (2). This is termed a "setup" and can be accomplished in several ways. These setups include fake attacks, as well as changes in the tempo or speed of an attack. An effective setup alters the center of gravity of the opponent and makes the opponent's posture unstable. We recently demonstrated that, for men's elite freestyle wrestling, an effective setup before a leg attack improves the success rate of the leg attack and also increases the points awarded to the attacker (3). Wrestlers almost always use their hands to seize an opponent's arms. In addition, when wrestlers engage in close proximity, it is critical to react quickly to an unpredictable disturbance from the opponent. Therefore, not only voluntary reactions but also reflexive actions must be swiftly recruited in the rapid changes of motion that occur during a match. However, little is known about the control of reflexes that govern the excitability of muscles in the arms of wrestlers.

In the current study, we focus on the stretch reflex, which is made up of short-latency and long-latency components. The former is a monosynaptic reflex, which occurs at the spinal level, whereas the latter appears to involve a spinal polysynaptic reflex or be organized at supraspinal levels (4,5). The magnitude of the stretch reflex can be modified by different task instructions (6–9). For example, MacKinnon et al. (10) recorded the EMG during a perturbation to the wrist (a quick extension). The subjects were given three ways to react to the

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perturbation: "passive" (not react to the disturbance), "resist," and "extend." There were no differences among the three tasks for the short-latency stretch reflex, but the task instructions affected the magnitude of the EMG for the long-latency reflex. The effect was largest for "resist," less for "extend," and least for "passive." This result suggests that the short-latency stretch reflex is less affected by signals from supraspinal structures, whereas the long-latency stretch reflex could well be influenced by the subject's intention (10).

Plastic changes in the spinal reflex of athletes have been reported in several previous studies. For example, the magnitude of the stretch reflex in the soleus muscle of ballet dancers is smaller than in that of sedentary people, may be because they maintain unstable postures during ballet dancing (11,12). The dancers appear to stabilize their standing posture by suppressing the reflex. On the other hand, experienced swimmers had a larger stretch reflex in soleus muscle as compared with nontrained individuals (13). Swimmers practice for a long time in the low gravity environment of water, which effectively reduces their body weight. Load-related afferent information is suppressed, and this likely results in a higher excitability of the reflex on a chronic basis. Thus, the stretch reflex in athletes is plastic and can be modulated by experiences that occur during sports and training.

The objective of this study was to determine the characteristics of the upper limb stretch reflex in wrestlers, as well as to investigate its task dependency. We hypothesized that stretch reflexes, which occur more quickly than voluntary reactions, would be augmented in amplitude in wrestlers as compared with nonwrestlers.

MATERIALS AND METHODS

Participants. Participants were male adults with no known history of neurological disease. The 10 wrestlers (20.4 ± 1.2 yr, 169.5 ± 6.3 cm) had all wrestled more than 5 yr and had placed in national competitions. The 11 control subjects (23.2 ± 0.8 yr, 172.8 ± 5.8 cm) were individuals who did not exercise regularly. All subjects were right side dominant in accordance with the Edinburgh inventory (14). Before the experiment, written informed consent was obtained from all subjects. The study was approved by the Human Research Ethics Committee of Waseda University.

Participants sat on a dynamometer (Biodex system 4, Biodex Medical System Inc, USA) with the body secured to the dynamometer with straps. The right arm was fixed to the dynamometer at the neutral position of 70 degrees shoulder abduction, 30 degrees shoulder horizontal flexion, and 75 degrees elbow flexion (Fig. 1).

The EMG of the right biceps brachii (BB) and the triceps brachii (TB) were recorded with bipolar surface electrodes 40 mm in diameter (Vitrode M, Nihon Kohden, Japan) with an interelectrode distance of 40 mm. The sampling rate was 2000 Hz. The EMG signals were amplified with a Multichannel Amplifier (×500, MEG-6018, Nihon Kohden, Japan), and bandpass filtered (15–1000 Hz). We saved data of the EMG signal, torque, position and angular velocity in PC software (Labchart ver.8; ADInstruments) through an A/D converter (ML880 Power lab 16/30; ADInstruments, USA).

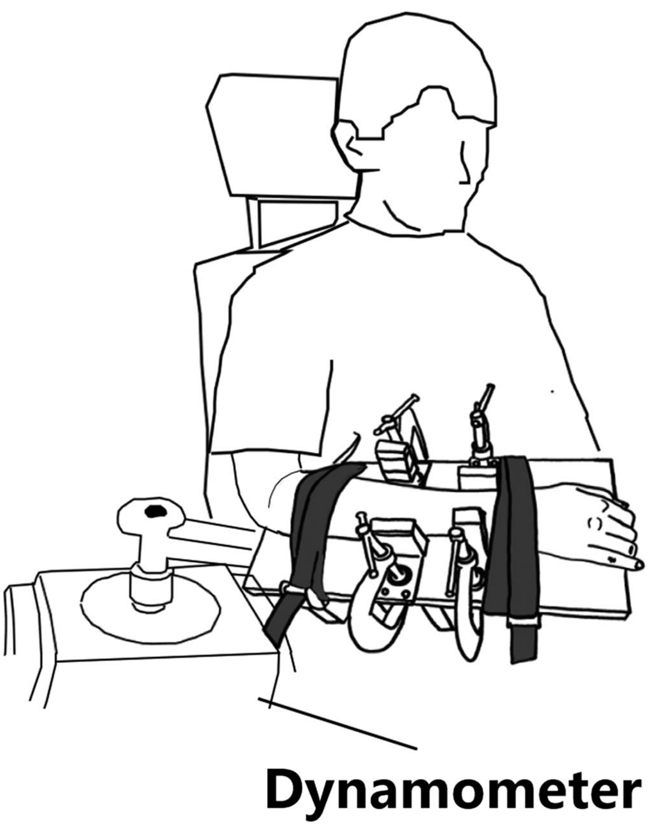

FIGURE 1—Experimental setup for delivering a perturbation to the right arm with a dynamometer.

Protocol. We conducted two sessions, one involving elbow extension perturbation and another involving elbow flexion perturbation. The order of the sessions was randomized, with a 10-min break between sessions, and counterbalanced across subjects. Initially, the participant's maximum voluntary contraction (MVC) of BB and TB during elbow flexion and extension, respectively, were assessed (at the neutral position, twice).

In the extension perturbation session, by watching the torque displayed on a monitor, the participants first kept isometric elbow flexion torque at 10% of the MVC. Then, to evoke the stretch reflex in BB, the elbow was extended 20 degrees using the dynamometer (Fig. 1). Subjects were asked to respond, once they detected the perturbation, in the relax task by relaxing the precontracted muscles as quickly as possible, and in the flexion task by contracting flexor muscles as quickly and strongly as possible. Participants conducted each of two tasks 30 times, respectively, in a random order. There was a 15-s break between trials and participants took a 5-min break every 20 trials.

In the flexion perturbation session, by watching the torque displayed on a monitor, participants first kept isometric elbow extension torque at 10% of the MVC. Then, to evoke the stretch reflex in TB, the elbow was flexed 20 degrees using the dynamometer (Fig. 1). Subjects were asked to respond, once they detected the perturbation, in the relax task, by relaxing the precontracted muscles as quickly as possible,

TABLE 1. The frequency of short-latency stretch reflex in each group, task, and muscle.

		Control	Wrestler
Muscle	Task	Average (%)	Average (%)
TB	Relax	94.2 ± 6.0	96.7 ± 4.5
	Extension	94.8 ± 8.0	98.3 ± 2.4
BB	Relax	89.4 ± 8.5	86.7 ± 6.1
	Flexion	90.6 ± 5.4	88.7 ± 7.6

and in the extension task by contracting extensor muscles as quickly and strongly as possible. Participants conducted each of the two tasks 30 times, respectively, in a random order. Subjects were allowed to rest *ad libitum* during the session.

The mean angular velocity in the 100-ms period from the start of perturbation did not significantly differ between the two sessions ($25.6°\cdot s^{-1} \pm 0.5°\cdot s^{-1}$ in the extension perturbation session, and $26.5°\cdot s^{-1} \pm 0.3°\cdot s^{-1}$ in the flexion perturbation session, $P > 0.05$).

Analysis. Thirty perturbations were applied in each task, meaning that in total, 120 perturbations were given to each subject. The BB and TB EMG for each trial were first rectified. Then, we conducted two types of analyses.

First, we checked how often the short-latency stretch reflexes were elicited in each task and for each subject (Table 1). We defined a reflex in a trial as occurring when peak muscle activity within the M1 window exceeded twice the averaged activity over a 50-ms period before the perturbation was initiated. This definition of the short-latency reflex followed that used by Dietz et al. (7).

Second, we obtained the magnitude of the three reflex components by following the definition of Yamamoto and Ohtsuki (15): M1 (20–50 ms after perturbation), M2 (50–80 ms after perturbation), and M3 (80–100 ms after perturbation). Following this: 1) The EMG of 30 trials in each task (relax, flexion, or extension) for each subject were averaged. 2) Background EMG (bEMG) of both agonist and antagonist muscles were obtained as average values in the 50-ms time window just before perturbation onset. 3) The averaged EMG was normalized using the bEMG (16), because the level of the bEMG affects reflex size (17–19). 4) The normalized background muscle activity (100%) for each subject was subtracted from the normalized EMG, which was denoted as "net EMG." 5) The size of each reflex component (M1, M2 or M3) for each subject was obtained as the average of the net EMG in each time window (20). 6) Finally, this value was averaged for each subject group.

Statistical analysis. The data were analyzed using a statistical software package (SPSS statistics version 24, IBM). To compare the subject's height between the controls and wrestlers, we conducted an unpaired *t* test. To compare the frequency of the short-latency stretch reflex between tasks and groups for both muscles, we conducted a two-way ANOVA. To compare the bEMG, precontraction torque, and angular velocity between the controls and wrestlers, we conducted an unpaired *t*-test for each muscle (BB/TB) and task (relax/flexion or extension). To compare the reflex size between the controls and wrestlers, we conducted a Mann–Whitney *U* test, because some data had nonnormal distributions for each muscle (BB/TB), task (relax/flexion or extension), and reflex section (M1, M2, and M3). To compare differences in the magnitude of the reflex size between the relax and flexion/extension tasks, we conducted a Mann–Whitney *U* test, because some data had nonnormal distributions for each muscle (BB/TB) and reflex section (M1, M2, and M3) using the average of all subjects. Significant differences were recognized at $P < 0.05$ in all cases.

RESULTS

EMG and kinematic pattern during the tasks. There was no significant difference in height between the control group and the wrestler group ($P = 0.224$, $r = 0.280$). There was no significant difference in the frequency of occurrence of a short-latency stretch reflex between tasks and groups in either muscle (TB interaction: $F(1,19) = 0.239$, $P = 0.630$; BB interaction: $F(1,19) = 0.500$, $P = 0.825$) (Table 1). Figure 2

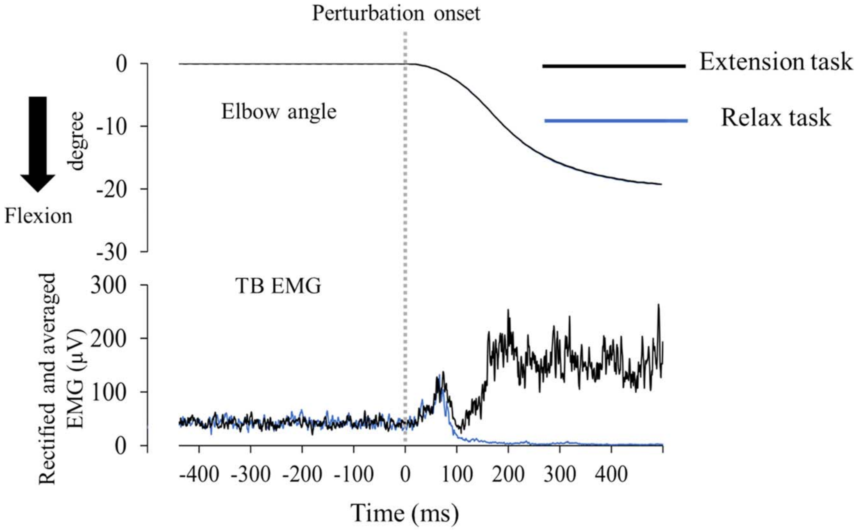

FIGURE 2—A representative response of a control subject's averaged joint angle and full-wave rectified and averaged EMG activity during the flexion perturbation task. The *top* and *bottom panels* indicate elbow angle and the TB EMG, respectively. The *black* and *blue lines* show the extension task and relax task, respectively.

TABLE 2. The value of bEMG, precontraction torque, and angular velocity of perturbation.

		bEMG (%MVC)			Torque (%MVC)			Angular velocity (°·s^{-1})		
Muscle	**Task**	**Control**	**Wrestler**	***P***	**Control**	**Wrestler**	***P***	**Control**	**Wrestler**	***P***
TB	Relax	8.96 ± 1.9	7.78 ± 1.8	0.153	9.54 ± 1.9	9.11 ± 0.6	0.500	26.6 ± 0.3	26.4 ± 0.6	0.231
	Extension	8.68 ± 1.4	7.67 ± 1.9	0.188	9.51 ± 1.8	9.05 ± 0.8	0.474	26.5 ± 0.3	26.4 ± 0.3	0.253
BB	Relax	7.41 ± 4.5	4.94 ± 1.7	0.111	9.31 ± 1.1	9.56 ± 0.6	0.546	25.8 ± 0.4	25.5 ± 0.5	0.090
	Flexion	7.61 ± 4.8	4.91 ± 1.5	0.099	9.54 ± 1.1	9.71 ± 0.6	0.670	25.7 ± 0.4	25.5 ± 0.5	0.382

shows the rectified/averaged EMG waveforms in TB, as well as the trajectories of elbow angle after flexion perturbation for a single subject. In the extension and relax tasks, the perturbation was given while the subject maintained a weak TB contraction. After this perturbation, multiple reflex components were observed in the TB EMG. Under the perturbation tasks (e.g., relax and contraction tasks), when comparing the control and wrestler groups, there were no significant differences in bEMG activity, precontraction torque, or angular velocities (Table 2).

TB stretch reflex induced by flexion perturbation. Figure 3 shows the grand averaged waveforms of elbow angle displacement and net EMG for TB in the control ($n = 11$) and wrestler groups ($n = 10$) for the flexion perturbation task. After flexion perturbation of the elbow joint, clear reflex components were elicited at latencies around 20 ms (M1) and 50 ms (M2). Although M1 magnitudes did not differ between contraction and relax tasks ($P = 0.320$, $r = -0.15$), marked differences in M2 ($P < 0.001$, $r = -0.71$) and M3 ($P < 0.001$, $r = -0.81$) amplitude were observed between the extension and relax tasks. As for the difference between subject groups, peak amplitude of M2 for the relax task in the wrestler group was smaller than that of the control group ($P = 0.035$, $r = -0.46$). In contrast, the later components, at about 80 ms from the perturbation (M3) of the extension task in the wrester group, were enhanced as compared with the control group ($P = 0.020$, $r = -0.51$). M3 components were not generated in the relax task in either subject group.

Figure 4 shows the amplitudes of the three reflex components for TB. In the relax task (Fig. 4A), there was no significant difference between the control group and the wrestler group in either the M1 ($P = 0.573$, $r = -0.12$) or M3 ($P = 0.139$, $r = -0.32$) components. However, M2 amplitudes in the wrestler group were significantly smaller than those in the control group ($P = 0.035$, $r = -0.46$). Interestingly, for the extension task (Fig. 4B), M3 amplitudes in the wrestler group was significantly larger than those in the control group ($P = 0.020$, $r = -0.51$). In contrast, there was no significant difference between the control group and the wrestler group for M1 ($P = 0.159$, $r = -0.31$) or M2 ($P = 0.833$, $r = -0.05$) amplitudes.

BB stretch reflex induced by extension perturbation. Figure 5 shows the grand averaged waveforms for elbow angle displacement and the net EMG of BB for the control and wrestler groups of the extension perturbation task. After extension perturbation of the elbow joint, M1 did not differ between flexion and relax tasks ($P = 0.538$, $r = -0.10$) nor between the control and wrestler groups (relax: $P = 0.526$, $r = -0.14$, flexion: $P = 0.260$, $r = -0.25$). M2 ($P < 0.001$, $r = -0.57$) and M3 ($P < 0.001$, $r = -0.78$) were different between the two tasks. However, there was no significant difference between the control group and wrestler group in any of the components or tasks (relax, Fig. 6A; M2: $P = 0.526$, $r = -0.14$, M3: $P = 0.944$, $r = -0.02$, flexion, Fig. 6B; M2: $P = 0.673$, $r = -0.09$, M3: $P = 0.181$, $r = -0.29$).

DISCUSSION

One of the main findings of the present study was that the magnitude of the stretch reflex response in the M2 and M3 components for TB differed between wrestlers and controls. When we made the EMG measurements at the MVC of elbow flexion or extension, only slight activity was observed from the electrodes over the antagonist. Thus, although we cannot deny the possibility that crosstalk from other muscles occurred, we believe that its influence on the results was minimal or nonexistent. The degree of modulation of the stretch reflex response depends on the velocity of the perturbation (21) and activity level of the background EMG (17–19). In the present study, we attempted to keep these factors as constant as possible. In

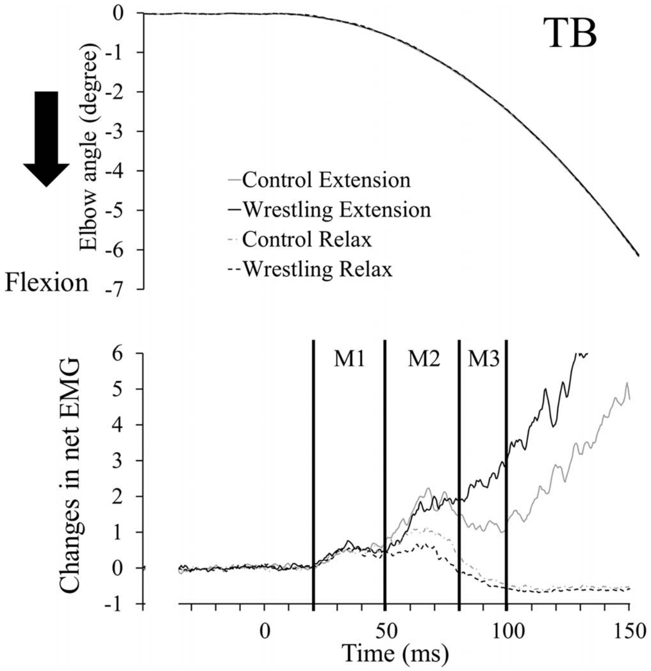

FIGURE 3—The averaged net EMG of the TB for each group. Zero on the horizontal axis (*dashed line*) shows the start of the perturbation. The upper trace depicts change of elbow angle and the lower trace shows muscle activity for each group. The *black line* represents the wrestler group and the *gray line* represents the control group. The *solid line* represents the extension task while the *dotted line* represents the relax task.

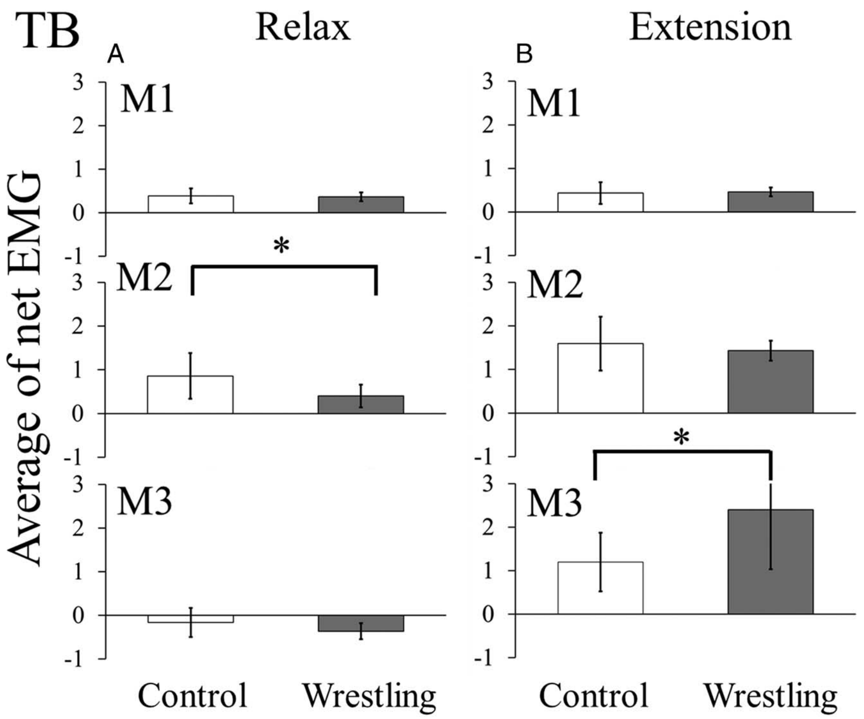

FIGURE 4—The magnitude of the average of net EMG activity for TB. Left graphs (A) show the result of the relax task and right graphs (B) show the result of the extension task. There was significant difference in the relax task in M2 section and in the extension task in M3 section between groups (*$P < 0.05$). *White bars* and *gray bars* represent the average of net EMG activity of the control group and the wrestler group, respectively.

fact, bEMG activity and angular velocity of the perturbation were not significantly different between the two groups (Table 2). Thus, the difference in stretch reflex magnitudes could not be attributed to differences in these parameters during the tasks of both groups. As a result, this protocol can steadily elicit reflexes in both muscles of the two groups (Table 1). Thus, the amplitude and angular velocity of the perturbation were large enough to elicit the stretch reflex.

Moreover, modulation of the long-latency components can be altered by task (6–8). In this study, the participants conducted two tasks, contracting or relaxing the target muscle in response to the perturbation as soon as possible once they felt the perturbation. When the participants were instructed to resist the perturbation, the long-latency component (M2 and M3) was greater than the relax task, whereas a short-latency component (M1) did not differ between the tasks (Fig. 3 and Fig. 5). This result is in line with previous studies in that the long-latency component was affected by the task instruction (6–8), which would be related to the change of corticospinal excitability at least in part (21). This confirms that the participants performed the tasks correctly.

Neurological considerations. In this study, for BB, there were no significant differences between the control and the wrestler groups for any of the reflex components. On the other hand, there were significant differences between the groups of the M2 and M3 components for TB. However, there was no difference in the M1 component. There are several hypotheses about the reflex arc, which is involved in the long-latency component, for example, a polysynaptic spinal reflex (22), input from supraspinal levels (10), and being generated via signals from nonmuscular proprioceptors (23). One possibility for the difference in the long-latency components between the

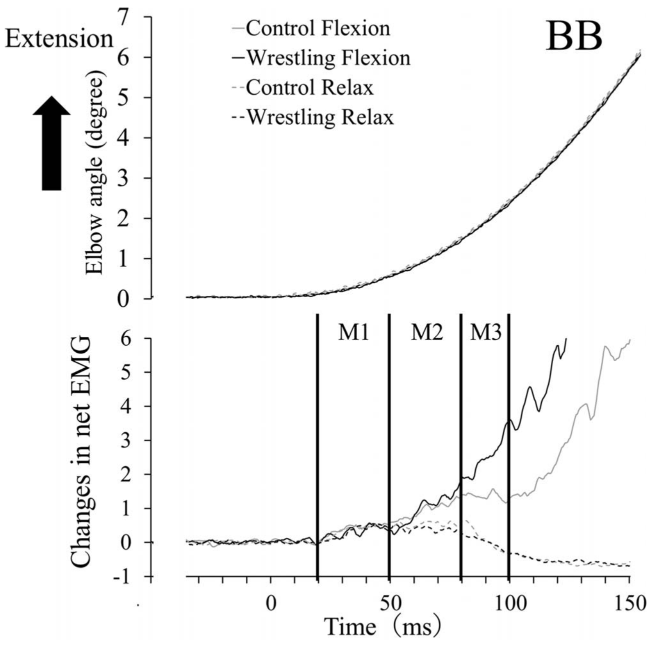

FIGURE 5—The averaged net EMG of the BB for each group. Zero of the horizontal axis (*dashed line*) indicates the start of perturbation. The upper trace shows the change of elbow angle and the lower trace shows muscle activity for each group. The *black line* represents the wrestler group and the *gray line* represents the control group. The *solid line* represents the flexion task and the dotted line represents the relax task.

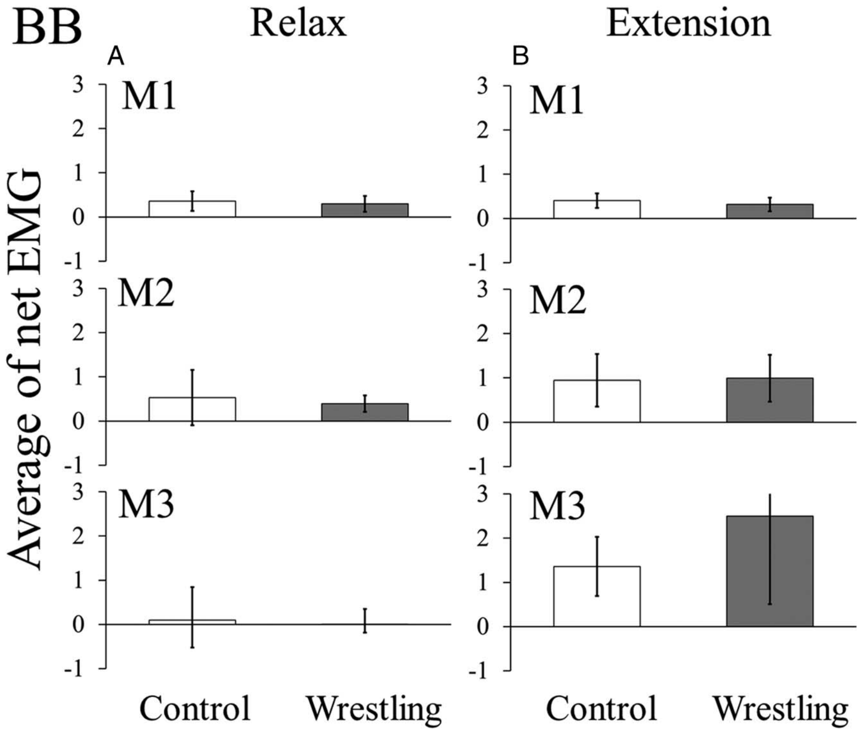

FIGURE 6—Size of the average of net EMG activity for BB. Left graphs (A) show the result of the relax task, and right graphs (B) show the result of the flexion task. *White bars* and *gray bars* represent the average of net EMG activity of the control group and the wrestler group, respectively.

groups might be that it reflects the characteristics of wrestling training and motor capability that top-level wrestlers necessarily possess. The stretch reflex is made up of short-latency and long-latency components. The former is a monosynaptic reflex, which occurs at the spinal level, whereas the latter is considered to involve a spinal polysynaptic reflex with potential inputs via supraspinal arcs (4,5). Matthews et al. (5) measured the stretch reflex of hand muscles in patients with the Klippel–Feil syndrome. The patients had "axons descending from neurons in the motor cortex unusually bifurcate and make connections to homologous motor neurons on both sides of the body." (5,24). They observed both long- and short-latency components in the muscle that was stretched, as in normal subjects. Furthermore, they observed only the long-latency component in the contralateral muscle in the patients. This result strongly suggests that the long-latency component involves a response via the cortex. Moreover, using transcranial magnetic stimulation, Lewis et al. (25) indicated that cortical excitation increased with a timing that suggested a long-latency component.

The ability to anticipate an opponent's action and tactics are important in combat sports (26). In wrestling, the competitors engage in a very small area, so they have to react quickly to any unpredictable perturbation. Wrestlers need to pay close attention to various situations, such as the opponent's hand movement or a postural shift that indicates a leg attack. Depending on the situation, they have to resist or relax the arm muscles that are gripping the opponent. In this study, we observed different reflex responses between wrestlers and controls in the long-latency component, which would, thus, be associated with cortical excitation (5,25). This would indicate that wrestlers had specific characteristics in the modulation of cortical excitation. In line with this result, fencers showed characteristic cortical activity in the event-related potential seen during a go/no-go task (27). Before the go/no-go stimulus was delivered, fencers showed higher cortical activity, which is related to motor preparation and attentional control, than did the novices. In addition, Kendo competitors, who are required to handle their sword in a delicate manner, had a higher event-related potential than control subjects when they needed to adjust grip strength as quickly and accurately as possible to obtain the desired target force (28). These examples support the concept that long-term sport training can enhance motor-related cortical activity in a way appropriate to each sport. Likewise, differences between wrestlers and controls in the long-latency reflex component would, thus, reflect the specific characteristics of the cortical excitation system found in high-level wrestlers. However, in this study, we only measured EMG, so we could not identify which factors caused the difference in the reflex between wrestlers and the control subjects who exercised sparingly. The subject's height was not different between the groups and, thus, it is unlikely that the difference in reflex response was due to a difference in height. Forgaard et al. (29) showed that the long-latency component can be affected by a voluntary reaction; that is, M3 may partly involve voluntary input. A previous study showed that the latency of a voluntary reaction is 100 ms (30). Thus, dealing only with the present results, it is possible that the faster reaction time of the wrestlers was caused a difference in M3 between the groups. In future studies, we need to investigate what factors change the wrestlers' M3 component in more detail.

Previous studies on the stretch reflex in athletes have focused mainly on the short-latency stretch reflex (11–13). These studies revealed that the short-latency stretch reflex of lower limbs can be suppressed in dancers (11,12) or enhanced in swimmers (13), although without any specific directive on how to respond to a perturbation. Thus, modulation of the short-latency reflex in those specific athletic groups could be attributed to a long duration of exercise involving specific postural or gravitational situations encountered in ballet or swimming. In this study, wrestlers showed dynamic changes (enhancement or suppression) in the long-latency stretch reflex (M2 and M3 components in TB) in a situation-specific manner, whereas there was no change in the short-latency stretch reflex (M1 component). The latter may reflect the fact that the "automatic" property of M1 is unsuitable for situation-specific modulation.

Functional implications. Difference in reflex activities between the wrestlers and controls might reflect the characteristics of wrestling training and/or the techniques that wrestlers are required to master to succeed in matches. Both contraction and relaxation are important action repertoires in actual wrestling matches, in which perturbation is frequently applied to one's upper limbs by an opponent (31). For example, when a wrestler has to respond to an opponent's leg attack and/or setup, just countering it with an intentional voluntary reaction is too late. Thus, wrestlers need to develop involuntary reflexes to deal with the opponent's actions. Interestingly, sometimes it is important for wrestlers to not automatically react to an opponent's attack. Also, in some cases, distancing themselves from their opponent can be an important factor for success in wrestling (32). In other cases, they may have to close the distance or maintain an optimal distance. Thus, wrestlers' reflexes need to be altered in a situation-specific manner. In addition, when the protagonists are pushing each other back and forth, they may need to absorb the opponent's balance. Triceps brachii has a role in absorbing the pressure (33). Therefore, the ability to change the response to a disturbance generated by an opponent depends on the particular situation and is very important for success in wrestling (26). To execute these complex actions involuntarily, and thus very rapidly, modulation of reflex activities (M2 and M3) is essential. Because the control group was not accustomed to reacting to unpredictable perturbations, modulation of their reflexes would be expected to be smaller than those of the wrestlers.

In this study, the wrestlers showed a characteristic, unique response only in TB, and not in BB. As noted above, the major role of TB is to respond defensively to an unexpected and sudden action of the opponent such as setting up for a leg attack. Thus, the best TB response should be involuntary and very quick. On the other hand, the role of BB is mainly to pull an opponent's arm or leg when trying to execute an attack. This mainly involves voluntary movements and reflexes likely play a minor role. Thus, the contrasting roles of TB and BB might have led to a divergent modulation of M2/M3 responses that are specific to wrestlers.

CONCLUSIONS

The present study analyzed the characteristics of the upper limb stretch reflex in wrestlers. The wrestlers exhibited a modulation of the long-latency reflex components, but not the short-latency portion. This was done in a task-dependent manner. It involved not only enhancement but also suppression. It was suggested that the responses seen would aid wrestlers by modulating the gain of the reflex so as to respond to an unpredictable perturbation as quickly and adequately as possible. Interestingly, differences between the wrestlers and control group in the long-latency reflex component were observed only in TB and not in BB. This suggests that the changes observed are related to the special functional role of TB in wrestling. Wrestlers have specific characteristics of the long-latency stretch reflex for TB, and these reflexes have been altered in a situation-specific manner. This study will provide useful information for coaches and athletes from a new perspective. Moreover, these findings will help wrestling coaches and athletes make plans for training, practices, and match strategies.

This study is unfunded. The authors declare no conflicts of interest associated with this manuscript. The results of the present study do not constitute endorsement by the American College of Sports Medicine. The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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