Modulation of the Presynaptic Inhibition of Spinal $\alpha$-Motoneurons during Mechanical Stimulation of Different Types

Yu. A. Povareshchenkova and D. A. Petrov
Velikie Luki State Academy of Physical Education and Sports, Velikie Luki, Pskov oblast, Russia
Received December 12, 2005

Abstract—Using the method of assessing the presynaptic inhibition of heteronymous Ia afferents and $\alpha$ motoneurons of the m. soleus during a homonymous vibration effect on the tendo calcaneus in ten subjects, changes in the inhibition of spinal $\alpha$ motoneurons during 15 min of the aftereffect of mechanical stimulation of different types were studied. Intense mechanical stimuli and weak tactile, vibratory stimuli applied in combination intensify inhibitory processes in the afferent fibers of group Ia, their effects differing in the value of the increase in the presynaptic inhibition of spinal $\alpha$ motoneurons.

DOI: 10.1134/S0362119708010155

From the viewpoint of the undoubted existence of a common pattern of organization of sensory systems, it seems expedient to consider the formation of responses of the neuromuscular apparatus to external physical factors for understanding the general principles of organization of the activity of spinal structures. The study of the mechanisms of transformation processes in the neuromotor apparatus upon changes in the qualitative and quantitative composition of somatosensory afferentation may serve as the basis for understanding the specific activity of other systems, their interaction, and adaptation of the human body to changing environmental conditions. The external factor in our study was different techniques of massage. Massage manipulations are external mechanical stimuli having different modal characteristics (touch, pressure, and skin displacement) and quantitative characteristics (strength, rate, and direction of stimulus action). The differences in the action of different massage techniques are based on the afferentation from activated receptors and the mechanisms of processing of this afferentation in the corresponding higher regions of the central nervous system. The diversity of massage manipulations and the possibility of graded, local, and adequate stimulation of mechanoreceptors of different groups permits using massage as a model for the assessment of the organization of the information flow and central interactions under exposure to mechanical factors.

The available literature contains no data on the expression of the presynaptic inhibition of Ia afferents under exposure to combined external mechanical stimuli. Our previous studies have demonstrated that intense mechanical stimuli decrease the expression of the presynaptic inhibition of spinal $\alpha$ motoneurons and weak tactile and vibratory stimuli in the case of their selective use intensify inhibitory processes in afferent fibers of group Ia immediately during the restoration [1, 2].

The purpose of this study was to detect the action of measured external physical stimuli on the state of intrasegmental and intersegmental systems of the presynaptic inhibition of Ia afferents.

EXPERIMENTAL

To study the expression of the presynaptic inhibition of spinal motoneurons during vibrostimulation in use of stimulatory and relaxing massage, 26 tests were performed on ten subjects aged 18.9 ± 0.52 years (height, 176.3 ± 2.21 cm; weight, 67.3 ± 2.01 kg) who were engaged in ski racing and had 8.3 ± 0.41 years of experience in sports. The used frequency of homonymous vibrostimulation of the tendo calcaneus was in the range 50–70 Hz, and the amplitude of oscillations was 0.8 mm. The H reflex was recorded during 30 s from the vibrostimulation of the tendo calcaneus and for 50 s of the aftereffect. The recording of bioelectric potentials was performed using bipolar electrodes (Fig. 1). For processing the results, the Myo software (ANO Vozvrashchenie, St. Petersburg, Russia, 2003) was used.

The presynaptic inhibition of heteronymous Ia afferents running from the m. quadriceps to motoneurons of the m. soleus was assessed with a method developed by the authors of [4]. The essence of the method was the measurement of the facilitation of the m. soleus H reflex caused by conditioning stimulation of the n. femoralis. Surface electrodes were used to stimulate the n. tibialis and n. femoralis. Rectangular impulses with a duration of 1 ms were used as stimuli. During testing stimulation, the control H reflex of the m. soleus with an amplitude of 20–40% of the maximum value was used. The
conditioning stimulation of the n. tibialis was performed using bipolar electrodes that were located at the proximal part of the m. soleus at a distance of 1–1.5 cm from each other. The stimulation of the n. femoralis that preceded the testing stimulation of the n. tibialis was performed using unipolar electrodes with a delay of 5.5 ms [5]. The active electrode was placed in the trigonum femorale and the reference electrode, at the m. gluteus maximus (Fig. 2).

The recording of bioelectric potentials of the m. soleus and m. quadriceps was performed using a Mini-Electromiograph device; processing of obtained data was performed with the Myo software (ANO Vozvrashchenie). Petrissage, pressing, rubbing, and percussing techniques were used in the stimulatory massage. Shaking and stroking were used in the relaxing massage. The baseline indices (control) were recorded prior to massage. After massage, from the 8th to the 15th minute of the aftereffect, the recording of the studied parameter was repeated. The massage was applied to the anterior surface of the thigh.

RESULTS AND DISCUSSION

The results of our study indicated that the presynaptic inhibition of motoneurons of the spinal cord is intensified during the vibrostimulation of the tendo calcaneus in the course of a 5-min stimulatory massage. This was expressed in a greater inhibition of the amplitude of the m. soleus H reflex on exposure to vibrostimulation (Table 1). After a session of stimulatory massage, the recording of the testing m. soleus H reflex against the background of vibrostimulation of the tendo calcaneus indicated that the amplitude of the monosynaptic reflex of the m. soleus, compared to the baseline values, decreased throughout the vibration period.

The time course of the inhibition of the m. soleus H reflex in response to vibrostimulation of the tendo calcaneus was different at different moments of recording (Fig. 3). The range of changes was limited to 25–35%, the maximum changes being recorded at the eighth minute of the postmassage period and the minimum ones immediately after the cessation of the treatment.

Of interest is the time course of the expression of presynaptic inhibition of Ia afferents of the m. soleus caused by stimulatory massage after the cessation of vibrostimulation (Table 2). The data obtained testify to a delay in the recovery of the value of the presynaptic inhibition of spinal α motoneurons after vibrostimulation at different moments of recording in the case of stimulatory massage.

The time course of recovery of the amplitude of the m. soleus H reflex after massage differed at different moments of recording (at the 1st, 8th, and 15th minutes). The maximum differences of the data obtained from the control were recorded at the 15th minute of the aftereffect of massage consisting of petrissage, pressing, rubbing, and percussing. At the first and eighth

Table 1. The amplitude of the m. soleus H reflex (mV) during vibrostimulation of the tendo calcaneus after stimulatory massage (M ± m)

<table>
<thead>
<tr>
<th>Period</th>
<th>1 s</th>
<th>10 s</th>
<th>20 s</th>
<th>30 s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before massage</td>
<td>3.56 ± 0.23</td>
<td>2.44 ± 0.21</td>
<td>1.39 ± 0.11</td>
<td>0.96 ± 0.06</td>
</tr>
<tr>
<td>After massage</td>
<td>2.67 ± 0.23*</td>
<td>1.82 ± 0.17*</td>
<td>1.04 ± 0.06*</td>
<td>0.73 ± 0.04*</td>
</tr>
<tr>
<td>8th minute</td>
<td>2.42 ± 0.18*</td>
<td>1.64 ± 0.15*</td>
<td>0.91 ± 0.06*</td>
<td>0.63 ± 0.04*</td>
</tr>
<tr>
<td>15th minute</td>
<td>2.51 ± 0.19*</td>
<td>1.73 ± 0.17*</td>
<td>0.98 ± 0.09*</td>
<td>0.7 ± 0.02*</td>
</tr>
</tbody>
</table>

* Significant difference from the control (p < 0.01).