KnE Engineering
RFYS
Russian Forum of Young Scientists
Volume 2018

Knowledge E
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Conference Paper

# The Influence of Hypoxic Hypoxia and Antiorthostatic Hypokinesia on the Activity of Motoneuron Pools in Man

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## Abstract

The paper presents study results of the possible modulating effects of intermittent normobaric hypoxic hypoxia and antiorthostatic hypokinesia on motoneuron pools activity m. soleus and m. gastrocnemius. The unidirectional conditioning of the monosynaptic spinal H-reflex was revealed under non-specific effects of hypoxia and antiorthostasis. After 19 days of exposure, an increase in the amplitudes of the H- and M- responses, activation thresholds of the action potential of Ia sensory fibers was observed, which led to the induction of a maximal H-response in both muscles at a greater stimulus level. There was also a pronounced decrease in the H-reflex depression, which is apparently associated with a weakening effect of suprasegmental control systems in the cumulative effect of a 19-day intermittent (interval) normobaric hypoxic hypoxia and antiorthostatic hypokinesia.

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Received: 10 February 2018
Accepted: 14 April 2018
Published: 7 May 2018

Publishing services provided by Knowledge E



Selection and Peer-review under the responsibility of the RFYS Conference Committee.



One of the main problems of movement physiology remains an understanding of the mechanisms that cause possible violations of the neuromuscular functions in humans under conditions of the different genesis nonspecific factors influence [1; 3; 4; 12]. It is not accidental that natural and barometric hypoxia is used to analyse the electrophysiological phenomena of the neuromuscular system and simulate various motor situations [5; 6; 10; 12], antiorthostatic effects [7; 8; 9], hypokinesia [6; 11], etc. In this experiment, an attempt was made to study the possible modulating effect of intermittentnormobaric hypoxic exposures and antiorthostatic effects on the monosynaptic spinal H-reflex and direct muscle M-wave obtained from the soleus and medial gastrocnemius muscle with stimulation of the posterior mixed tibial nerve.

# 1. Materials and Methods

The study was conducted on neurologically healthy males (19-26 years), who were conditionally divided into two groups: I (n=15) underwent dosing intermittent normobaric hypoxic training (IHT) (breathing air with an $O_2$ content of 9.9%, $CO_2$ – 0.03% for 30 to 50 minutes for 19 days). The exposure of IHT consisted of 8-10 repeated cycles of 5-minute breathing with a hypoxic normobaric gas mixture alternating with 2-minute intervals of respiration with atmospheric air. The hypoxic gas mixture was prepared by the oxygen concentrator "Onyx" (AirSep Corporation, USA). Another group, II (n=16), underwent daily anti-orthostatic hypokinesia (ANOHK) during the same period-the subjects were lying downside down on a couch standing at an angle of -$20^0$ for 60 minutes. In the background study and after 19 days, the IHT and ANOHK evaluated the temporal and amplitude characteristics of the Hoffmann monosynaptic reflex and the direct M-response. Registration of H-reflex and M-response m. soleus and m. gastrocnemius was performed with a neuromuscular analyzer NMA-4-01 Neuromian (Medicom-MTD, Russia). Stimulation of low threshold afferents Ia group n. tibialis was performed in the popliteal fossa by means of a monopolar surface electrode with rectangular current pulses of intensity from 12 to 50 mA (20 times with 2 mA steps) and a duration of 0.7 ms with intervals between stimulations at least 10 s [1; 2; 3]. The withdrawing skin electrodes with silver chloride coating (diameter 0.5 cm, electrode distance 2.5 cm) were topographically arranged in accordance with the standard procedure [2]. The ground electrode was somewhat distal to the stimulating electrode. In each study, the threshold of occurrence, the latent period, the maximum amplitude of the H-reflex and the M-response, as well as the normalized amplitude of the Hoffman reflex (Hmax / Mmax * 100%) were determined.

Mathematical processing of the data was performed using MS Excel 2003 spreadsheets and Statistica V. 6.0 statistical software package. Methods of variational and descriptive statistics were used-analysis of variational series, comparison of mean values and relative frequencies. The reliability of the differences in the investigated electroneurophysiological parameters was assessed according to Student's t-criterion. Differences were recognized as significantly significant at significance level $p<0.05$.

# 2. Results

In the process of obtaining experimental material, which makes it possible to characterize the quantitative differences in the study groups, certain qualitative features of the studied neurophysiological phenomena were revealed. In the background study, in determining the activation threshold of the H-reflex in the entire study population (n = 31), the inhomogeneity of the sample was observed, apparently related to the preconditioning effect [4]. In some individuals from group I (n = 7) activation and preservation of monosynaptic H-reflex in m. Soleus occurred with submaximal and maximum electrical stimulation in the range of 12 to 50 mA, which is associated with an increase in activity of motor neurons of the anterior horns of the spinal cord due to, as a rule, a decrease in inhibitory regulatory influences on the part of suprasegmental structures.

When analyzing the influence of IHT and ANOHK on the amplitude characteristics of the direct muscle response, we detected similar tendencies of amplitude increase by day 19. However, in group II, the M-response is m. soleus in the range of stimulation from 24 to 34 mA was significantly lower ($p < 0.01$), which is probably due to the effect of gravity discharge in ANOG on phasic musculature [7]. It should be noted that the amplitude of the M-responses m is significantly higher. Gastrocnemius in group I (32-40 mA) and m. Soleus (38-46 mA); The first peak Mmax of both muscles in representatives of group I was determined at 20 mA, whereas in group II the M-response reached a maximum with supramaximal stimulation (48-50 mA). The latent periods of recruitment of direct responses of both muscles did not differ ($p > 0.05$) and were, respectively, for m. Soleus in the range of 5.31-5.43 ms; for m. gastrocnemius within 5.1-5.2 ms, which may be due to the absence of lesion in the efferent part of this monosynaptic arc. The temporal difference in latency between the phasic and tonic muscles studied is determined by the longer length of the segment (the point of stimulation is the distal part of the motorial portion of the tibial nerve - the lead electrodes) with innervation of m. Soleus in relation to the length of the site: popliteal fossa is the motor point on m. Gastrocnemius. When analyzing the influence of IHT and ANOHK on the activation of motoneuronic pools of "fast" medial gastrocnemius and "slow" soleus muscles, the amplitude peaks are shifted towards a greater stimulation force. I group: Hmax m. gastrocnemius - 20 mA, Hmax m. soleus - 18 mA in the background study, after 19 days ANOHK Hmax m. gastrocnemius - 24 mA, Hmax m. soleus - 24 mA; Group II: Hmax m. gastrocnemius - 16 mA, Hmax m. Soleus - 16 mA in the background study, after 19 days ANOHK Hmax m. gastrocnemius - 32 mA, Hmax m. soleus is 26 mA, which indirectly can characterize the non-specific effects on the activity of the motoneuron pools of the studied leg muscles as modeling.

Within each group, similar tendencies of recruitment of monosynaptic H-reflex of both muscles after IHT and ANOHK were revealed, which, apparently, is characterized by adaptive settings of the spinal and suprasegmental systems in response to the nonspecific stimulus.

## 3. Conclusion

Preliminary results of the study showed that, to some extent, IHT and ANOHKunilaterally affect the activation of the motoneuron pool m. soleus and m. gastrocnemius. The maximum activation of the H-reflex of the gastrocnemius muscle occurred under conditions of stimulation of the tibial nerve with an average intensity current, which may indicate an increase in the excitability threshold Ia of the sensory fibers after exposure to IHT and ANOHK. The amplitudes of the maximum H-responses in both groups increased with the induction of an electric current in the range from 22 to 32-40 mA ($p < 0.05$). Amplitudes of M-responses at the same levels of stimulus as in the background study (from 12 to 50 mA), after 19 days, the IHT and ANOHK doubled in both groups with an electrical stimulus level of 22 to 50 mA. There were no significant changes in the latent period of the maximal M-response in group I, although there was a tendency to decrease it, in group II there was a reverse orientation ($p > 0.05$).

The main mechanism for reducing inhibitory reactions of segmental excitability in IHT and ANOHK is, apparently, modulation of presynaptic inhibition and inhibitory effect of Ranshaw cells. The absence of pronounced presynaptic inhibition is probably due to the influence of hypoxia and postural effects on the interneurons of the segmental apparatus of the lumbar spinal cord thickening ($S_1$) on the term sensory neurons monosynaptically associated with the motor cells of the anterior horns of the spinal cord. Also, the overall decrease in inhibitory influences may be due to the decrement of descending cerebral influences on the spinal cord of the human spinal cord when adapting to hypoxia factors and postural effects.

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