# RUNNING-INDUCED CHANGES IN H-REFLEX AMPLITUDES IN NON-TRAINED MEN

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***Abstract***

Effect of 5-weeks running training on modulation of the H-reflex amplitude on soleus muscle in non-trained men was studied. It was established that modulation of the H-reflex amplitude occurs in two phases. In the course of the first 3 weeks of running training (first phase) statistically significant ($p < 0.05$) increase in H-reflex amplitudes and the maximum H-reflex to the maximum M-response amplitudes ratio (10%) were registered. In contrast to the first phase, decrease in investigated parameters up to initial values were observed during the next 2 weeks of the training (second phase). An increase in the of the soleus H-reflex amplitude, is probably due to the enhanced drive in descending pathways, increased motoneuron excitability and changes in presynaptic Ia afferent inhibition, whereas decrease in the amplitude of the H-reflex might occurs presumably due to motor learning. Apparently, that the repetitive task, which automatically performed and controlled on a spinal or brainstem level can be reflected in the normalization and stabilization of the H-reflexes registered after running training in later period.

***Key words**: H-reflex, soleus muscle, running training, non-trained men*

## Introduction

Moderate physical activity is an important component of health and longevity (Langhammer, Bergland, & Rydwik, 2018), and exercise training has fundamental beneficial effects on ischemic and nonischemic heart failure (Akyuz, 2020). Running is one of the most popular types of such activity, which is also a key element to achieve health and longevity (Lee, Brellenthin, Thompson, Sui, Lee, & Lavie, 2017). Thus, an important point is to determine the changes in the human organism that occur under the influence of running. Skeletal muscle fatigue in long-distance runners, sprinters and untrained peoples was studied (Skurvydas, Dudoniene, Kalvėnas, & Zuoza, 2002). It has been shown difference in mechanical and energy cost between highly, well, and non-trained runner (Slawinski & Billat, 2004) and also biomechanical components of running: stride length and frequency, flight time and ground contact time (Mero, Komi, & Gregor, 1992). Besides, it was demonstrated that 6-week and even 3-week assisted training improve running speed, stride frequency, etc. (Makaruk, Stempel, & Makaruk, 2019). Holtermann, Roeleveld, Vereijken, & Ettema (2007) have shown that 5 days of maximal isometric dorsiflexion training of the ankle joint can cause increases in maximal force and rate of force development of more than 15%, and few weeks of resistance training can cause increases in isometric single-joint tasks of up to 30% in maximal force (Pucci, Griffin, & Cafarelli, 2006). Taking into account the positive impact of trainings, becomes necessary to investigate a changes on the level of the central nervous system (CNS), which occur during or after such trainings. One of the most significant ways of changes estimation in CNS is the H-reflex. This measurement method is used for evaluating modulation of monosynaptic reflex activity in the spinal cord (Gajos, Kujawski, Gajos, & Chatys, 2014). The H-reflex is an estimate of α-motoneuron excitability when presynaptic inhibition and intrinsic excitability of the α-motoneurons remain constant (Palmieri, Ingersoll, & Hoffman, 2004). In addition the maximal amplitude of the H-reflex ($H_{max}$) contains information of the maximal number of recruited motor units, the maximal amplitude of the M-response ($M_{max}$) gives information of the absolute number of motor units, and therefore the $H_{max}$ to $M_{max}$ ratio shows the percentage of excited α-motoneurons upon electrical stimulation (Holtermann, Roeleveld, Engstrøm, & Sand, 2007). Values of the H-reflex parameters can be used to assess the response of the nervous system on different stimuli, musculoskeletal injuries, exercise training performance of motor tasks and other (Palmieri, Ingersoll, & Hoffman, 2004). It was shown that 3 weeks of isometric maximal plantarflexion resistance training provided increases in maximal force of 18% and H-reflex amplitude during voluntary contractions of 17% while no changes occurred in the control group (Holtermann, Roeleveld, Engstrøm, & Sand, 2007). Capaday & Stein (1986, 1987) investigated amplitude modulation of the soleus H-reflex in the human during walking and standing, and during waking and running. It was demonstrated that at an equal stimulus strength and EMG level, the H-reflex was up to 3.5 times larger (during steadily maintained contractions) while standing than during walking. Also it was revealed that H-reflex was on average significantly smaller during running than during walking. Moreover, fatigue-induced modulation of the H-reflex of soleus muscle in humans, and gender and age-related peculiarities of the H-reflex indices in athletes were demonstrated (Kolosova, & Slivko, 2006; Dornowski, Kolosova, & Gorkovenko, 2017). However, despite a large number of scientific works in this field, the effect of training on changes in the amplitude of the H-reflex, especially in untrained people, is still unclear. Based on literature analysis, we suggested that running training should induce H-reflex modulation in people who are not athletes. Thus, the aim of this study was to determine how amplitude of the soleus H-reflex changes in untrained men during 5 weeks of training.

**Methods**

This study was performed on eight healthy men, aged between 38 and 49 years (weight: 85.6 ± 5.3 kg, height: 185.0 ± 2.5 cm, BMI: 24.8 ± 2.4) without any diseases of the musculoskeletal system and neurological disorders. None of the subjects was involved in physical activities that required running for the past five years and did not do any sports professionally. All volunteers were informed about the aim of the experiment and gave written informed consent to participate in the study. Experiments were approved by the Local Ethics Committee of the Gdansk University Physical Education and Sport and performed in accordance with the Declaration of Helsinki 1964.

According to the aim of the study, the participants had to run for 5 weeks (3 times a week for 2 km, with averaged speed 7 km/h). Three weeks before training beginning, the H-reflex and M-response were recorded twice a week in all participants (the obtained values were taken as a control). During this period, the participants lived a normal life and did not do any heavy physical exercise. During the training period, measurements were made once a week. To avoid fatigue-induced effect on the amplitude of soleus H-reflex, the values were recorded the next day after running. The maximal peak-to-peak amplitude of the H-reflexes and M-response were determined and evoked by bipolar electrical stimulation of the tibial nerve in the political fossa of the soleus muscle (Sol). For recording of the H-reflex and M-response from the Sol, were used a pair of standard surface myographic electrodes (Biopac System EL 503, USA) with a 25 mm spacing between their centers. Stimuli were square-shaped pulses 1 ms in duration (separated by rest intervals of 20 s), delivered by the isolated current stimulator (Digitimer DS3, Great Britain). The electrodes were located along the mid-dorsal line of the leg approximately 4 cm distal from the part where the medial and lateral heads of the gastrocnemius join the Achilles tendon. Stimulation electrode (cathode proximal) was fixed by an elastic band encircling the thigh just above the patella. A proper location was selected in which the H-reflex could be evoked with the weakest stimulus strength. The stimulus intensity increased gradually until H-reflex and M-response were obtained. Three sets of 10 stimuli were obtained in each experiment (one of the sets was used for data analysis). The recorded signals were amplified by a Model 440 amplifier (Brownlee Precision, USA). A 12-bit AD/DA converter, CED Power 1401-3A (Cambridge Electronic Design, Great Britain), was used for recording of the signals.

*Statistical analysis*

Data analysis was performed using "Spike 2" (Cambridge Electronic Design, Great Britain) and "Origin 8.5" (OriginLab Corporation, USA). Mean values ± standard deviation (SD) of the maximum H-reflex and maximum M-response amplitudes, and $H_{max}/M_{max}$ relation were determined. Differences between the analyzed parameters were compared using one-way ANOVA. In the case of significant intergroup differences ($p < 0.05$), a posteriori Bonferroni's multiple comparison test was used.

**Results and discussion**

Control mean values ± SD (before running training) of Sol H-reflex amplitude for all participants was 5.2±1.9 mV. It was revealed that in comparison with the control, the mean H-reflex amplitude increased during 3 next weeks of training period and was amounted 6.7 ±0.9, 10.5±2.0, 13.5±3.2, respectively (figure 1). Sol H-reflex amplitude gradually increased in all participants, however the statistical analysis showed a significant effect running training time on Sol H-reflex amplitude only at the 2-nd and 3-rd weeks. The control results versus data obtained at the 2-nd and 3-rd weeks of training were as follows: $F_{1,158}$=901.8, p<0.001 and $F_{1,158}$=886.4, p<0.001, respectively. In figure 2 are shown examples of M-responses and H-reflexes in one of participants during whole experiment. Although, in this case, the reflex increased significantly, nevertheless, on average for the group of participants, the increase in the amplitude was notably lower. Thus, observed increased in $H_{max}/M_{max}$ ratio of the Sol muscle was only 10 % for this period of training (Control = 0.4, 1-st week = 0.437, 2-nd week =0.47, 3-rd week = 0.5 (fig. 3)). In contrast to the first 3 weeks of running training both the mean Sol H-reflex amplitude and $H_{max}/M_{max}$ ratio were gradually decreased in the last 2 training weeks. In addition after 5-th week the values reached initial values 5.2 ± 0.9 ($F_{1,158}$=0.05; p=0.83) and $H_{max}/M_{max}$= 0.44 (figures 1 and 3).

Note that statistically significant differences (p > 0.05) in the H-reflex latency between control values and data obtained during experiments were not found.

**Figure 1.** Changes in soleus H-reflex amplitude (mean ± SD) in course of the 5-weeks running training.
* – differenses between the control values and data obtained during 5 weeks.

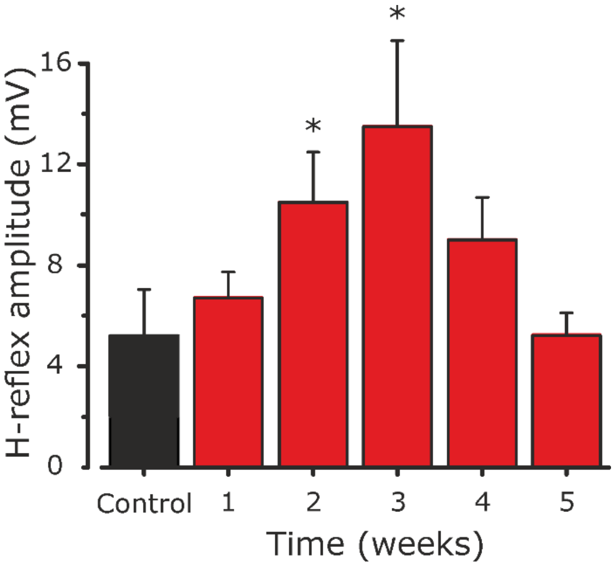



**Figure 2.** M-responses and H-reflexes in one of participants during the 5-weeks running training (each line was averaged by 10 tracks)

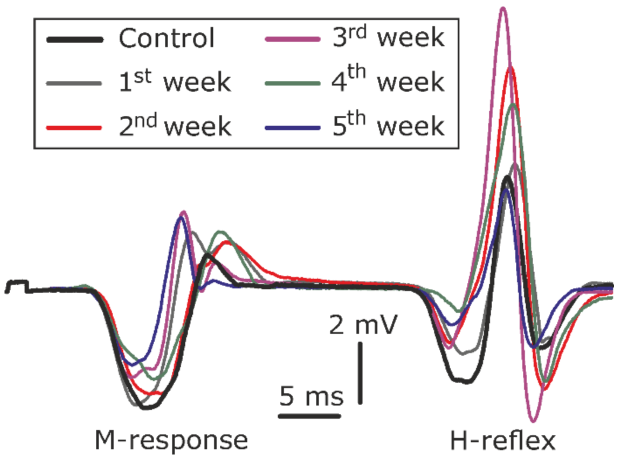
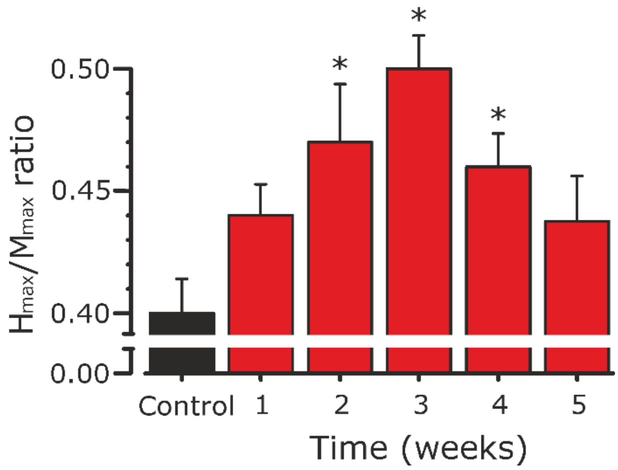



**Figure 3.** Changes in the $H_{max}/M_{max}$ amplitudes ratio (mean ± SD) in course of the 5-weeks running training. * – differenses between the control values and data obtained during 5 weeks.




In our study effects of 5-weeks running training both the Sol H-reflex amplitude and the $H_{max}/M_{max}$ ratio in non-trained men was observed. It was registered that in the first 3 weeks training the amplitude of the H-reflex and the $H_{max}/M_{max}$ ratio increased significantly and next 2 weeks gradually decreased to initial values.

Earlier it was shown that modulation of the H-reflex is reflects adaptive changes induced by repetitive movement in healthy subjects (Hess, Hedel, & Dietz, 2003). This is consistent with the spinal reflex modulation is involved in learning and maintaining motor skills (Meyer-Lohmann, Christakos, & Wolf, 1986; Nielsen, Crone, & Hultborn, 1993). It was suggested that adaptive changes observed during the acquisition of a specific locomotor task might be due to changes on a spinal level (Anstis 1995; Prokop, Berger, Zijlstra, & Dietz, 1995). It is assumed that adaptation occurs in two phases: the first phase may last for several hours or days and the second phase may last for several weeks. During the first phase, an increase in the amplitude of the H-reflex occurs, which is probably due to the descending influence on the spinal reflex arc. During the second phase, there is a decrease in the amplitude of the H-reflex during training, which may reflect a descending influence during the course of motor learning (Wolpaw, & O'Keefe 1984; Hess, Hedel, & Dietz, 2003). Earlier it was demonstrated the effect of resistance training on the neural adaptation and shown increase in H-reflex amplitude during maximal voluntary muscle contraction in response to 38 training sessions of heavy-resistance strength training. Such increase in H-reflex amplitude might have been caused by an increase in descending motor drive from higher centers, although reduced presynaptic inhibition of Ia afferents cannot be excluded (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 1985). Holtermann, Roeleveld, Engstrøm, & Sand (2007) in their work have revealed not only significant strength gain, but also increase in H-reflex amplitude during 3 weeks resistance training.

These data in line with the values obtained in our study. Thus, it can be assumed that, depending on the task, the first phase can last much longer.

**Conclusion**

It is conclude, that neural adaptation occurs at both supraspinal and spinal levels, involving an enhanced drive in descending pathways from higher motor centers as well as increased motoneuron excitability and/or changes in presynaptic Ia afferent inhibition, respectively (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2002). Consequently, the H-reflex amplitudes increase during running training, reflecting a substantial rise in efferent motor output of spinal motoneurons, during the first adaptational phase. Decrease in the H-reflex amplitudes during second phase occurs presumably due to motor learning. It is possibly, that the repetitive task, which automatically performed and controlled on a spinal or brainstem level can be reflected in the normalization and stabilization of the H-reflexes registered after running training in later period.

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