

ANALYSIS OF WORK PATTERNS OF THE ACCESSORY RESPIRATORY MUSCLES

L. S. Romanova, L. E. Sapuntsov, and L. L. Shik

UDC 612.217

Cross-correlation analysis of interference electromyograms of the accessory respiratory muscles (the pectoralis major and rectus abdominis muscles) showed absence of correlation during their voluntary contraction and presence of correlation during forced breathing. A synchronized or random work pattern of the motor units of the accessory respiratory muscles depends on the character of the supraspinal effects.

As reported previously [2, 3], a definite synchronization of electrical activity of motor units of the intercostal muscles has been found. No such synchronization is observed during the work of other skeletal muscles [1, 3].

This paper describes the results of analysis of the work of the accessory respiratory muscles.

EXPERIMENTAL METHOD

Electrical activity of the accessory respiratory muscles – the pectoralis major and rectus abdominis muscles – was investigated by electromyography. Electromyograms (EMGs) were recorded by bipolar leads from the pectoralis major and rectus abdominis muscles on both sides of the trunk symmetrically. The distance between the electrodes of each pair was 2 cm and between each pair of electrodes 15 cm. Information obtained from the EMG was analyzed by the cross-correlation method, providing statistical frequency analysis of the processes examined. Besides the usual photographic recording of the EMG on an electromyograph (Disa), the EMG was also recorded on magnetic tape, later to be processed on the VNIIMP correlometer [1].

EMGs recorded from these muscles during voluntary contraction and during work as accessory respiratory muscles were investigated. The EMG of the pectoralis major muscle was recorded during voluntary forced respiration, during breathing against an increased resistance during inspiration, and during breathing a mixture of air with 7% CO₂; the EMG of the rectus abdominis muscles was recorded during inspiration and expiration of maximal depths and during breathing against a resistance to inspiration and expiration.

EXPERIMENTAL RESULTS

Electrical activity of the pectoralis major muscles during voluntary contraction is characterized by action potentials of high amplitude (about 200 μ V). The values of the cross-correlation coefficients (R) thus obtained lay outside the limits of instrumental error, i.e., they were close to zero ($R = 0.00-0.08$). The EMG and typical appearance of the cross-correlation function are shown in Fig. 1 (I and III). The mean values of R are given in Table 1.

If the subject was asked to breathe more deeply, to breathe against an increased resistance to inspiration, or if 7% CO₂ was added to the air, the EMGs of the pectoralis major muscles obtained during all these types of forced breathing gave high cross-correlation coefficients ($R = 0.19-0.74$). The mean values of R are given in Table 1. Electrical activity of the pectoralis major muscles in these cases was of the

Department of Experimental and Clinical Physiology, A. V. Vishnevskii Institute of Surgery, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR A. A. Vishnevskii.) Translated from *Byulleten' Éksperimental'noi Biologii i Meditsiny*, Vol. 73, No. 2, pp. 9-11, February, 1972. Original article submitted October 15, 1971.

© 1972 Consultants Bureau, a division of Plenum Publishing Corporation, 227 West 17th Street, New York, N. Y. 10011. All rights reserved. This article cannot be reproduced for any purpose whatsoever without permission of the publisher. A copy of this article is available from the publisher for \$15.00.

TABLE 1. Mean Values of Cross-Correlation Coefficients (R) during Investigation of EMG of Accessory Respiratory Muscles Working under Different Conditions

Muscles tested	Conditions of work			
	voluntary contraction		forced breathing	
	n	mean value of R	n	mean value of R
Pectoralis major	8	0,05	8	0,37
Rectus abdominis	5	0,05	35	0,30

Note: n denotes number of tests.

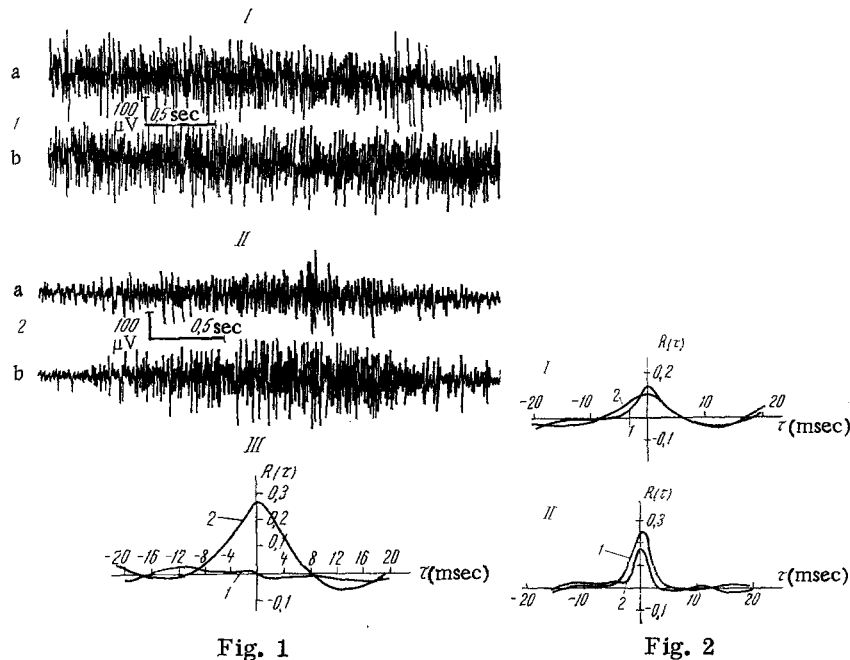


Fig. 1. Electromyograms (I and II) and cross-correlation functions (III) of EMGs recorded from both pectoralis major muscles (subject M-ya). 1) During constant contraction; 2) during forced breathing; a) EMG recorded from right pectoralis major muscle; b) the same from the left muscle.

Fig. 2. Cross-correlation functions of EMGs of left and right rectus abdominis muscles in different investigations: I) breathing against resistance to inspiration (1) and to expiration (2); II) deep inspirations (1) and deep expirations (2).

same order or lower (amplitude 200-150 μ V) than during their voluntary contraction (amplitude about 200 μ V). The EMG and the typical appearance of the cross-correlation function are shown in Fig. 1 (II and III). Hence, when the pectoralis major muscles work as accessory muscles of respiration, i.e., during deep breathing, considerable synchronization of electrical activity of their motor units arises, as the high values of R show. If, however, their activity is associated with voluntary movements of a nonrespiratory character, no synchronization is observed.

Similar results were obtained by the investigation of EMGs of the rectus abdominis muscles. During the deepest inspirations and expirations, or during breathing against resistance to inspiration or expiration,

considerable electrical activity was observed in these muscles (amplitude about $100\text{ }\mu\text{V}$). Correlation analysis of the EMGs revealed high coefficients of cross-correlation, i.e., synchronization of the electrical activities of the motor units of these muscles was observed (Table 1).

The typical appearance of the cross-correlation function is shown in Fig. 2.

The presence or absence of synchronization of electrical activity of the motor units of the accessory respiratory muscles naturally depends on the conditions of function of the motoneurons supplying it. The phenomena discovered thus show that these groups of motoneurons discharge either synchronously or independently of each other in time, depending on the controlling signals which activate these neurons. If the signals are sent from the respiratory center, synchronization develops, but this is not observed during voluntary contraction of these muscles unconnected with respiration. The presence of synchronization in discharges of the motoneurons innervating the respiratory muscles is attributable not to the permanent features of the corresponding groups of motoneurons, but to the character of the supraspinal influences evoking their activity.

LITERATURE CITED

1. R. S. Person and L. N. Mishin, *Fiziol. Zh. SSSR*, No. 9, 1050 (1963).
2. L. E. Sapuntsov, *Byull. Éksperim. Biol. i Med.*, No. 6, 9 (1971).
3. L. L. Shik, V. P. Gundarov, and L. S. Romanova, *Novosti Med. Priborostroeniya*, No. 1, 11 (1967).