CHANGES IN THE FUNCTIONAL STATE OF THE HUMAN BICEPS MUSCLE PRODUCED BY TIRING PHYSICAL WORK

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Changes in muscle tone, in intramuscular pressure, and in the electromyogram found in clinically healthy young persons during tiring physical work are described. Exertion leads to an increase in skeletal muscle tone, an increase in intramuscular pressure, and increased spontaneous electrical activity of the motor units. These changes follow a different course in individuals at different levels of training. More marked changes in the functional state of the skeletal muscles are found in untrained individuals.

Despite several investigations [1-3, 5, 6, 8] the mechanisms of disturbances of muscle tone arising as a result of tiring physical work have not been adequately studied.

The object of this investigation was to study changes in muscle tone, in electrical activity of the motor units, and in the intramuscular pressure of clinically healthy young persons under the influence of tiring physical work.

EXPERIMENTAL METHOD

Functional changes taking place in the right biceps muscle through tiring work, the amount of which was determined by means of a dynamograph designed by the authors [7], were investigated in 30 clinically healthy men aged 19-23 years. The work consisted of flexing the forearm at the elbow (with the arm fixed) with an original force of 11 kg at the rate of 50 times per minute in time with a metronome. Before physical exertion and immediately and 14-16 h thereafter (next morning, immediately after sleep), the state of the upper limb was investigated by palpation, the muscle tone was determined by means of Sirmai's myotonometer, the electromyogram (EMG) was recorded in the muscle showing maximal relaxation (in the recumbent subject), and the intramuscular pressure was measured by Henderson's method [11] in Panfilov's modification [4]. The EMG was recorded by means of a 3-channel electromyograph (Disa) using concentric needle electrodes (diameter 0.65 mm). The electrodes were removed during physical exertion. On repeated testing they were inserted into the same area of muscle to the previous depth. In some subjects, the EMG was also recorded on the day after physical exertion from those areas of the muscles in which the greatest tenderness was found on palpation.

EXPERIMENTAL RESULTS AND DISCUSSION

Depending on the degree of physical training of the subjects they were divided into two groups with 15 persons in each group: untrained and trained (mainly first-grade athletes and "masters of sport").

Before physical exertion in most of the untrained subjects (55%) irregular potentials, not exceeding 10-15 μV, were recorded during electromyographic investigation of the biceps brachii muscle against a

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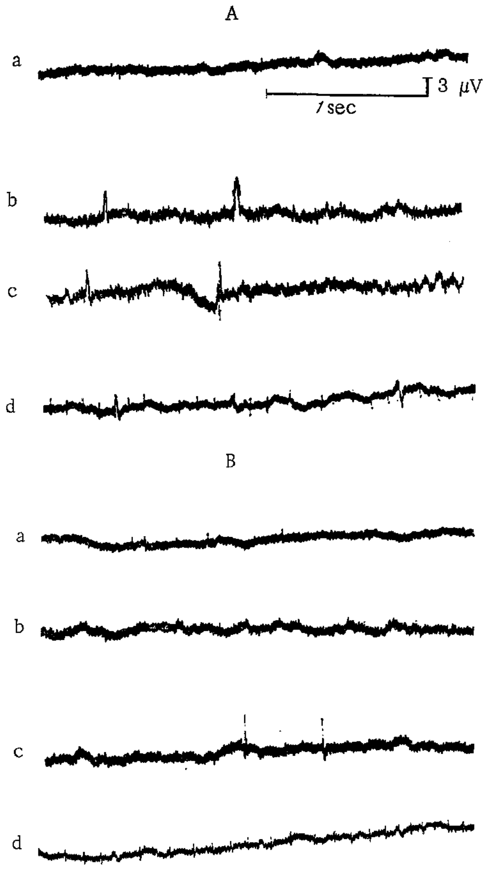

Fig. 1

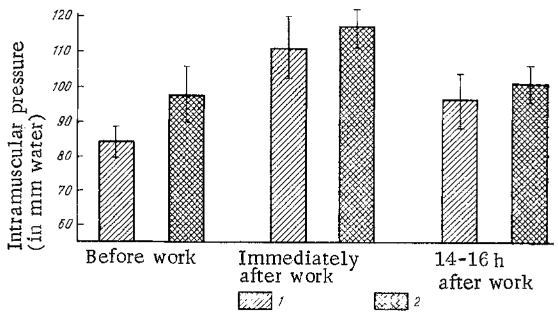

Fig. 2

Fig. 1. Electromyograms of untrained (A) and trained (B) men recorded by concentric needle electrodes from relaxed biceps muscle of right arm: a) before physical work; b) immediately after tiring work; c) 14 h after work; d) EMG recorded from tenderest area of the same muscle during movement and palpation (14 h after work).

Fig. 2. Changes in intramuscular pressure in untrained (1) and trained (2) persons after performing tiring physical work.

background of an ill-defined wave pattern of the EMG. The frequency of these oscillations varied from 1 to 4 per second. Similar results were obtained also with the trained subjects (Fig. 1).

In the tests carried out immediately after tiring work, irregular potentials of low amplitude also were found on the EMGs recorded from the relaxed muscles of most of the subjects. However, by contrast with the initial state, in 35% of untrained subjects the EMG oscillations reached an amplitude of 30-50 μV. In the remaining subjects the oscillations on the "resting" EMG remained close to those obtained before physical exertion. In both groups the muscle tone was increased after physical work.

In both groups of subjects 14-16 h after physical work palpation and myotonometry of the muscles fatigued by work the day before revealed a higher-than-initial level of muscle tone. The increase in muscle tone, as well as tenderness of the muscles on movement and palpation, was more marked in the untrained subjects. In 5 untrained subjects areas of the muscles which were highly tender on palpation and painful during voluntary movements were discovered. The EMG recorded from these areas of the muscle showed spontaneous electrical activity of higher intensity than that obtained before and immediately after physical work (Figs. 1 and 2). This activity was manifested as single, irregular waves up to 30-50 μV in amplitude.

In isolated cases, mainly in untrained subjects, regular waves of fasciculation type, up to 20 μV in amplitude and resembling the discharges of a single motor unit, were recorded.

The intramuscular pressure in the right biceps muscle before work averaged 84.20 ± 1.26 mm water in the untrained and 96.80 ± 2.31 mm water in the trained subjects. After physical work in both groups of subjects a statistically significant increase in intramuscular pressure occurred (Fig. 2), and it was more marked in the trained subjects (the difference between the two groups was not statistically significant). The intramuscular pressure in the trained subjects 14-16 h after work was approximately the same as initially, while in the untrained subjects it still remained high, although it was lower at this time than in the trained subjects before physical work.

These investigations showed that in clinically healthy young trained and untrained men, certain changes in the functional state of the exercised muscle, accompanied by a sensation of fatigue and pain, take place during tiring physical work. Objective investigation reveals an increase in muscle tone and tenderness of the muscles during palpation and pain on movement. Instrumental tests (electromyography and measurement of intramuscular pressure) revealed changes in the functional state of the working muscles not only immediately after physical work, but as long as 14-16 h after it had ended. Characteristically in the untrained subjects there was a more marked spontaneous electrical activity of the muscles which did not disappear even after a night's rest. These phenomena were less marked in the trained subjects and the indices of the state of the muscles returned more quickly to their initial level.

The intramuscular pressure in the initial state was higher in trained subjects and it rose significantly after tiring physical work, but by 14-16 h it had almost returned to its initial value. The intramuscular pressure of the untrained subjects increased by a lesser amount after work, but 14-16 h later it still remained high, even though its mean value at this time had fallen below the level observed in the trained subjects before physical work.

The results show that tiring physical work, besides causing well-known biochemical changes in the skeletal muscles [9, 10], also causes pain and an increase in muscle tone, accompanied by increased electrical activity of the relaxed muscles and a rise of intramuscular pressure. The degree of these changes varied depending on the standard of training of the individual.

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