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Endurance and Fatigue Caused by Local Muscular Performance in Skilled Athletes[1]

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Abstract—We have done EEG tests on athletes and in unfit subjects aged between 18 and 23 in order to study endurance and changes in bioelectrical activity of the brain caused by local forearm muscular performance by means of an ergograph until fatigue set in. We have found that all the endurance parameters in both dynamical performance and static tensions were higher in the athletes than in the unfit subjects. As fatigue set in, an elevated spectral power of slow α- and θ-waves was detected in all of the subjects, but the changes in question set in later in the group of athletes and were less pronounced than in the group of unfit subjects and yielded synchronized α-waves and reduced low-frequency and high-frequency β-waves on the EEGs. We have concluded that the athletes, in contrast to the unfit subjects, have higher endurance and lower fatigability throughout local muscular performance, which is in accord with bioelectrical changes recorded in the EEG tests.

Keywords: local muscular performance, fatigue, athletes, endurance, electroencephalography

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It is common knowledge that fitness exercise enhances functional properties of muscles by increasing the strength of slow muscle fibers and aerobic capacity (mitochondrial mass) of muscle fibers upon muscle capillarization and building up muscle mass [1, 2]. Finding solutions to the problem of mechanisms underlying onset of fatigue in individual muscle groups is a topical issue in sport physiology.

For major muscle groups, most researchers support the theory that changes in blood chemistry, e.g., lactic acid accumulation in the bloodstream, and other humoral changes can be the cause [3], while other researchers place emphasis on central nervous mechanisms [4–6], attaching great importance to inhibitory processes in the central nervous system.

Numerous research data suggest that the lower the initial contracting muscular mass, the more important central mechanisms to the organization of performance and onset of fatigue [7, 8], which is in accord with bioelectrical changes recorded in the EEG tests as the subjects experienced an onset of fatigue during local muscular performance [9].

It was the objective of our research to study parameters of physical endurance and bioelectrical activity of the brain in skilled athletes and in unfit subjects aged between 18 and 23 during local performance of forearm muscles.

[1] The article was translated by the authors.

METHOD

We have examined two groups of subjects, namely, (I) an experimental group that consisted of skilled kick boxers (Candidates for Master of Sport and Masters of Sport) aged between 18 and 23, and (II) a control group that consisted of unfit university students of the same ages. The subjects were instructed to perform, by means by a Mosso ergograph, work until fatigue set in (that is, until the subjects felt they were unable to do the work any longer). In doing dynamical exercise, the subjects lifted, by means of a Mosso ergograph, a load of 1/3 of the "average" (according to Weber, [10]) at a rate of 60 lifts per minute; in static exercise, they had to hold a load of 1/3 of the maximal load. The subjects demonstrated duration of performance (which was a sign of endurance) of 1.5 to 3.0 min; that is, the performance was of medium intensity, which was sufficient to detect incipient fatigue.

EEGs were recorded over three-minute-long restorative periods in monopolar configuration for eight standard deflections located in accordance with the 10–20 system. The following functional tests were done: background recording, eye closing, eye opening, and local performance until fatigue set in by an ergograph.

Our findings indicate that all the endurance parameters, both in dynamical and in static performance, were higher in the athletes than in the unfit subjects. The presence of α-waves was characteristic of the bioelectric activity of the brain of the athletes; in contrast, EEGs detected α-waves in only 1/3 of the

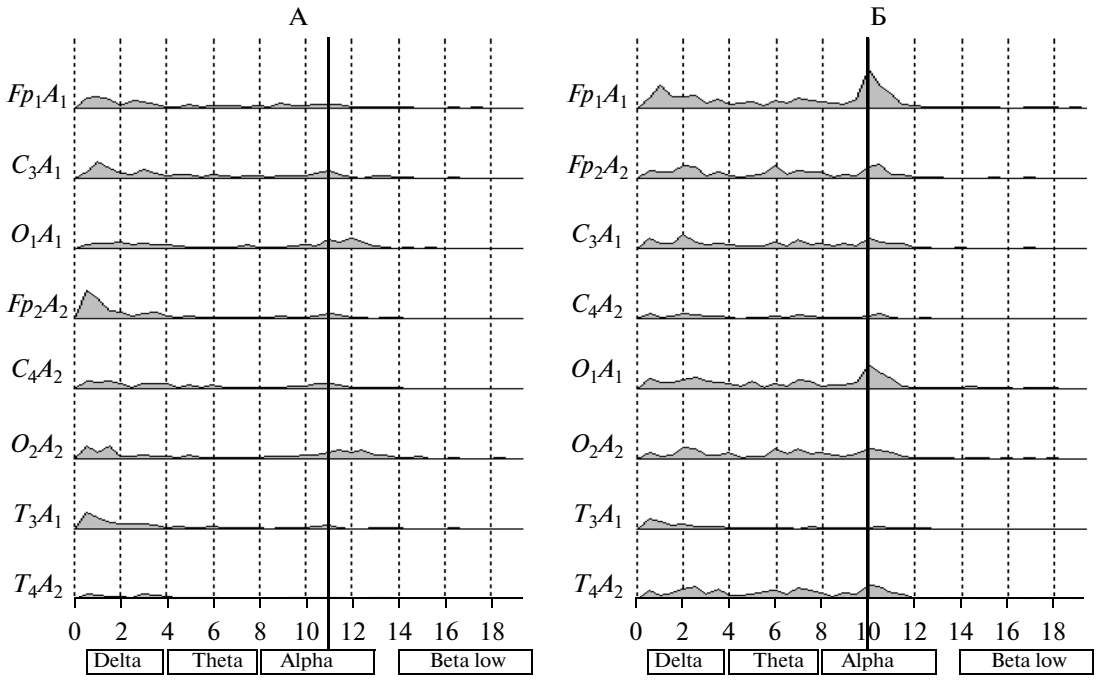

Fig. 1. Parameters of bioelectric activity in the subjects. The vertical line denotes α-wave. (À) Unfit subjects, (Â) athletes. Notation: Fp1, Fp2—frontal; C3, C4—central; T3, T4—temporal; O1, O2—occipital deflections. EEG wave ranges are plotted along the *x* axis.

unfit subjects. The unfit subjects had α-wave amplitudes ranging between 15 to 20 μV and α-wave indices ranging between 5% and 20%, while the athletes had α-wave amplitudes and α-wave indices higher by 25% to 30%.

α-wave spectral analysis in the athletes suggested that α-waves predominated in both their occipital and fronto-central areas, with α-wave powers being higher in the frontal deflections than in the central ones (see figure). Weak α-waves were detected in occipital areas of the unfit subjects and in the left hemispheric deflections in most of them as well.

For θ-waves, transitions of the dominant frequency from α-waves to θ-waves and back again were detected, followed by increased power of θ-waves, during muscular performance. The transitions in question coincided with incipient fatigue and were 50% of the total performance time for the unfit subjects and 70% for the athletes. Therefore, an increase in the spectral powers of slow α-waves and θ-waves was detected in all the subjects as fatigue set in, but the changes set in later in the group of athletes and were less pronounced than those in the group of unfit subjects; fatigue set in later in the athletes as well.

As fatigue set in during local performance, a short increase in the bioelectric activity was detected in the frontal cortex in 5 out of the 16 unfit subjects and 8 out of the 12 athletes, followed by a depression in θ-waves and α-waves. The θ-wave index increased up to 20% of the initial value in one-half of the athletes and up to 40% in all of the unfit subjects. No pronounced changes in α-waves and in θ-waves or any decreases in the low-frequency and high-frequency β-waves were detected in the athletes that demonstrated high endurance (exceeding 100 s).

Therefore, the athletes, in contrast to the unfit subjects, experienced less fatigue during local muscular performance, with their bioelectric parameters being characterized by minimal changes in the slow-wave activity and a decreased low-frequency and high-frequency β-wave index as recorded in EEG tests.

Some researchers attribute morphofunctional changes that occur in a locomotive apparatus during physical performance mainly to local structural and biochemical changes in muscles [11, 12]. However, publications by researchers [2, 7] suggest that central mechanisms play a dominant role in the development of the exercise effect in extensive skeletal muscle groups during various loads. The data of our present work also confirm the dominant role of central mechanisms in enhancement of functional levels of individual muscles in perfectly fit individuals.

CONCLUSIONS

Our present findings suggest that athletes have an elevated mobilization of resources, reflected by synchronized performance of nervous centers, which enhances the performance of local muscle groups (forearm muscles).

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SPELL: 1. ergograph, 2. dynamical