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EFFECT OF MUSCULAR EXHAUSTION ON MYO-ELECTRIC FUNCTIONS IN ADOLESCENTS WITH ATHETOSIS AND OR DYSTONIA

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ABSTRACT. EMG studies of ten dystonic and, or, athetoid subjects before and after severe physical exercise revealed their EMG response to be unaffected by fatigue. Their EMG spectrum during isometric contraction was similar to that in normal subjects. Fatigue, however, significantly increased their voluntary muscular control as studied in a man/machine system.

It is a well-known observation among physiotherapists working with Cerebral Palsied patients that physical exhaustion lessens tension and increases voluntary controllability temporarily. This observation has been the basis for a method of treatment introduced by Beeman in England in which patients are tired out by vigorous shaking and then are given physiotherapy.

Such relaxation and improved voluntary control has been found to be clinically evident in a group of adolescents who participated in a physical training program aiming at an increase of the physical working capacity (1). After each training session was noted less distortion of walking patterns, better ability of severely dystonic patients to stand with minimal support, faster typewriting, more legible hand-writing (Fig. 1) and more fluent and intelligble speech. Thus the effects were widespread and not only noted in muscles directly concerned with the training program. These more obvious effects seemed to decline in a few hours, but several subjects reported pleasant relaxation and better motor performance for the rest of the day. In a few cases, the relaxation period was used for physiotherapy and skills exercised seemed to be well retained after relaxation ceased.

The modifications occurring in the frequency spectrum of the voluntary EMG under influence of a strong isometric contraction have been studied previously in normals (5) showing that under these conditions the needle electrode EMG from muscles in the face and in the limbs modifies as follows:

(*a*) the low-frequency part of the spectrum increases in amplitude, and
(*b*) the high-frequency part decreases, both with respect to the medium-frequency level.

The total signal level was found to be essentially unchanged in cases of maximal voluntary contraction. In a preliminary study by Kadefors, Kaiser & Petersén (6) it was shown that the high frequency decay was less pronounced in cases with peripheral nerve lesions, myopathy and amyotrophic lateral sclerosis than in normal cases. It was concluded that this method may serve as a test on the ability of performing a high level muscle contraction.

This report will be concerned with the relaxation effects in cerebral palsied subjects as revealed by EMG techniques and a myoelectrically controlled man/machine test system, after general exercise and after local voluntary isometric contraction. The result will be compared to effects in normals.

MATERIAL

All subjects were patients at the Bräcke Östergård Pediatric Habilitation Centre of Western Sweden. The participants, aged 16 to 28 years, had cerebral palsy from birth of dystonic or athetoid type. Intellectually, they were in the IQ range of 90–120 on the Terman Merril scale, though some of them had very uneven profiles. Associated handicaps were common in the material.

Selection for this study was primarily done on the

Fig. 1. Handwriting before (above) and after (below) severe physical exercise.

basis of whether the subject was able to participate efficiently in a physical training program and whether he showed clinical signs of improvement in voluntary control and relaxation ability after physical exercise. However, some students were chosen without signs of objective clinical improvement if improvement subjectively was reported by the subjects (case numbers 2, 4 and 7 of Table I). Case number 1 did not personally experience any benefit, but was noted to talk much more fluently afterwards.

Table I contains detailed information on the ten subjects involved in the course of the present investigation.

METHODS

Electromyographic activity was recorded, employing a Disa Electromyograph 13A69 as an amplifier and an Elema Schönander Mingograph 42 as a recorder. Skin electrodes were used for recordings during rest, one placed on M biceps brachii, the other on the bulk of the forearm extensor muscles. In the case of maximal voluntary contactions two needle electrodes were inserted into the biceps muscle. All recordings were performed on the right arm.

The principle of the apparatus used for recording of myoelectric control ability has been reported previously (2, 3). In short, it consists of a flywheel with an indicator connected through a friction system to a motor. The number of impulses per unit time regulating the motor is proportional to the rectified average of the myoelectric activity in the muscle to the tested. This myoelectric control signal is subtracted from a tape-recorded signal of variable magnitude, constituting a test program. The subject is told to keep the flywheel indicator in a central position, where it stays if the myoelectric activity of the tested muscle compensates for the recorded signal. If there is too much muscle activity, the flywheel will move out of position in one direction; with too little muscle activity, the flywheel will move in the other direction, Recordings were done from M. biceps brachii and the knee extensors. The time during which the subject is able to keep the flywheel in the central position can be calculated from a graph and is used as an indication of his motor control ability.

Different methods for displaying the dynamic spectrum changes have been described in detail elsewhere (5). In the course of the present investigation, the EMG was amplified and recorded on tape. The analysis was performed on an octave-band spectrum analyser (Brüel and Kjaer 2112) employing two filters with center frequencies of 63 Hz and 1000 Hz respectively. The output signals were rectified and smoothed and DC levels, proportional to the r.m.s. value of the portion of the signal concerned, were recorded graphically on a logarithmic potentiometer recorder (Brüel and Kjaer 2305). The difference in dB between the two curves (63 Hz and 1000 Hz octave bands) was studied as a function of time.

The experiments were performed as follows: The subject was seated in a relaxed position in an easy chair adjusted for best individual comfort.Care was taken to have the apparatus, the chair, and the head of the subject in the same position in the room so that various tonic reflexes from the neck and elsewhere would not interfere.

Then the following set of experiments was performed.

A. Recording of spontaneous activity in biceps and extensors (60 sec).

B. Fatigue test of the biceps: 2 brisk contractions followed by a contraction lasting 30 sec; then another 2 brisk contractions followed by 30 sec relaxtion; another pair of brisk contractions, etc. All contractions were isometric and performed with maximal voluntary strength.

C. Motor control test of the biceps employing the electromechanical system described above; two sequences of 3 min each, of which the first one was given as a learing period only. Detailed instructions were given and practice time was allowed before the first test.

D. Physical training during 20 min under the supervision of the physiotherapist of the patient in accordance with his physical capacity.

E–G. As in A–C, immediately following the exercise.

Table I. *Material*

Case no.	Age in years	Sex	CP type	Method of ambulation
1	16	F	Severe dystonia and athetoid movements	Wheelchair
2	18	F	Athetosis and dystonia	Self ambulant
3	16½	M	Athetosis	Self ambulant
4	17	M	Dystonia and athetoid movements	Self ambulant
5	17½	M	Severe dystonia	Wheelchair
6	18	M	Severe dystonia and athetosis	Electrical wheelchair
7	19	M	Athetosis	Self ambulant
8	19½	M	Dystonia and athetosis	Wheelchair
9	24	M	Dystonia and athetosis	Self ambulant
10	28	M	Athetosis	Self ambulant

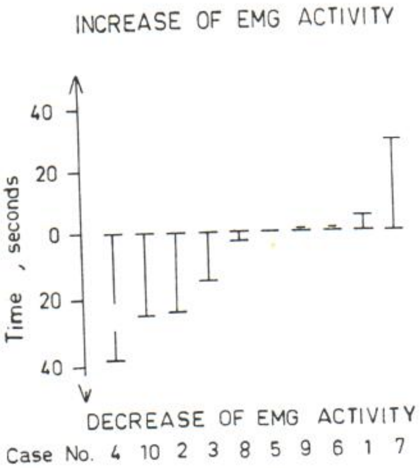

Fig. 2. Level of increase or decrease of spontaneous EMG activity in the biceps brachii muscle as revealed by comparison of 60 sec, before and immediately after physical exercise.

Table II. *Improvement in seconds after exercise*

The figures show the decrease in seconds when the flywheel indicator was out of position after exercise as compared to the original performance. The registration time period was 180 sec.

	After general exercise			After local contraction	
Case no.	Arm	Leg	Sign test	Arm	Sign test
1	−33	−12	−	0	−
2	27	2	+	—	—
3	5	58	+	0	−
4	96	34	+	—	—
5	6	37	+	2	+
6	8	1	+	16	+
7	42	91	+	—	—
8	15	2	+	−10	−
9	15	9	+	27	+
10	55	50	+	−	—

A second set of experiments was performed on six of the subjects on a later occasion with the myoelectric man/machine system only. Then two initial recordings of three minutes each were followed by local muscular exhaustion. The subject performed a maximal voluntary contraction until exhaustion occurred. Immediately afterwards, another three minute test was undertaken.

RESULTS

The EMG recordings during relaxation demonstrate activity in several cases, constant or intermittent, as reported earlier (e.g. 4). Some cases reveal a marked decrease of spontaneous activity after the physical exercise, but others do not (Fig. 2). The mean decrease of spontaneous activity was 7.1 sec over a total of 120 sec recorded, which is not a significant difference.

The dynamic spectrum analysis reveals considerable modifications in spectrum of EMG from the muscles concerned as a result of a fatiguing contraction. The tendency is much the same as what has previously been found for muscles of normal subjects. Fig. 3 shows the relative decay of the 1000 Hz component occurring during a maximal voluntary contraction. The result of the experiments on the dystonic subjects are compared to a material of normal subjects (5). No tendency has been found in the present investigation towards any difference in character between the fatigue EMG from the two heads of the biceps (in accordance with the findings in the normal cases). Nor has any difference between the analyses of fatigue EMG before and after general physical exercise been found. Consequently, these experiments have all been considered members of the same statistical population.

In some cases, the variability in the activity and in the analyses has made quantitative interpretation of the curves impossible. This tendency is very much pronounced in many cases during the rest after the voluntary effort; partly, this can be attributed to needle displacements occurring at the spontaneous movements of the patients. It was not possible to study the recovery of the muscles for this reason.

It is seen from the figure that in a few cases (group 1) the EMG is virtually unaffected by the voluntary effort. In most cases, however, the results are in complete accordance with previous findings regarding the normal muscle (group 2). The group 1 and group 2 characteristics are quite

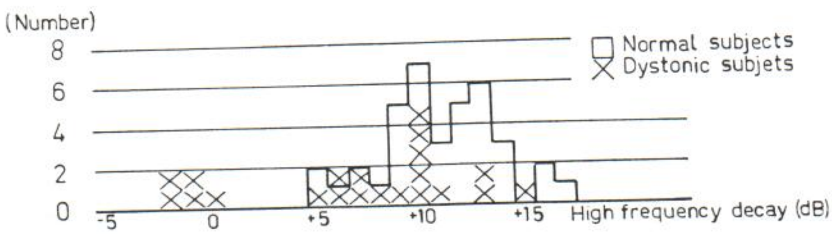

Fig. 3. The relative decay of the 1000 Hz EMG spectrum component during a 30 sec maximal of the biceps brachii muscle in cases of dystonia and in normal cases.

different, which may be caused by either one of two possibilities: variation in the experimental conditions or variation in the physiological mechanisms of the patients. We shall return to this below for a brief discussion.

The test employing the myo-electric man/machine system verifies the clinical impression of a better voluntary control after general physical exercise (see Table II). The mean improvement was 24 sec in the arm and 27 sec in the leg during 180 sec of registration. The sign test is significant on the 5% level. Local contraction till exhaustion was achieved after 1–2 min and was performed only on six of the original ten cases. However, of the six subjects, three demonstrated no improvement at all in the voluntary control after the contraction which means that there was not a significant increase of control in that material, and would not have been in the total material either, even if the missing four subjects had all shown improvement.

DISCUSSION

The results of the EMG recordings agree with the expectations. Since there is no primary disease of muscles in cerebral palsy, the muscle activity can be expected to be normal, as long as it is not modified by nervous impulses. The spontaneous activity during rest is caused by abnormal nervous stimuli to the muscles, and it probably cannot be expected that the muscles stop reacting to such nervous stimuli after they have been subject to relatively short physical exercise, unless there are extreme conditions, such as disease, starvation, or similar things, complicating their activity.

Also in the interpretation of the findings of the dynamic spectrum analysis, we find it most likely that the muscles under test are capable of achieving almost the same maximal contraction levels as is the case in normal muscles. The group 1 exceptions may be caused by a submaximal effort, resulting in significantly smaller spectral changes (5, 7).

The ability to voluntarily control the muscles was found to be significantly greater after general exercise, but not after local contraction of short duration. Also, the general exercise was, in all cases, bicycling, which can be expected to stress legs more than arms. Nevertheless, the improvement was very similar in both arms and legs. This points to a general effect of fatigue not limited to the muscles exercised and most probably located within the nervous system.

SUMMARY

Ten young adults with dystonia and, or, athetosis were subjected to severe physical exercise on bicycle ergometer. Before and after the exercise, they were studied with EMG during rest and during maximal isometric contraction. Their voluntary control was also tested in a man/machine system. There was no significant decrease of spontaneous EMG activity during rest after the training. The modifications of the EMG spectrum during maximal contraction were essentially the same as reported as normal, and the response was not modified by the exercise. The clinical impression of better voluntary control after general physical exhaustion was verified ($p < 0.05$) also in muscles not directly concerned with the physical work.

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