Electromyographic Rationale for Manual Muscle Testing

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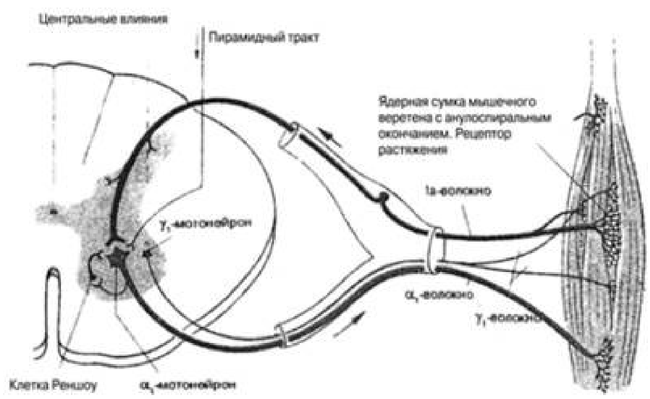
SUMMARY

The manual muscle test is widely used in clinical practice to diagnose various somatic dysfunctions. At the same time, studies confirming the objective existence of the phenomenon of functional muscle hypotonia do not fully describe its features. In particular, this concerns the electromyographic characteristics of muscle contraction in a state of normotonia and hypotension. The article is devoted to the study of interference curves taken during the manual muscle test.

Key words: manual muscle test, EMG, interference curve, musclehypotension, somatic dysfunction.

INTRODUCTION

A manual muscle test is one of the most informative methods for the clinical diagnosis of muscle contraction dysfunctions [1]. The neurophysiological basis of the manual muscle test (MMT) is the myotatic reflex or the muscle stretch reflex. The arc of the monosynaptic reflex includes receptors for intrafusal muscle fibers, type Ia afferent fiber, alpha1-motor neurons and an effector link - extrafusal muscle fibers (Fig. 1).



Rice. 1. The arc of the muscle tensile reflex (according to Peter Duus,1996).

External short-term muscle stretching causes activation of the reflex and short-term muscle contraction [2, 4]. This phenomenon can be visually expressed in the form of limb movement in the study of tendon reflexes and kinesthetic expression in the form of an increase in muscle tone in MMT. A positive MMT indicates muscle normotonia. The absence of an increase in muscle tone during MMT indicates muscle hypotension, i.e. lack of muscle stretching reflex.

The phenomenon of muscle hypotension is observed in the presence of various somatic dysfunctions and is caused by a change in the nature of extrapyramidal influences on alpha and gamma motor neurons. The phenomenon of muscle hypotension is reproduced by external influences using the north pole of a magnet and pinched inhibition of the receptors of the neuromuscular spindle of intrafusal muscle fibers.

The manual muscle test has good clinical reproducibility and sensitivity to somatic dysfunctions. However, there are still doubts about the possibility of kinesthetic diagnosis of the muscle stretching reflex and its clinical significance. In order to objectify the results of MMT, an electromyographic study of the electrical activity of muscles during MMT was performed.

MATERIALS AND METHODS

The study was conducted in 10 apparently healthy people aged 14 to 65 years. The voluntary muscle contraction and the manual muscle test were accompanied by the registration of an electromigraphic curve. Currently, surface EMG is used in various systems for analyzing movement and in the dynamics of rehabilitation treatment in cases where it is necessary to assess the general contractile function of the muscle under study [3, 5]. The study was carried out on the device "Neuro-MPV" manufactured by "Neurosoft" by the method of surface EMG [5]. The active skin electrode was located in the projection of the motor zone of the muscle, the reference electrode - distal over the tendon of the muscle. The study was conducted using the deltoid and rectus femoris muscles. The interference curve was obtained in the initially normotonic muscle and again in the hypotonic muscle. Temporary muscle hypotension was caused by pinched inhibition of the neuromuscular spindle receptors of intrafusal muscle fibers. Or, the data were recorded in the initially hypotonic muscle, as well as after treatment and restoration of muscle tone.

The resulting curves were subjected to visual and turn-amplitude analysis.

RESULTS OF THE STUDY

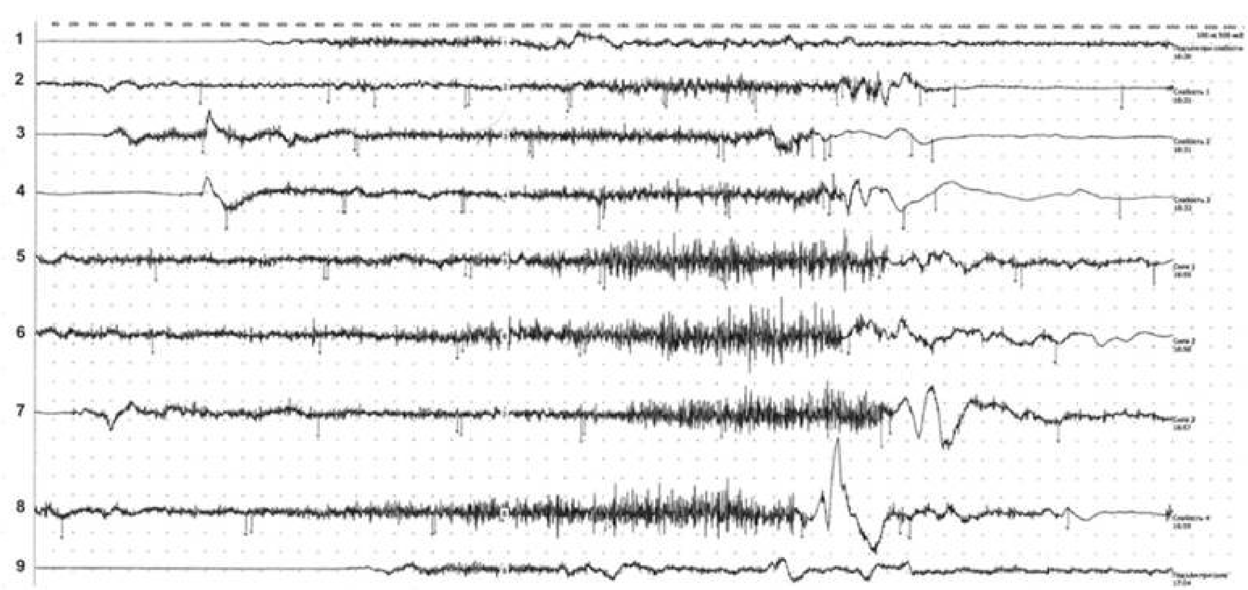
The analysis of the obtained curves revealed the presence of type I EMG in all analyzed cases.

At the first stage, we studied the reactivity of the normotonic rectus femoris muscle under conditions of arbitrary isotonic contraction (Fig. 2).

Rice. 2. The interference curve of the normotonic rectus femoris muscle at arbitrary isotonic contraction.

The turn-amplitude analysis revealed the following data: the average vibration amplitude was 143 μV, the average vibration frequency was 50.8 per second, the ratio of the amplitude to the vibration frequency was 2.82 μV / s.

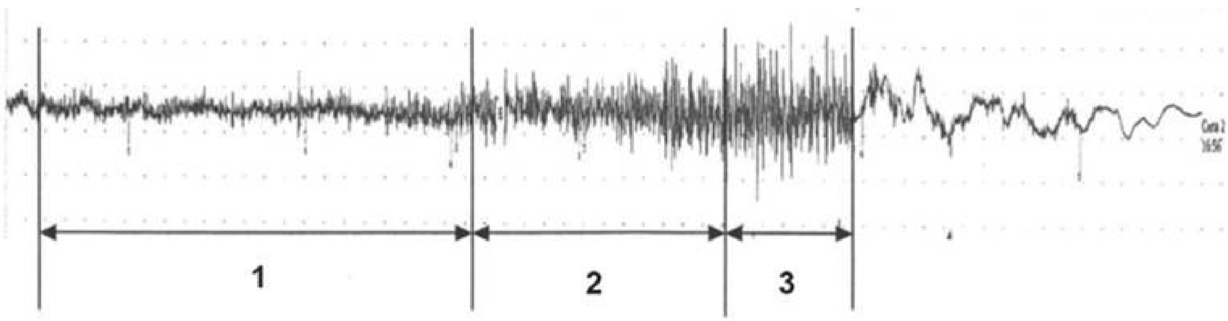
At the next stage, we compared the reactivity of normal and hypotonic muscles. As an example, we present the interference curve of the initially hypotonic rectus femoris muscle and the curves of the same muscle after the restoration of tone (Fig. 3). Curve 1 - voluntary isotonic contraction of the hypotonic muscle, curves 2, 3, 4 - MMT of the hypotonic muscle before treatment, 5, 6, 7, 8 - MMT of the normotonic muscle after treatment, curve 8 - voluntary isotonic contraction of the normotonic muscle.



Rice. 3. Interference curves of the rectus femoris muscle.

Visual and turn-amplitude analysis does not reveal the differences between curves 1 and 8, which indicates the impossibility of assessing muscle tone with arbitrary isotonic contraction.

Curve 6 was used to analyze the normotonic muscle. This is a typical interference curve recorded during MMT of the normotonic muscle, containing three main segments corresponding to the MMT phases. The first segment of the curve corresponds to the first phase of the muscle test - the initial isometric contraction of the muscle and has an arbitrary duration on average of 2 s. The second segment of the curve corresponds to the second phase of the muscle test - an arbitrary enhanced isometric contraction of the muscle and has an average duration of 1–1.5 s. The third segment of the curve corresponds to the third phase of the muscle test - an involuntary increase in muscle tone and has an average duration of 0.5–0.8 s (Fig. 4). Visual analysis of the curve shows an increase in the amplitude of the curve in the second phase of the test and a significant increase in the third phase of MMT.



Rice. 4. Interference curve of the normotonic rectus femoris during MMT.

The turn-amplitude analysis of this curve revealed that under conditions of increased muscle contraction in the isotonic mode, the normotonic muscle gradually increases the amplitude and frequency of oscillations. The dynamics of indicators is reflected in table. 1, where 5 and 4 fragments correspond to 1 curve segment, 3 and 2 fragments correspond to 2 curve segments and 1 fragment corresponds to 3 curve segments. In general, along the curve, the average amplitude increased from 167 to 436 μV with a relative increase of 2.61. The average amplitude in the second phase of MMT increased 1.6 times, in the third phase relative to the second it increased 1.54 times. The average oscillation frequency increased from 124 to 316 per second with a relative increase 2.54. In the first and second phases of MMT, the amplitude-to-frequency ratio drops from 1.35 to 1.02 with a relative increase of 0.76, but in the third phase of MMT, during muscle stretching, the ratio sharply increases from 1.02 to 1.38 μV / s with a relative gain of 1.35.

Table 1

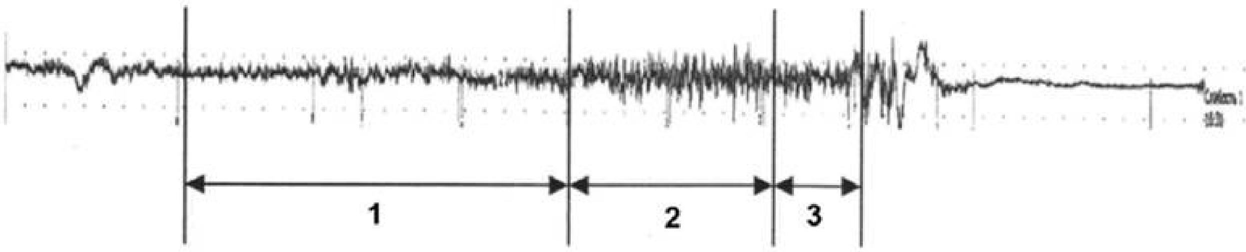
Turn-amplitude analysis of the normotonic rectus femoris during MMT

Кривая	Фрагмент	Макс. ампл. мкВ	Средн. ампл. мкВ	Сумм. ампл. мВ/с	Средн. част. 1/с	Ампл./част. мкВ*с
6	1	1996	436	138	316	1,38
	2	1287	319	91,1	286	1,11
	3	891	247	59,8	242	1,02
	4	560	185	32,7	177	1,04
	5	694	167	20,8	124	1,35

For the analysis of the hypotonic muscle, curve 2 is presented, where 6, 5 and 4 fragments correspond to 1 segment of the curve, 3 and 2 fragments - 2 segment of the curve and 1 fragment corresponds to 3 segment of the curve. Visual assessment of curve 2 shows a decrease in the amplitude of oscillations in all three segments relative to the curve of the normotonic muscle, no gain, even a slight decrease in amplitude in the third segment during stretching of the muscle abdomen (Fig. 5).

Turn-amplitude analysis of curve 2, recorded from the hypotonic muscle, revealed the following dynamics of indicators (Table 2). The average amplitude increased from 124 to 214 μV, with a relative increase of 1.72. In the second phase of the test, an increase in the average amplitude with a relative increase of 1.52 is observed. In the third phase of MMT, a decrease in the average amplitude from 214 to

177 μV (relative gain - 0.83), and an average frequency from 232 to 199 oscillations per second (relative gain - 0.86), which indicates functional muscle hypotonia. The average oscillation frequency increased from 26.5 to 232 per second with a relative increase of 3.31. The dynamics of the amplitude-to-frequency ratio underwent changes again: the ratio falls in the second and third phases of MMT from 4.7 to 0.97 (relative increase - 0.21) and then to 0.89 with a relative increase of 0.92.



Rice. 5. Interference curve of the hypotonic rectus femoris during MMT.

table 2

Turn-amplitude analysis of the hypotonic rectus femoris during MMT

Кривая	Фрагмент	Макс. ампл. мкВ	Средн. ампл. мкВ	Сумм. ампл. мВ/с	Средн. част. 1/с	Ампл./част. мкВ*с
2	1	472	177	35,2	199	0,89
	2	774	214	49,8	232	0,92
	3	527	179	32,8	184	0,97
	4	333	140	13,7	97,4	1,44
	5	327	140	7,94	56,6	2,47
	6	221	124	3,29	26,5	4,7

At the third stage of the study, we compared the turn-amplitude analyzes of the normo- and hypotonic rectus femoris during the MMT performed on one muscle, before and after treatment (Table 3).

Table 3

Comparative characteristics of normo- and hypotonic muscle

Показатель	Нормотоничная мышца	Гипотоничная мышца	Нормотоничная / Гипотоничная
Средняя амплитуда в 1 фазе теста	167–185 мкВ	124–140 мкВ	1,33
Средняя амплитуда в 2 фазе теста	247–319 мкВ	179–214 мкВ	1,44
Средняя амплитуда в 3 фазе теста	436 мкВ	177 мкВ	2,46
Прирост средней амплитуды	2,61	1,72	1,52
Прирост ср. ампл в 2 фазе к 1	1,6	1,52	1,05
Прирост ср. ампл в 3 фазе к 2	1,54	0,83	1,86
Средняя частота в 1 фазе теста	124–177/с	26,5–97,4/с	2,4
Средняя частота в 2 фазе теста	242–286 /сек	184–232/с	1,27
Средняя частота в 3 фазе теста	316/с	199/с	1,59
Соотношение амп./част. в 1 фазе	1,04–1,35	1,44–4,7	0,4
Соотношение амп./част. в 2 фазе	1,02–1,11	0,92–0,97	1,13
Соотношение амп./част. в 3 фазе	1,38	0,89	1,55
Прирост соотношения в 2 фазе	0,76	0,21	3,61
Прирост соотношения в 3 фазе	1,35	0,92	1,46

The largest differences in EMG data between normand hypotonic muscle are as follows:

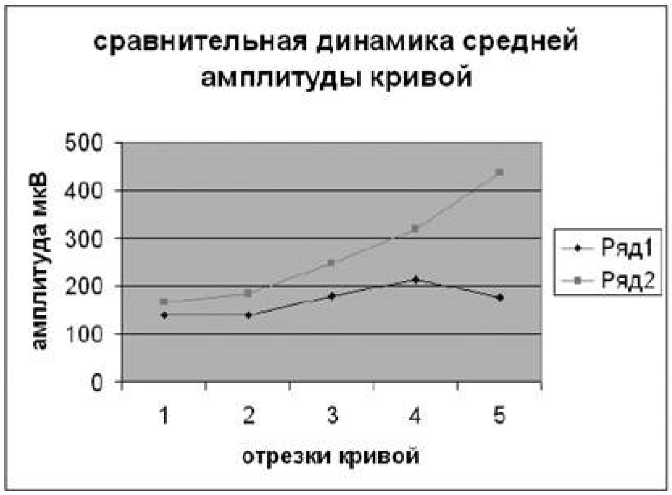
• the increase in the average amplitude as a whole along the curve of the normotonic muscle is 1.52 times higher than hypotonic muscle (Fig. 6), while the increase in the second phase of MMT prevailed only 1.05 times, and in the third phase relative to the second - 1.86 times;

• the average amplitude in the third phase of MMT of normotonic muscle is 2.46 times higher than hypotonic muscle;

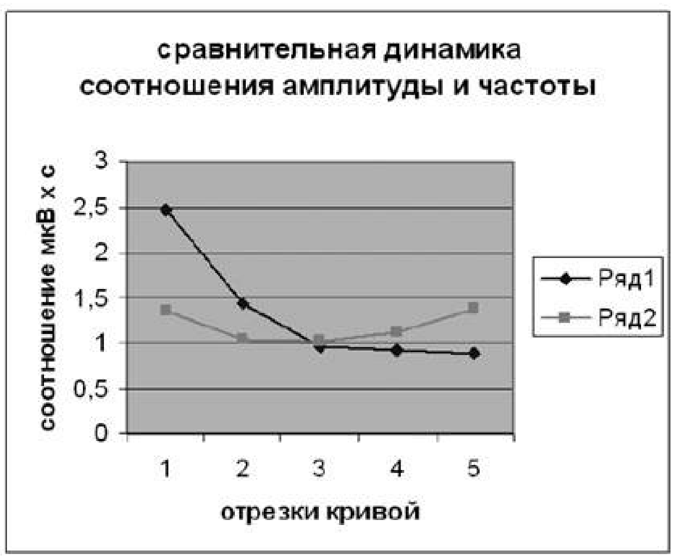
• the average frequency in the third phase of MMT of normotonic muscle is 1.59 times higher than that of hypotonic muscles;

• the amplitude / frequency ratio in the third phase of the test increases in the case of normotonic muscle and decreases in the case of hypotonic muscle - the difference is 1.55 times (Fig. 7); the increase in the ratio in the third phase of the test also changes - the difference is 1.46 times.

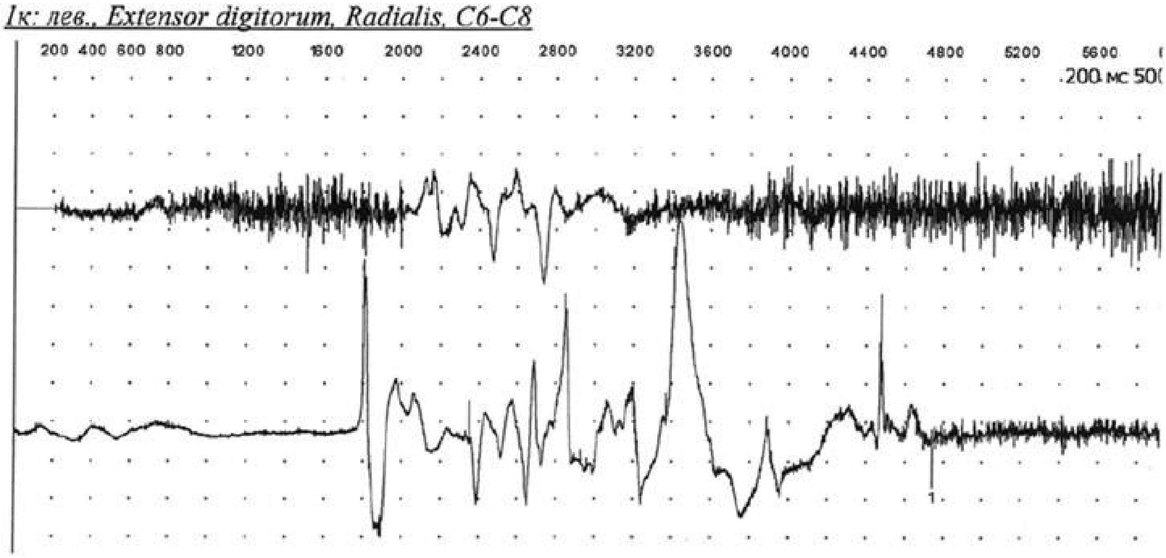
• one of the criteria for a hypotonic muscle is the presence of high-amplitude low-frequency oscillations localized in the second section of the curves when the second phase of MMT is performed. These fluctuations are caused by the movement of the limb in space and reflect the phenomenon of "pallidary tremor", which is a sign of functional muscle hypotonia (Fig. 8).



Rice. 6. Comparative dynamics of the average amplitude of the normal and hypotonic muscle curve.



Rice. 7. Comparative dynamics of the ratio of the amplitude and frequency of the curve of normotonic and hypotonic muscle.



Rice. 8. The phenomenon of "pallidary tremor".

DISCUSSION

When performing MMT, the normotonic muscle increases tension in two stages. An increase in the amplitude of oscillations with increasing muscle tension reflects the process of recruiting motor neurons and an increase in the number of MUs involved in contraction. An increase in the frequency of oscillations can be explained by an increase in the intensity of the work of each unit. A decrease in the ratio of the amplitude to the oscillation frequency indicates that at the beginning of the muscle contraction, a sufficient number of MUs are switched on with a moderate level of intensity of the work of each of them.

Gradually, with an increase in muscle tension, the frequency of work of each unit increases to the optimal level. In our study, this ratio is 0.89–1.15 μV / s. However, under conditions of isometric loading and stretching of the abdomen of the muscle, the amplitude again grows at a faster pace.

This can be explained by the additional recruitment of middle alpha1-motoneurons, which makes it possible to quickly increase the tension of the normotonic muscle in response to the stretching of its abdomen. The hypotonic muscle is incapable of increasing tension in the third phase of MMT, which manifests itself in the absence of an increase in the amplitude of oscillations or a decrease in it. After correction, the rectus femoris muscle increases the average amplitude of oscillations as a whole along the curve, the rest of the differences are concentrated in the 3rd fragment of the curve: the amplitude of oscillations is increased to a greater extent, and the frequency and their ratio are to a lesser extent. Thus, the normotonic muscle in response to abdominal distension increases tension mainly due to the recruiting of motor neurons.

CONCLUSIONS

1. EMG study confirms the presence of significant differences in neurophysiological reactivity of normal and hypotonic muscles, differentiated by MMT.
2. The normotonic muscle is characterized by a higher oscillation amplitude interference curve in comparison with hypotonic muscle (2.46 times); an increase in the average amplitude is observed mainly in the third phase of MMT (by 1.86 times).
3. An increase in the tension of the normotonic muscle is carried out by increasing the amplitude fluctuations, the amplitude / frequency ratio and is provided mainly by additional recruiting of alpha1-motor neurons. The hypotonic muscle does not respond to stretching with an increase in the amplitude of the curve and the amplitude / frequency ratio.

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Vasilieva, L.F. Electromyographic substantiation of manual muscle testing / L.F. Vasilieva, Yu.V. Shishmakov, I. D. Zotov // Traditional medicine. - 2009. - No. 3 (18). - P.19-24.

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