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OBJECTIVIZATION OF THE EFFECT OF A COMPLEX OF PHYSICAL FACTORS IN PATIENTS WITH CARPAL TUNNEL SYNDROME BY ELECTROMYOGRAM TEST

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ABSTRACT

CTS is the most common compression neuropathy with an incidence of 125-515/100 000. It is a result of compression of the median nerve by the transverse carpal ligament. It is observed in 2 to 5% of the general population, more frequently in women.

Electromyography is considered the most accurate diagnostic procedure, although it cannot be fully accepted as a gold standard due to the possibility of false positives (about 15%) and false negatives (about 18%) [1]

However, because of its low cost, in comparison to other diagnostic methods, its high diagnostic reliability, and the few contraindications to its application, it remains a method of choice for diagnosis and follow-up of the reinnervation of the median nerve in CTS patients.

Aim of study. To investigate the effect of a complex of physical factors on the reverse development of symptoms of moderate carpal tunnel syndrome using electromyography.

Materials and methods. 57 patients with mild to moderate degree of carpal tunnel syndrome clinically proven by electroneurographic study were examined. 38.60% of the patients were with right hand affected, 9 patients (15.80%) with left hand affected and 26 patients (45.60%) with bilateral involvement (n=26). In the last group, we examined both hands, i.e. 57 patients and 82 hands were investigated.

Based on the analysis of our own studies, we applied the following complex physiotherapeutic program to the patients involved in the study: ultrasound, electrophoresis with Nivalin (Galantamine), and traditional kinesitherapy program.

In our study, we examined the sensory and motor fibres of the n. medianus. Changes in distal latency, amplitude, and conduction velocity were observed.

Results and discussion. The electroneurographic examination we performed showed a statistically significant change ($p < 0.001$) in the normalization of distal latency, conduction velocity and M amplitude in both the sensory and motor fibres of the affected nerve. These results were reported between the first and fourth months after physiotherapy. There is also a tendency for their retention within the next 4-8 months.

Correlation analysis shows that there is a very strong, statistically significant ($p < 0.001$) relationship between the ENG parameters for n. medianus sensory and motor fibres conductivity (distant latency, SNAP and conduction velocity) and the treatment performed, which is established even at the first check-up (1-4 months) after end of the treatment, and the results achieved are maintained over time.

The statistically significant changes in the values of ENG parametric fibers of n. medianus, we refer to the complex physiotherapy treatment, aimed at improving the trophic and nerve conduction, accelerating the regenerative processes of the nerve structures, improving the trophic and vascularizing the structures located in the carpal tunnel.

Last but not least, the fibrolytic action of ultrasound therapy leading to the spreading of fibrous seals, which is quite common in CTS, is also important.

Although different in their mechanism of action, the physiotherapeutic procedures included in our program have a synergistic effect aimed at overcoming the functional deficiency and reversing the symptoms of CTS.

Conclusions. Our study on the effectiveness of a complex of physical factors in the conservative treatment of the CTS showed that early diagnosis and timely initiation of physiotherapeutic treatment are a prerequisite for achieving very good results in terms of functional recovery of the affected hand and the reverse development of clinical symptoms in patients with proven mild to moderate CTS.

The segmental demyelination of the sensory and motor fibers of n. medianus in the initial stages, as a result of its compression in the area of the carpal canal, is a reversible process. An integrated approach to the treatment of CTS, including early diagnosis, prevention and treatment, is the key for success in mild and moderate forms of the syndrome, and competent and timely medical advice is often crucial.

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Introduction. Compression neuropathies are focal lesions of the peripheral nerves with a different etiology and are caused by narrowing or mechanical stretching of the nerve root in a fibrous or fibrous bone canal, or by fibrous tissue. They are characterized by pain, sensory impairment and/or loss of function as a result of chronic pressure (compression).

Carpal tunnel syndrome (CTS) is the most common compression neuropathy with an incidence of 125-515/100 000. It is a result of compression of the median nerve by the transverse carpal ligament. It is observed in 2 to 5% of the general population, more frequently in women. It is considered that there is a link between this condition and the occupational load on the wrist when working on a keyboard, in the presence vibrations, in cases of overexertion of the upper limbs, etc.

Electromyography (EMG) is a highly specialized method for the diagnosis of peripheral motor neuron damage (fore-horn cells, peripheral nerve roots, and peripheral nerves themselves, muscles and neuromuscular transmission).

Electromyography examines the bioelectric activity of muscles. In routine testing, 2 groups of methods are applied: needle and stimulation.[2]

The most sensitive technique is wrist-palm stimulation (61% sensitivity). Needle EMG has a limited role in diagnosis and confirms neurogenic damage in the affected muscles. There are 3 main indications: muscle weakness and tenor hypotrophy. and history of acute distal hand injury [3,4,5]

Electromyography is considered the most accurate diagnostic procedure, although it cannot be fully accepted as a gold standard due to the possibility of false positives (about 15%) and false negatives (about 18%) [1]

However, because of its low cost, in comparison to other diagnostic methods, its high diagnostic reliability, and the few contraindications to its application, it remains a method of choice for diagnosis and follow-up of the reinnervation of the median nerve in CTS patients.

Electroneurographic examination is indicative not only of CTS, but also in the differential diagnostic plan in conditions with similar symptoms: cervical radiculopathy, polyneuropathy, compression of n. medianus outside the area of the carpal canal, др. [7,8]

Aim of study. To investigate the effect of a complex of physical factors on the reverse development of symptoms of moderate carpal tunnel syndrome using electromyography.

Materials and methods. 57 patients with mild to moderate degree of carpal tunnel syndrome clinically proven by electroneurographic study were examined. 38.60% of the patients were with right hand affected, 9 patients (15.80%) with left hand affected and 26 patients (45.60%) with bilateral involvement (n=26). In the last group, we examined both hands, so 57 patients and 82 hands were investigated.

Criteria for inclusion.

- Persons over 18 years old;
- Persons with mild to moderate CTS, according to electrophysiological standards of the Association of Clinical Electromyography and Evoked Potentials of electroneugraphy (ENG) Research;
- Persons who have not undergone surgical treatment;

Based on the analysis of our own studies, we applied the following complex physiotherapeutic program to the patients involved in the study:

- ***Ultrasound / 3-4 min*** / locally in the projection of the carpal tunnel at a rate of 0.2 - 0.3w / cm2 with a view hydrolytically, anti-inflammatory and antiedematous action of ultrasound, and in order to improve the effect of subsequent electrophoresis because thermal and the mechanical effect of KH proved to improve the absorption capacity of the skin.
- ***Electrophoresis with Nivalin (Galantamine) (+)*** locally, with the positive electrode located in the carpal canal projection of 10 to 18 minutes and a current of 6-16mA in order to improve the nerve conductivity
- ***Traditional kinesitherapy program*** including analytical exercises, facilitating techniques, massage, soft-tissue mobilization, muscle relaxation and stretching techniques, joint mobilization

techniques, active musculoskeletal exercises to strengthen forearm and arm muscles and training precision gauges and reeducation of sensation.

In our study, we examined the sensory and motor fibers of the n. medianus. Changes in distal latency, amplitude, and conduction velocity were observed. Usually, with mild or moderate nerve damage, the following electromyographic abnormalities occur:

1. Conduction velocity on the motor fibers of n. Medianus for the elbow-wrist section most often in the norm - 3.0 to 4.5 ms;
2. Extended distal motor and sensory latencies;
3. The amplitudes of SMAP and SNAP may be reduced in cases of secondary axonal degeneration;
4. The velocity of conduction on the motor and sensory fibers of n. medianus through the carpal canal is most often delayed (<50ms);
5. Significant decrease in the amplitudes (conduction block) of SMAP and SNAP when stimulating the nerve in the wrist area.

In patients suspected of CTS with normal EMG parameters for the conductivity of the sensory fibers, simultaneous examination of motor and sensory fibers increases the diagnostic prognosis by 10% (Chang MH L. L., 2006)

Results.

Evaluation of the effect of physiotherapy treatment on the improvement of trophic and nerve conduction of the affected nerve.

The electroneurographic examination of the sensory and motor fibers of n. medianus was performed three times - before the start of treatment, at 1-4 and 4-8 months after the end of the physiotherapy course. Clinical experience and scientific literature indicate that changes in ENG parameters cannot occur immediately after one or another type of conservative treatment (in this case, within 10 days), so we did not perform a control ENG study immediately at the end of the physiotherapy course.

ENG examination of the sensory fibers of the n. medianus.

By electroneurographic examination of n. medianus - sensory fibers we found that the mean values of the investigated parameters (distant latency, SNAP amplitudes and conduction velocity) deviate from the reference values within the limits of the electroneurographic criteria for mild to moderate degree of manifestation of CTS.

From the ENG results presented graphically in fig. 1 we found prolonged mean distant latency values of sensory fibers before initiation of physiotherapy treatment - 4.09 ms for the right hand and 4.01 ms for the left hand, which dropped statistically significantly to 3.49 ms for the left and 3.51ms. for the right hand (p <0.001), and this statistically significant tendency for lowering the mean values and maximal approximation to the reference values is maintained in the coming months (4-8) (p <0.001).

No statistically significant difference was found in the recovery of left and right hands.

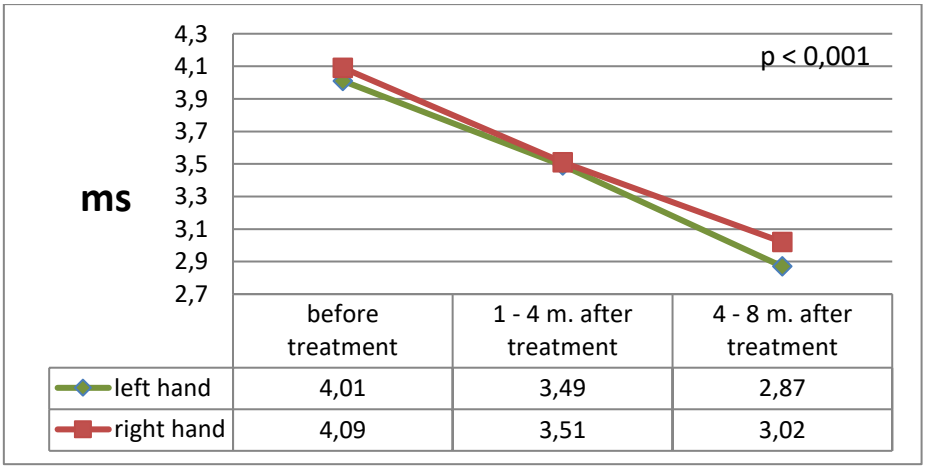
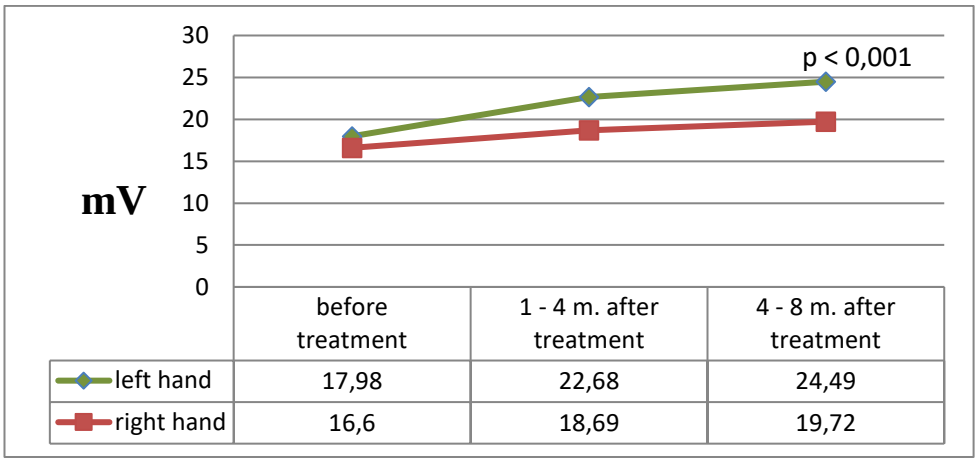


Fig. 1. Change in the mean value of distant latency parameters before and after treatment.

Comparison of mean values of SMAP amplitudes for sensory fibres of n. medianus before treatment, 1-4 and 4-8 months reported a statistically significant tendency to increase these values (p =

0.001) at the first checkup, increasing from an average of 17.98 ms before treatment to 22.68 ms at 1-4 month and reaches an average of 24.48 ms at 4 -8 months after the end of treatment for the left hand and from an average of 16.6 ms before FT to 18.69 ms at 1-4 months and 19.72 ms at 4-8 months after end of treatment for the right hand (Fig. 2).

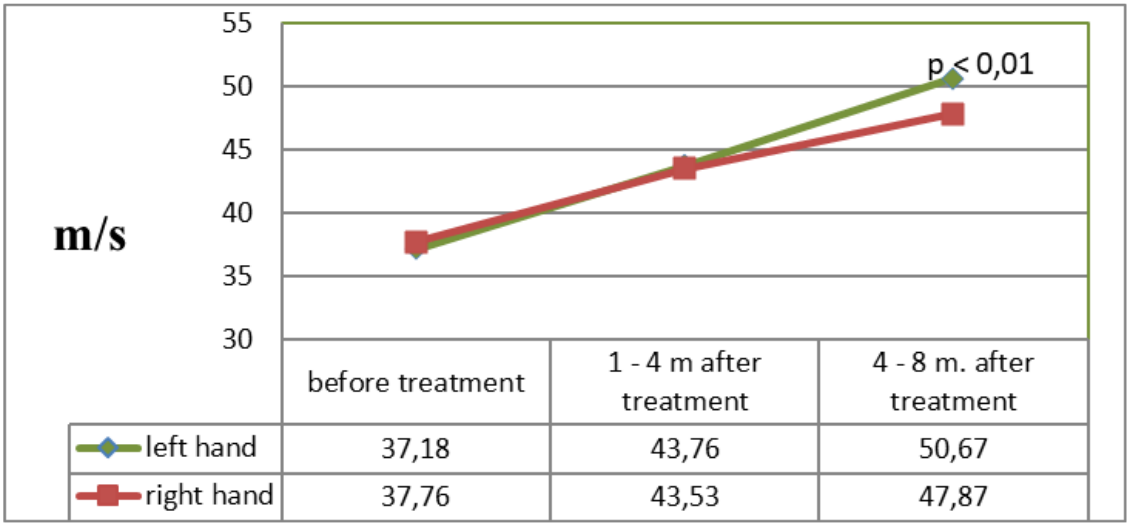
From the graph of Fig. 2 it can be seen that from the same starting position in the left and right hand indicators, the rate of change towards increasing the mean value of the M response amplitude at 1-4 months is higher with the left hand affected and this the trend persists in the coming months - 4-8 m.



	before treatment	1 - 4 m. after treatment	4 - 8 m. after treatment
left hand	17,98	22,68	24,49
right hand	16,6	18,69	19,72

Fig. 2. Change in the mean value of SNAP amplitude parameters before and after treatment

We found that the comparison of the average velocities of n. medianus - sensory fibres of the hands we studied showed a statistically significant tendency (p <0.001) towards increasing the speed of conducting and equalizing it with the reference values as early as 1-4 months - from 37.76 m/s to 43.53 m/s, which persists in the following months (4-8) after the treatment (47.87 m/s), with a parallel recovery in left and right hands up to 1-4 months, with a tendency for a greater change in the average rates of sensory fibre conduction for our left hand subjects, with almost identical mean baseline values before treatment (Fig. 3).



	before treatment	1 - 4 m after treatment	4 - 8 m. after treatment
left hand	37,18	43,76	50,67
right hand	37,76	43,53	47,87

Fig. 3. Change in the average of the parameters of the speed of conduction on sensory fibres, before and after treatment.

After correlation analysis, we found a very strong relationship between the change in the ENG parameters of n. medianus for sensory fibers and the physiotherapy treatment with statistically significant correlation (p <0.001) between the change of the mean values of the studied parameters and their approximation to the reference values, both for distant latency and SNAP amplitude and the speed of conducting up to 4 months after FT treatment, within 4-8 months after the end of the procedures, the effect achieved is maintained (Table 1).

Table 1. Effect of physiotherapy on ENG - parameters of n. medianus - sensory fibers

	Time after treatment	correlation coefficient (r)	p
Distant latency (ms)	1-4 м.	0,892	< 0,001
	4-8 м.	0,668	< 0,001
SNAP amplitude (mV)	1-4 м.	0,888	< 0,001
	4-8 м.	0,855	< 0,001
Velocity conduction (m/s)	1-4 м.	0,914	< 0,001
	4-8 м.	0,696	< 0,001

ENG study of motor fibers of n. medianus.

By electroneurographic examination of n. medianus - motor fibers we found that the mean values of the investigated parameters (distant latency, M amplitude and conduction velocity) showed deviations relative to the reference limits before initiation of physiotherapy treatment within the limits corresponding to electroneurographic criteria for mild to moderate manifestation of the CTS.

There is a tendency to gradually approach the normal values 1-4 months after the start of the treatment and keeping the results achieved in the coming months.

We report prolonged distant latency of motor fibers with an average of 5.07 ms for the right hand and 4.89 ms for the left hand, before treatment begins, which at the check-up (1-4 months) shows a tendency to normalize (3.86 ms) - in the affected left hands, 4.05 ms - in the affected right hands and keeping the results within the reference values for up to 4-8 months after the end of treatment - 3.62 ms for left and 3.38 ms for right hands, respectively.

The comparison of mean distant latency values before treatment and in ENG control studies reveals a statistically significant tendency (p = 0.001) for a decrease in distant latency values after treatment, both at the first (1-4 m) and at the second control examination (4-8m).

Here again, the correlation analysis shows a significant degree of dependence between physiotherapy treatment and shortening of distant latency (Fig. 4)

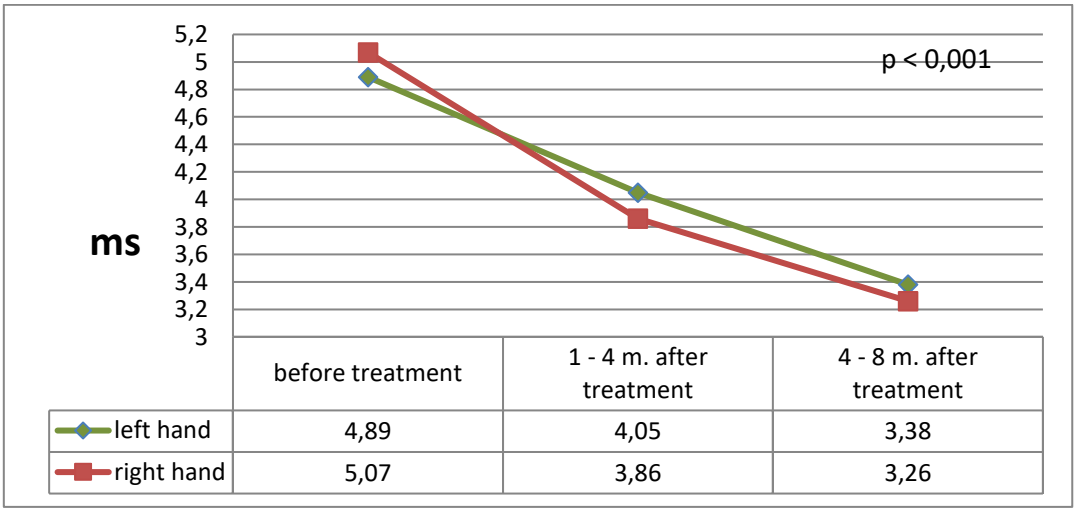
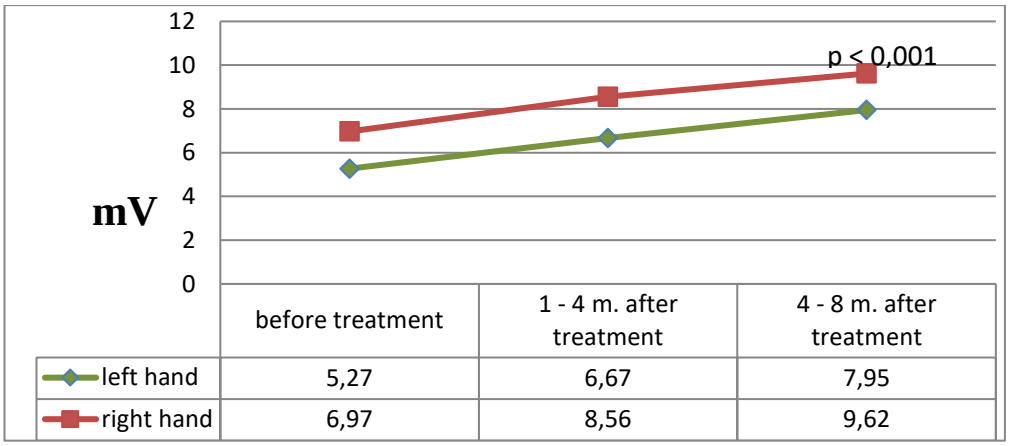


Fig. 4. Change in the mean value of distant latency parameters before and after treatment.

Comparison of the mean values of SMAP amplitudes of motor fibers before the FTP, 1-4 and 4-8 months reveals a statistically significant tendency for their increase (p = 0.001) at the first check-up - from an average of 5.27 ms before treatment to 6.67 ms at 1-4 months and 7.95 ms at 4-8 months after treatment ends for left hand and from an average of 6.97 ms before FT to 8.56 ms at 1-4 months and 9.62 ms at 4-8 months after the end of FTP for the affected right hand (Fig. 5).

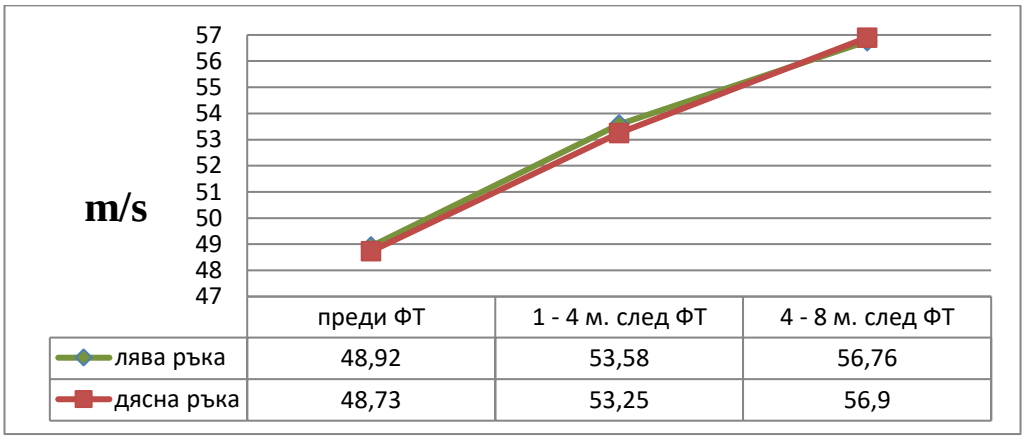


	before treatment	1 - 4 m. after treatment	4 - 8 m. after treatment
left hand	5,27	6,67	7,95
right hand	6,97	8,56	9,62

Fig. 5. Change in the mean value of SMAP amplitude parameters before and after treatment.

It can be seen that left-hand indicators are better before the start of treatment, and the rate of change to increase the amplitude of the M response is the same for left and right hands up to 1-4 months. The trend continues in the coming months (4-8) - p <0.001.

Comparison of the average velocities of n. medianus -motor fibers of the examined hands showed a statistically significant tendency to increase the speed of conducting (p = 0.001) and aligning it with the reference values at 1-4 months, which persists in the following months (4-8) after the treatment, with no significant difference in recovery between left and right hands (Fig. 6).



	преди ФТ	1 - 4 м. след ФТ	4 - 8 м. след ФТ
лява ръка	48,92	53,58	56,76
дясна ръка	48,73	53,25	56,9

Fig. 6. Change in the average of the parameters of the conduction velocity of motor fibers, before and after treatment.

Correlation analysis shows that there is a very strong, statistically significant (p <0.001) relationship between the ENG parameters for n. medianus motor fiber conductivity (distant latency, SNAP and conduction velocity) and the treatment performed, which is established even at the first check-up (1-4 months) after end of the treatment, and the results achieved are maintained over time. (Table 2).

Tab. 2. Effect of treatment on the ENG parameters of n. medianus - motor fibers

	Time after treatment	**correlation coefficient (r)**	**p**
Distant latency (ms.)	1-4 м.	0,759	< 0,001
	4-8 м.	0,675	< 0,001
SNAP amplitude (mV)	1-4 м.	0,838	< 0,001
	4-8 м.	0,795	< 0,001
Velocity conduction (m/s)	1-4 м.	0,856	< 0,001
	4-8 м.	0,697	< 0,001

Discussion. Neurophysiological study revealed data on lengthening of the distant latency of n. medianus - sensory fibers. This is due to the major pathogenetic process of demyelinization resulting from the compression of n.. medianus in the carpal tunnel. Before the motor, there is a sensory deficiency due to the thinner myelin sheath of the sensory fibers and their greater vulnerability.

Sensory fiber ENG results show not only prolonged distant latency but also reduced amplitude and reduced rate of conduction on sensory fibers meeting ENG criteria for mild to moderate nodal involvement.

This speaks in favor of the reverse development of the processes of demyelinization, which is a particularly important prerequisite for the reverse development or progression of the development of CTS and the worsening of the symptoms of the disease.

In the analysis of these results we found a statistically significant tendency to decrease the average values of distant latency at the first control examination (1-4 months) and their maximum approximation to the reference ones, which is maintained in the following months (4-8 months) ($p < 0.001$).

There was a statistically significant tendency to increase the amplitude values ($p = 0.001$) at the first control examination (1-4 months), persisting at the second control examination (4-8 months).

There is also a statistically significant tendency towards an increase in the speed of conduction on the sensory fibers and its alignment with the reference values as early as 1-4 months, which persists in the following months (4-8) after the treatment, which we refer most to the local iontophoresis with Galantamine and the resulting skin depot, without of course underestimating the importance of the other components of physiotherapy treatment.

Through the results of the correlation analysis, we found a very strong correlation with a high correlation coefficient ($r = 0.668 - 0.914$) between the change in the ENG parameters of n. medianus for sensory fibers and the physiotherapy treatment performed in the last two stages of our study. 1-4 and 4-8 months, with a statistically significant relationship ($p < 0.001$) between the change in the mean values of the studied indicators and their approximation to the reference values, both at distant latency and at the SNAP amplitude and the speed of conduction 1 -4 months after treatment, and within 4-8 months after the end of the procedures the achieved effect is maintained.

Analyzing the electroneurographic examination of n. medianus - motor fibers we found that the mean values of the studied parameters (distant latency, M-response amplitude and conduction velocity) before starting treatment showed deviations, relative to the reference ones, corresponding to electroneurographic criteria for mild to moderate manifestation of CTS - extended distant latency, reduced amplitude and conduction velocity on motor fibers.

Motor fibers also show a statistically significant tendency to normalize the parameters studied at 1-4 months after completion of the treatment for latencies, M-response and conduction velocity ($p = 0.001$), which is also preserved at the second examination (4-8 months). And here we have a very high level of correlation ($r = 0.675 - 0.856$) in the last two stages of our study.

The statistically significant changes in the values of ENG parametric fibers of n. medianus, we refer to the complex physiotherapy treatment, aimed at improving the trophic and nerve conduction, accelerating the regenerative processes of the nerve structures, improving the trophic and vascularizing the structures located in the carpal tunnel.

Last but not least, the fibrolytic action of ultrasound therapy leading to the spreading of fibrous seals, which is quite common in CTS, is also important. Although different in their mechanism of action, the physiotherapeutic procedures included in our program have a synergistic effect aimed at overcoming the functional deficiency and reversing the symptoms of CTS.

Conclusions. Our study on the effectiveness of a complex of physical factors in the conservative treatment of the CTS showed that early diagnosis and timely initiation of physiotherapeutic treatment are a prerequisite for achieving very good results in terms of functional recovery of the affected hand and the reverse development of clinical symptoms in patients with proven mild to moderate CTS.

Electroneurographic examination objectifies the results obtained in physiotherapy treatment There is a tendency for normalization of electroneurographic parameters, which lasts up to 4 months after the end of physiotherapy and continues for a period of 4 to 8 months after treatment. The results achieved are conditioned by the proven prolonged action of the physiotherapy procedures included in the complex, the formed skin depot after electrophoresis with Galantamine, as well as the included kinesitherapy program designed for the needs of patients with CTS and its individualization according to the specific functional symptoms of each patient.

The segmental demyelination of the sensory and motor fibers of n. medianus in the initial stages, as a result of its compression in the area of the carpal canal, is a reversible process. An integrated approach to the treatment of CTS, including early diagnosis, prevention and treatment, is the key for success in mild and moderate forms of the syndrome, and competent and timely medical advice is often crucial.

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