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ROLE AND IMPACT OF PROPHYLACTIC INTERVENTIONS IN THE CONSERVATIVE TREATMENT OF CARPAL TUNNEL SYNDROME

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Abstract

Carpal tunnel syndrome (CTS) refers to the compression or tension over the median nerve at the level of the wrist and represents the most commonly encountered compression mononeuropathy. It is diagnosed significantly more often in individuals, whose work involves similar, repetitive movements. The condition affects approximately 4–6% of the active population. Its social aspect stems from the significant deterioration of patients' professional and private life, which, in a high percentage of cases, leads to a change in profession. Multiple surgical and conservative treatment approaches have been described. The literature proposes a general recommendation for compliance with prophylactic interventions and a specific mobilization regimen but a consensus on the subject has not yet been achieved. In our study, we followed 45 patients diagnosed with CTS who reported pain and altered sensation, over a period of 6 months. The patients were divided into three groups which were randomly assigned to different treatment modalities. All patients received the same prophylactic interventions with regard to the physical load and exercises, which were to be followed individually over the course of the study. At the end of the study, the obtained data were analyzed statistically and we reported a correlation between patient improvement and the frequency of the exercises.

Key words: carpal tunnel syndrome (CTS), conservative treatment, physical therapy, exercises, long-term effect

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Introduction. Carpal tunnel syndrome (CTS) is the clinical term describing the condition which develops upon compression or increased tension over the median nerve at the level of the wrist. It is the most often encountered compression mononeuropathy [1, 2]. This condition leads to a significant deterioration of patients' quality of life because it is characterized by a numbing sensation in the innervation zone of the median nerve, reduced grip strength, and impaired hand dexterity, which causes difficulty in the execution of their professional activities, impairs sleep at night, thereby worsening their everyday life as a whole and their social contacts [1, 3]. CTS affects 4–6% of the general population [3]; usually, its onset occurs between 30 and 55 years (i.e. in working-age individuals) and it affects females more often than males [3,4]. It develops significantly more often in the dominant arm and is usually associated with professions whose work involves vibrations, repetitive similar movements, typing on keyboards, etc. [3–5].

CTS is one of the most frequently diagnosed conditions associated with symptoms of numbing, reduced muscle strength, and painful movements of the wrist, palm, and fingers [3, 6], which raises the issue of the precision of this diagnosis in any patient with such symptoms [7, 8]. Our clinical experience shows a high incidence of wrongly diagnosed patients with tenosynovitis and/or cervical osteochondrosis who did not have additional instrumental examinations performed. Graham et al. [3] accept that the constellation of pain and numbing in the innervation zone of the median nerve, positive clinical examination tests specific for CTS (Tinel's sign, Phalen's test, digital test, Pryse-Phillips' flick sign, and Luthy sign), electromyographic, ultrasound and/or magnetic resonance imaging (MRI) findings are highly reliable for diagnosis verification [9]. Diagnostic scales such as the Boston carpal tunnel questionnaire are used to follow up the condition's evolution. The information contained in them refers to the patient's condition throughout the previous two weeks; patients fill them out by themselves and they represent a reliable method used to monitor the disorder's evolution [10].

The social impact of CTS and the multiple questions surrounding the optimal therapeutic approach caught our attention and we directed our efforts towards optimizing the clinical approach in these patients. There is only a general consensus in the literature regarding the need to use exercises and prophylactic interventions aimed at changing a patient's lifestyle. In addition, there is a lack of consensus concerning the various parameters – type, frequency, intensity, and duration of the exercises/interventions [3].

The aim of the present study was to monitor the impact of the exercises, as well as to reveal statistically their optimal frequency. To do so, we outlined the following tasks:

1. To monitor exercises, which:
   1.1. are aimed at putting minimal loads on the muscles affected by the compression of the median nerve;

1.2. are both optimally effective and easy to perform;

1.3. could be performed everywhere and are accessible, regardless of the patient's physical condition;

2. To monitor the impact of the selected combination of exercises under different settings, i.e. in various therapeutic regimens – together with physical therapy, placebo-physical therapy, and on their own (as a mono-therapy);

3. To monitor the exercises' impact on pain (measured on the visual analogue scale – VAS) and sensation;

4. To find out what is the optimal frequency of exercises.

Material and methods. A total of 45 patients aged between 18 and 82 (mean age 43.17) with documented CTS (through electromyography and/or ultrasound) were included in the present study. Of them, 29 were females (64.44%) and 16 were males (25.56%). After signing an informed consent form, they received general instructions to perform prophylactic interventions and exercises. Patients were randomly assigned to three groups. The first group ($n = 15$) received low-frequency pulsed electromagnetic field therapy (PEMF) and phonophoresis (PP) with Contractubex (Allantoin/Allii cepae extractum fluidum/Heparin sodium). The second group ($n = 15$) received placebo therapy – low-frequency PEMF and PP with Contractubex; the procedures were conducted with devices turned off and patients positioned in such a way, so as not to have visibility of the devices [11]. The third group ($n = 15$) was a control – without physiotherapy but with prophylactic interventions and exercises.

The prophylactic instructions included lifestyle changes in order to improve their condition, the type of movements they may perform with their arm, their frequency, duration, and intensity, as well as movements that should be avoided, along with instructions on how to perform self-massage and its intensity. Patients were trained to use the arm actively, with the range of motion only limited by pain, as well as to avoid carrying loads (such as a bag of groceries) with the impaired arm. In addition, they were instructed to perform maximal flexion in the wrist joint and to place compressive bandages and/or splints. Furthermore, with regard to self-massage, we trained patients to follow the direction of lymph drainage (from the fingers towards the elbow) and to perform self-massage with tender, stroking movements by covering the area of the fingers, palm, wrist, and forearm (in that order).

The exercises consisted of 14 analytical movements putting minimal loads on the wrist joint. The instructions consisted of written descriptions of the exercises with photos displaying the correct movements. The required parameters were the following: exercise frequency more than once daily (up to once per hour); slow tempo; duration of 5 to 10 minutes; including arms, regardless of whether the compression of the median nerve was unilateral or bilateral. At the follow-up visits – on day 12 and 6 months after the onset of therapy, we registered the frequency with which the exercises were performed.

All patients were evaluated before the onset of therapy, on day 12, and 6 months after the therapy onset. The sensation was determined on a 5-grade scale: 4 – no alterations in sensation, 3 – hyperesthesia, 2 – paresthesia, 1 – acroparesthesia, 0 – hypoesthesia. Pain intensity was assessed on a VAS, in which 0 was considered no pain and 10 – maximal pain.

For statistical processing, multiple analysis of variants (MANOVA) was used, with post-hoc multiple tests of Bonferroni, as well as correlation analysis of Pearson, with post-hoc regression analysis. MANOVA was used to check the presence or absence of statistical significance throughout all possible levels of interaction. The post-hoc multiple Bonferroni test was running simultaneously with MANOVA to isolate the clusters, having a statistically significant difference. Pearson's correlation analysis was used to compare the interactions between the comparative parameters. Post-hoc regression analysis was performed after Pearson correlation analysis to calculate the regression equations of interaction between parameters with statistically significant correlation.

Results. When monitoring the impact of the conducted therapies in the three groups, we found that all patients had improved sensation at the end of the treatment course. At the same time, there was no statistically significant difference (> 0.05) across the groups (Fig. 1B). With regard to pain, results were similar – no statistically significant difference was reported across the three groups, however, a significant difference was found regarding the pain intensity before the onset of therapy versus at the end of the treatment course (Fig. 1A).

A statistically significant correlation was found between the exercise frequency and pain intensity ($p < 0.05$). The regression analysis established that pain intensity was statistically dependent on the exercise frequency ($p < 0.05$) according to the following real calculated regression formula: VAS $= 5.39 - (0.253 \times$ number of daily exercises). The statistical power was sufficient (above 0.8) at $\alpha = 0.05$, with a normal statistical distribution of the clusters in the sample, which confirmed the significance of these results with the available number of variables [12–17]. Based on this real formula of the regression analysis, a total of 21 prognostic mathematical models were calculated corresponding to pain intensity (VAS in cm) at exercise frequency between 1 and 21 times daily. These mathematically derived prognostic models have the following graphical representation (Fig. 2).

As evident from Fig. 2, pain intensity (VAS in cm) tends to be close to zero at exercise frequency higher than 21 times a day.

In addition, a statistically significant correlation ($p < 0.05$) between sensation and exercise frequency was reported. The regression analysis established that sensation was statistically dependent on the exercise frequency ($p < 0.05$)

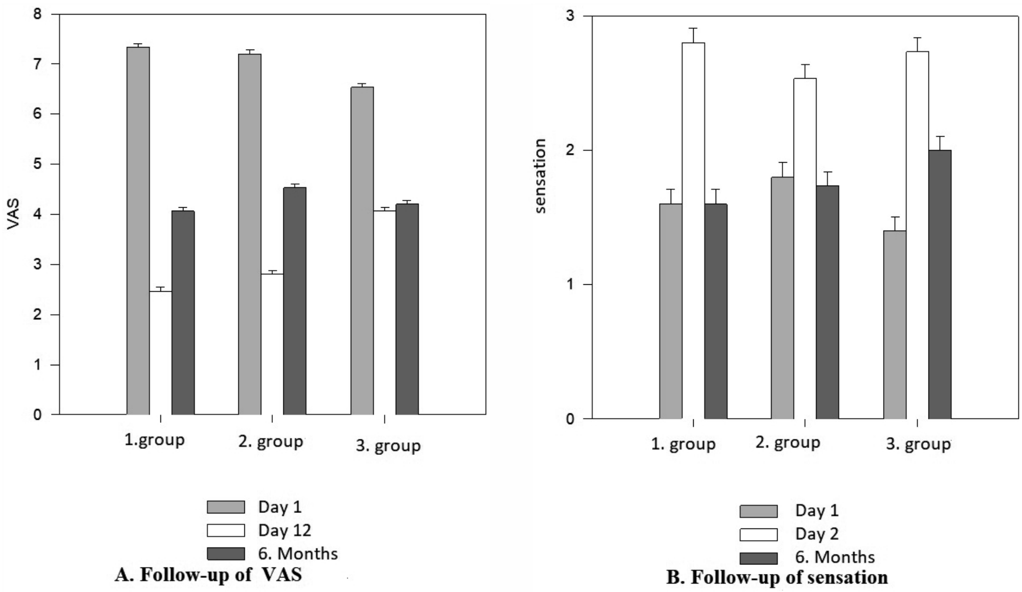

Fig. 1. Follow-up of sensation and VAS

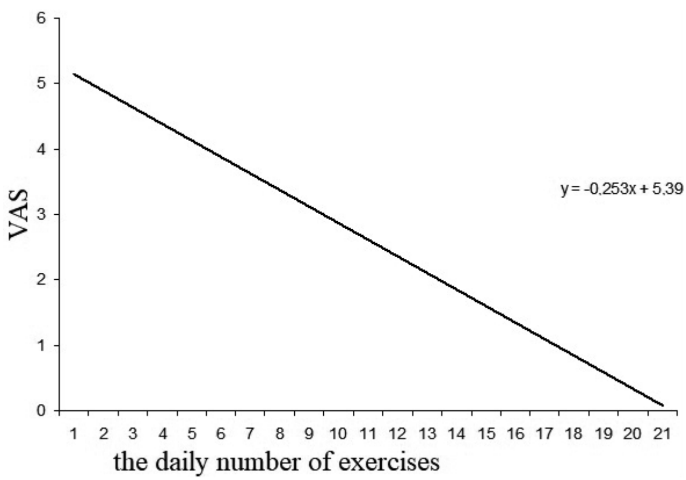

Fig. 2. Mathematically calculated prognostic correlation between pain intensity (VAS in cm) and the number of daily exercises

according to the following real calculated regression formula: Sensation = 1.91 + (0.0972 × number of daily exercises). The statistical power was sufficient (above 0.8) at $\alpha = 0.05$, with a normal statistical distribution of the clusters in the sample, which confirms the significance of these results with the available number of variables [12–17]. Based on this real formula of the regression analysis, a total of 21 prognostic mathematical models were calculated corresponding to

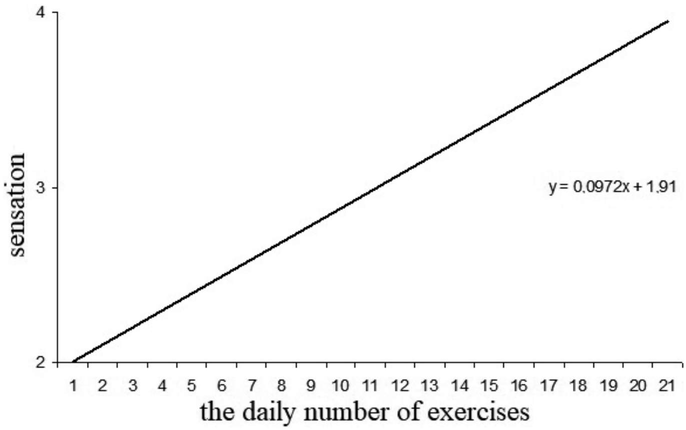

Fig. 3. Mathematically calculated prognostic correlation between sensation (4 = normal, 3 = hyperesthesia, 2 = paresthesia, 1 = acroparesthesia, 0 = hypoesthesia) and the number of daily exercises

sensation (4 = normal, 3 = hyperesthesia, 2 = paresthesia, 1 = acroparesthesia, 0 = hypoesthesia) at exercise frequency between 1 and 21 times a day. These mathematically derived prognostic models have the following graphical representation (Fig. 3).

As evident from Fig. 3, sensation tends to be close to normal at exercise frequency higher than 21 times a day.

The statistically significant real 3-dimensional correlation ($p < 0.05$) and regression ($p < 0.05$) between pain intensity, sensation, and the exercise frequency has the following graphical representation (Fig. 4).

The statistical power was sufficient (above 0.8) at $\alpha = 0.05$, with a normal statistical distribution of the clusters in the sample, which confirms the significance of these results with the available number of variables [12–17].

Discussion. The present study found that the number of daily exercises correlates with the evolution of pain intensity (measured through VAS) and sensation. This correlation shows that exercise frequency is a key factor in the reduction of pain and improvement of sensation in patients with CTS. The number of daily exercises during the short-term 12-day follow-up is significantly higher than that over the course of the long-term 6-month follow-up which corresponds to pain evolution – it decreases significantly throughout the short-term 12-day follow-up and increases during the long-term 6-month follow-up. The effect on sensation is similar – statistically, it improves significantly during the short-term 12-day follow-up and worsens over the course of the long-term 6-month follow-up. Moreover, the mathematical modelling and prognosis based on the real regression analysis found that pain intensity tends to be close to zero at exercise frequency higher than 21 times a day, i.e. when exercising twice every hour during the day. The trend is

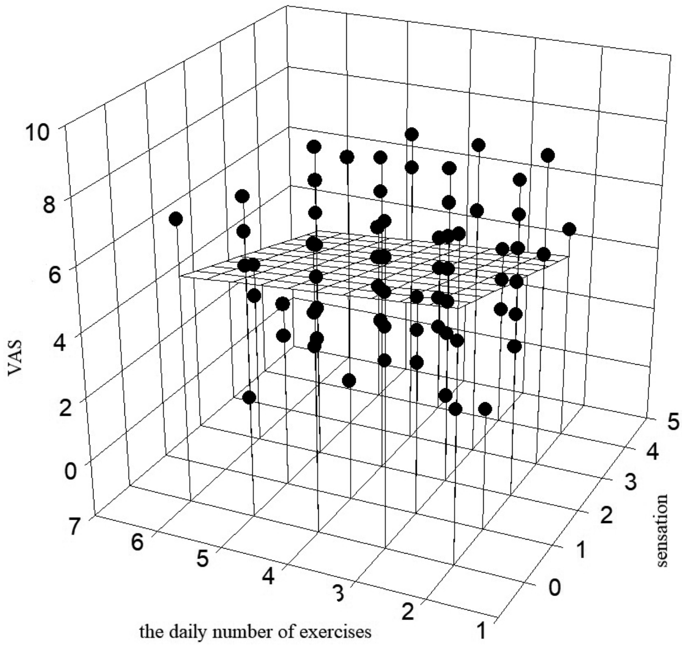

Fig. 4. Real 3-dimensional regression correlation between pain intensity, sensation, and the number of daily exercises

the same with regard to sensation recovery. The key significance of exercises is supported by the results of the multivariate analysis of variance (MANOVA). The absence of MANOVA difference between the three groups regarding pain intensity (VAS score) and the change in sensation together with the extremely high MANOVA difference ($p < 0.0001$) between the results of the follow-up regarding pain intensity means that the number of exercises has both a pronounced singular short-term and long-term pain reduction effect, as well as a notable short-term pain reduction effect as a supplementing element to the preformed physical factors. The latter do not have a long-term impact, i.e. do not provide a prophylactic effect on pain. Consequently, it would not be advisable to conduct prophylactic courses with preformed physical factors in an absence of pain; rather, they should be prescribed only in case of persistent pain or worsening of existing pain.

Conclusion. CTS is a compression phenomenon presenting with a characteristic clinical constellation of altered sensation, reduced muscle strength, and pain in the area of the wrist and palm. The usual approach in the treatment of median nerve compression – splinting during the night for a few days, local application of corticosteroids [3, 18, 19] and, if ineffective – surgical treatment [1, 18] does not correspond to patients' expectation. A large portion of them require that alternatives of the once customary therapy be suggested. The optimal exercise frequency seems to be around 5 minutes every hour. At the same time, pain during the night and acroparesthesias may be treated with the known methods, supplemented by the execution of the exercise programme. Even when taking the decision to proceed with surgical treatment, analytical gymnastics and the ability to follow a motion regimen would still be useful to the patient. The exercise programme suggested herein is easy to remember, may be executed fast and practically everywhere with readily available means (a softball, a rolling pin, or a stick), does not carry a financial burden, and is statistically proved to be effective. As with any other neurological disorder involving the peripheral nervous system, the main clinical problem in CTS is the loss of muscle tissue and muscle strength. Analytical gymnastics, when performed accurately and repetitively, restores muscle tissue in the most physiological way. Despite the relatively small sample of patients that we worked with (45 in total), our data unequivocally demonstrate the positive impact of following simple practical rules in the everyday life of every patient with regard to pain management and improvement of the alterations in sensation.

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