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EVALUATION OF THE THERAPEUTIC EFFECTS OF TRANSCUTANEOUS INTERFERENTIAL CURRENT THERAPY AND THERAPEUTIC EXERCISES ON MUSCULOSKELETAL SYMPTOMS IN PATIENTS WITH POST COVID-19

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Abstract: The aim of this research was to investigate the therapeutic effectiveness of a multi-component rehabilitation program including: transcutaneous interferential current therapy and therapeutic exercises in patients with musculoskeletal symptoms in post COVID-19 syndrome. Materials and Methods: 62 patients, mean age 55.9(13.99), aged 21 to 79 years, with persistent musculoskeletal symptoms in the recovery phase after experiencing COVID-19 were included in this study. All patients underwent a ten-day treatment course in an outpatient setting, including transcutaneous application of interferential current with four electrodes. The therapeutic parameters were selected with analgesic, trophic and stimulating effects (90-100 Hz, 5min and 0-100 Hz, 15min). Immediately after electrotherapy, kinesitherapy was performed including: breathing exercises, aerobic training, active and resistance exercises for the limbs, postural control exercises and exercises to improve the mobility of the peripheral joints and the axial skeleton. Results were evaluated by: Visual Analogue Scale (VAS) for assessment of back pain, Numerical Rating Scale (NRS) for arthralgia and myalgia assessment, Brief Fatigue Inventory (BFI) – fatigue assessment, functional tests of mobility, Goniometry in the spine, Ott Sign- for measuring the range of motion (ROM) of the thoracic spine, Schober's test to determine a lumbar spine range of motion (flexion), Tom Meyer's test for total hip joint and spine flexion mobility. The results were reported before and after the rehabilitation. The statistical significance level was specified as ($p<0.05$). Results: Musculoskeletal symptoms in the observed patients persisted for an average of 12 weeks, ranging from 7 to 20 weeks, and included: myalgia in 46.8% (29), arthralgia 29.0% (18), pain in various back departments 79.0% (49), fatigue 66.1% (41). Inpatient treatment for acute COVID-19 was performed in 35.5% (22) of patients, and home and outpatient treatment in 64.5% (40). There was a statistically significant reduction (Mean (SD)) after therapy in back pain (VAS) from 4.88(1.5) to 1.93(1.1), myalgia (NRS) from 3.66(1.2) to 1.29(1.1), arthralgia (NRS) from 3.27(1.2) to 0.89 (0.8), and fatigue index (BFI) showed a reduction from 5.73(1.4) to 3.22(1.4). There was an increase in mobility in Ott's symptom from 2.24(1.2) to 2.86(0.9) cm, Schober's test 1.41(1.2) to 2.38(0.9) cm, Tom Meyer's test from - 8.23(6.5) to - 2.46(3.7) cm. Conclusion: In the recovery phase post COVID-19, some of the patients had long-time persistent musculoskeletal symptoms (fatigue, myalgia, arthralgia, back pain). These are a common reason for these patients to be referred for outpatient rehabilitation. In order to design a multi-component rehabilitation programme, it is necessary to take into account individual characteristics and comorbidities. The inclusion of physical modalities such as electrotherapy requires an accurate assessment of the rehabilitation potential and the presence of any counterindications. Therapeutic exercises have been proven to be effective in post COVID-19 patients. The results of this study show that the combination of interferential current therapy and therapeutic exercise can effectively reduce back pain, myalgia, arthralgia, and perception of fatigue. On the other hand, this multicomponent program resulted in improvement in functional tests in the studied patients. Due to the small sample size, it is advisable to continue the study in the future, covering a larger number of patients with long-standing musculoskeletal symptoms as part of post-COVID-19 syndrome, in order to design an effective strategy that can efficiently reduce negative health consequences and improve functional activity in these patients.

Keywords: Post-COVID-19 Rehabilitation, Musculoskeletal symptoms, Transcutaneous electrical nerve stimulation, Interferential current therapy, Therapeutic exercises, Functional activity.
Field: Medical sciences and Health

INTRODUCTION

The emergence of the new corona virus (SARS-CoV-2) in 2019 caused the infection of many people worldwide. (Horton R. (2020)) The potential of the virus to spread rapidly caused the development of a pandemic that required effective acute infection treatment strategy while limiting the size of the

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affected population very quickly. The pandemic has affected and has changed the life style of millions of people around the world (Dos Santos PK. et al. (2022)) At highest risk and potentially most affected were, patients with chronic diseases and the elderly. (Mackenzie & Smith (2020)).

The disease was initially thought to affect primarily the respiratory system, with asymptomatic to mild manifestation. In the severe presentation of SARS-CoV-2 infection, some patients develop severe acute respiratory syndrome in addition to suffering from pneumonia. (Jiang F et al. (2019)) As the pandemic progressed, COVID-19 proved to be a multi-organ and multi-system disease. It progresses with acute, pathological damage to the respiratory system, but also affects the cardiovascular, nervous, kidney, gastrointestinal, and other systems, with musculoskeletal, hepatic, renal, dermatological, psychosocial, and cognitive impairments. (Barker-Davies et al. (2020); Zhang al. (2020)).

These multisystem effects can persist over time and cause the development of prolonged symptoms, characterized as Long COVID-19 lasting from 4 to 12 weeks, or post COVID-19 syndrome, lasting over 12 weeks. Cases have been described in which recovery lasts for more than 6 months. (Azadvari M. et al. (2022); Greenhalgh et al. (2020) Jimeno-Almazán et al. (2021)); Castro JP et al. (2022)) Most common symptoms include: fatigue, post-excersise malaise, breath shortness, headache, neurocognitive complaints such as: brain fog, disorientation, high stress levels, increased anxiety, depression, (Pfefferbaum & North (2020); Fujita et al. (2021); Hou et al. (2020)), difficulty performing activities of daily living, limited work capacity. (Baig (2020)) The musculoskeletal system affection is characterized by symptoms such as fatigue, arthralgia, myalgia, and muscle weakness. Musculoskeletal symptoms are commonly reported in the acute and post-acute phases of COVID-19. (Disser NP. et al. (2020)) These symptoms, may persist for weeks or months after the infection. (Akbarialiabad H. et al. (2021); Dos Santos et al. (2022))

Gradually, the number of patients who have experienced the acute phase of the infection and who have persistent musculoskeletal symptoms is also increasing (Lauwers M. et al. (2022)) These concomitant symptoms, complicate functional recovery and patients often report lower than premorbid functional activity. Physical factors, although considered an adjuvant therapy, would be potentially effective in the recovery period following COVID-19. Conducting rehabilitation, could limit pathological consequences, improve respiratory system functional status (Mollova K. et al. (2022)), reduce chronic pain level, myalgia, and arthralgia, and affect fatigue perception, as well as improve quality of life (Petrova M. et al. (2023))

Rehabilitation programs are most often conducted in outpatient settings (Betschart M. et al. (2021)) after patients have been accurately assessed for rehabilitation potential and comorbidities by a multidisciplinary team of specialists. In case of necessity and concomitant pathology, rehabilitation can also take place in hospital settings (Takeva I. et al. (2021) Negm AM. et al. (2022))

The aim of this research was to investigate the therapeutic effectiveness of a multi-component rehabilitation program including: transcutaneous interferential current therapy and therapeutic exercises in patients with musculoskeletal symptoms in post COVID-19 syndrome.

MATERIALS AND METHODS

62 patients, mean age 55.9(13.99), aged 21 to 79 years, with persistent musculoskeletal symptoms in the recovery phase after experiencing COVID-19 were included in this study. Arthralgia was recorded as pain in any joint for which there was no prior radiologically proven, degenerative, traumatic, or rheumatic disease. Myalgia was recorded as muscle pain that could not be explained by other concomitant disability. Fatigue was recorded according to the patients' subjective description. All patients underwent a ten-day treatment course in an outpatient setting, including transcutaneous application of interferential current with four electrodes. The therapeutic parameters were selected with analgesic, trophic and stimulatory effects (90-100 Hz, 5min and 0-100 Hz, 15min). Immediately after electrotherapy, kinesitherapy was performed including: breathing exercises, aerobic training, active and resistance exercises for the limbs, postural control exercises and exercises to improve the mobility of the peripheral joints and the axial skeleton.

Prior to therapy, patients were informend about the the goals and therapeutic approaches of the rehabilitation. The rehabilitation course was carried out in accordance with the Declaration of Helsinki, after written informed consent and in compliance with current anti-epidemic measures.

Visual analogue scale (VAS) was used to assess the back pain results (0 to 100 mm). Higher score indicates greater pain intensity. Numerical Rating Scale (NRS)) was used to assess arthralgia and myalgia. Pain is measured in whole numbers from 0 "no pain" to 10 "worst possible pain". Brief Fatigue Inventory (BFI) was used to describe fatigue in the past 24 h. The BFI is 9 position scale with 0 to 10 possible answers for each of them. Fatigue scores are as follows: 1-3 (mild), 4-7 (moderate), and 8-10 (severe). Levels of 4 (4.33) or more suggest the need for intervention apart from prevention activities. (Mendoza

TR. et al. (1999)) Ott Sign was used for measuring the range of motion (ROM) of the thoracic spine. From processus spinosis C7, 30 cm along the spine in the caudal direction are measured and marked. The patient then flexes the thoracic compartment and 30 cm are measured again. Normally, the difference between the two measurements is 2 to 4 cm. Schober's test was used to determine a lumbar spine range of motion (flexion). From the patient standing upright, are measured 10 cm from the processus spinosus to L5 cranial and marked. The patient then flexes the spine maximally and the difference between the two measurements is recorded. Tom Meyer's test was used for joint flexion mobility in the spine and hip joints. The patient steps onto a platform and bends over with arms pointing down. The distance from the tip of the third finger to the ground is measured in centimeters. Above the platform the distance is recorded with a '-' sign, below with a '+'. SPSS v. 24.0 is used for statistical processing purposes.

The results were reported before and after the rehabilitation. The statistical significance level was specified as ($p<0.05$).

RESULTS

Musculoskeletal symptoms in the observed patients persisted for an average of 12 weeks (Me(SD)), ranging from 7 to 20 weeks, and included: myalgia in 46.8% (29), arthralgia 29.0% (18), pain in various back departments 79.0% (49), fatigue 66.1% (41). Inpatient treatment of acute COVID-19 was performed in 35.5% (22) of patients, and home and outpatient treatment in 64.5% (40). There was a statistically significant reduction (Mean (SD)) after therapy in back pain (VAS) from 4.88(1.5) to 1.93(1.1) ($p<0.05$), myalgia (NRS) from 3.66(1.2) to 1.29(1.1) ($p<0.05$), arthralgia (NRS) from 3.27(1.2) to 0.89 (0.8) ($p<0.05$), and fatigue index (BFI) showed a reduction from 5.73(1.4) to 3.22(1.4) ($p<0.05$). There was an increase in mobility in Ott's symptom from 2.24(1.2) to 2.86(0.9) cm (Z=6.174, $p<0.001$), Schober's test 1.41(1.2) to 2.38(0.9) cm. (Z=6.515, $p<0.001$), Tom Meyer's test from - 8.23(6.5) to - 2.46(3.7) cm. (Z=-6.568, $p<0.001$). The results are published in Table 1.

Table 1. Dynamics in myalgia, arthralgia, fatigue, and functional tests

Sympoms assessment	Total(n=62) % (n)		Female(n=42) % (n)		Male (n=20) % (n)	
Post COV- 19 period	12 (7-20)		13.5 (7-20)		11.50 (8-17)	
Hospital treatment	35.5 (22)		28.6 (12)		50.0 (10)	
Home treatment	64.5 (40)		71.4 (30)		50.0 (10)	
Sympoms assessment	Before rehab	After rehab	Before rehab	After rehab	Before rehab	After rehab
Back pain	49 (79.0)	49(79.0)	35 (83.3)	35 (83.3)	14 (70.0)	14 (70.0)
VAS (Me±(SD))	4.88±1.5119	1,93±1,19	4.88±1.61	1.914±1.23	4.89±1.28	1.979±1.15
without pain **n (%)**	13 (21.0)		7 (16.7)		6 (30.0)	
Cervical pain 11 (17.7) Cervical and thorax pain 7 (11.3) Lumbar pain 24 (38.7) Back pain 7 (11.3)			Cervical 8 (19.0); Cervical and thorax 6 (14.3); Lumbar 15 (35.7); Back 6 (14.3)		Cervical 3 (15.0); Cervical and thorax 1 (5.0); Lumbar 9 (45.0); Back 1 (5.0)	
Myalgia n (%)	29 (46.8)	28 (45.2)	18 (42.9)	18 (42.9)	11(55.0)	10 (50.0)
NRS (Me±(SD))	3.66 ± 1.21	1.29 ± 1.12	3.44 ± 1.15	1.11 ± 1.08	4.02 ± 1.27	1.60 ± 1.17
without myalgia	33 (53.2)		24 (57.1)		9 (45.0)	
Total 5 (8.1); Cervical 5 (8.1); Cervical and thorax 1 (1.6); Lumbar 9 (14.5); Shoulder and Upper Limb 4 (6.5); Lower limb 5 (8.1)			Total 4 (9.5); Cervical 5 (11.9); Cervical and back 1 (2.4); Lumbar 3 (7.1); Shoulder and Upper limb 1 (2.4) Lower limb 4 (9.5)		Total 1 (5.0) Lumbar 6 (30.0) Shoulder and Upper limb 3 (15.0) Lower limb 1 (5.0)	
Arthralgya	18 (29.0)	18 (29.0)	12 (28.6)	12 (28.6)	7 (35.0)	6 (30.0)
NRS (Me±(SD))	3.27±1.165	0,89 ± 0,76	2.92±1.084	0,67 ± 0,65	3.89±1.107	1,33 ± 0,82
without Arthralgya	44 (67.7)		30 (71.4)		13 (65.0)	
Arthralgya: Shoulder 6 (9.7) Rist/Finger 1 (1.6) Hip 3 (4.8) Knee Joint 6.1 (10)						
Fatigue	41 (66.1)		31 (73.8)		10 (50.0)	
BFI (Fatigue)	5.73 ± 1.43	3.22 ± 1.39	5.76 ± 1.61	3.20 ± 1.52	5.62 ± 0.64	3.26 ± 0.97
without **Fatigue**	21 (33.9)		11 (26.2)		10 (50.0)	

DISCUSSION

As the pandemic of COVID-19 progresses, there are increasing numbers of patients who overcome the acute phase of the disease but continue to have persistent symptoms. These symptoms affect not only the respiratory system but also other organs and systems, including the musculoskeletal system. This calls for an effective post-covid care strategy (Barker-Davies et al. (2020)) and rehabilitation in order to impove recovery and to reduce the effects of post-covid symptoms. (Betschart M. et al. (2021)) Nowaredays, a number of studies have reported that the main musculoskeletal symptoms include: arthralgia, myalgia, chronic fatigue, pain in various back compartments. (Cipollaro L. et al. (2020); Motaqi M. et al. (2021))

In this study, patients referred for outpatient rehabilitation were found to have more than one musculoskeletal symptom. Almost one third of the patients had arthralgia, about half complained of myalgia, over 60% experienced fatigue, and back pain (summed different areas) occurred in three quarters of the patients. It should be noted that only one third of the patients had a severe acute infection from COVID-19, which was a reason for fospitalisation. Possible reasons for the presence of persistent musculoskeletal symptoms that are still debated are: causes that are a consequence of an excessive immune or inflammatory response (Dos Santos et al. (2022)) (indirect consequences of COVID-19 on skeletal muscle and joints) increased incidence of peripheral thrombosis that disrupts blood flow to the muscles and causes damage to the musculoskeletal system, (Magro C. et al. (2020)) or direct damage from the virus to the endothelium or peripheral nerves. (Cipollaro et al. (Dos Santos et al. (2022)) Furthermore, prolonged immobilization leads to impaired cardiorespiratory function, joint stiffness, contractures, postural instability, etc. Another reason for the presence of muscle weakness could be a consequence of catabolic muscle loss during prolonged immobilization and treatment in the intensive care unit (Hosey & Needham (2020))), or result of the use of steroid drugs or neuromuscular blocking agents (Simpson & Robinson (2020)), or by directly damaging skeletal muscle when SARS-CoV-2 binds to ACE2 receptors and the virus enters the muscle cell. (Dos Santos et al. (2022)) Furthermore, prolonged immobilization leads to impaired cardiorespiratory function, joint stiffness, contractures, postural instability, etc. Acquired muscle weakness and reduction of muscle mass, lead to functional impairment of the musculoskeletal system, delay the recovery process and limit the functional activity of patients. (Simpson & Robinson (2020))

Because of the multi-organ and multi-system impairment caused by COVID-19, rehabilitation of patients with persistent symptoms should address not only respiratory, cardiac or neurological problems, but also the persistent effects on the musculoskeletal system, including: myalgia, peripheral muscle weakness, muscle contractions, arthralgia, and limited mobility in joints, balance and postural disorders, and physical weakness. (Motaqi M. et al. (2021)) The application of a multi-component rehabilitation program is an effective strategy for a range of chronic diseases in elderly patients and those with multiple comorbidities. (Motaqi M. et al. (2021)) However, each patient should receive a program specific to his/her needs, which should be adapted depending on the degree of involvement of the musculoskeletal, cardiopulmonary, etc. systems.

The clinical algorithm includes: a detailed examination of the patient with a precise kinesiological assessment and determination of the rehabilitation potential and the design of a rehabilitation programme including the specific scientifically applied methodologies. When combining them, the aim is to achieve synergism and to avoid antagonism between physical factors. (Koleva I. et al. (2022))

There is much evidence that physical exercise improves respiratory function (Mollova K. et al. (2021); Hockele et al. (2022)), cardiovascular function, reduces mortality, need for hospitalization, and improves patients' functional status. Implementation of exercise and education programs, in patients with cardiopulmonary disease are also effective in improving functional and psychosocial status and improve quality of life. In patients with post COVID-19 syndrome, rehabilitation programs including overall muscle strengthening, (including stationary bicycle training), (Jimeno-Almazán et al. (2021)) occupational therapy sessions that improve daily activity, (Asly & Hazim (2020) as well as strength training (at low loads, low range and repetitions without failure) would also have a positive effect. These improve maximal dynamic strength and skeletal muscle trophicity, and reduce feelings of discomfort, fatigue and stiffness. All these, make the therapeutic exercises, suitable for patients with post-COVID-19 syndrome, who are demotivated to perform physical exercises due to fatigue, deconditioning and low tolerance to exercise and exercise. (Jimeno-Almazán et al. (2021)) On the other hand, the inclusion of therapeutic exercises in the rehabilitation program, leads to a reduction in anxiety and psychoemotional tension. Therapeutic exercises lead to improved quality of life, by increasing functional activity and modulating pain sensation. (Chen et al. (2020))

In this study, in addition to the therapeutic exercise complex in the multi-component rehabilitation program, transcutaneous interferential current stimulation (IFC) was applied to the patients. Interferential current therapy is a non-invasive non-pharmacological treatment used in clinical practice to reduce mainly musculoskeletal pain, edema, and spasticity and to increase muscle strength. (Özcan J. et al. (2004); Jin H K. et al. (2017) De-La-Cruz-Torres B. et al. (2021); Rampazo ÉP et al. (2022))

IFC, reduces stimulation of cutaneous sensory nerves (Wedenski's theory) below the electrodes and favors effects in deeply located tissues. (Noble GJ. et al. (2000) This effect is probably due to inhibition of C-nociceptive fibers. Pain reduction, is also mediated by the involvement of a "descending pain suppression mechanism" involving endogenous opioid substances. In terms of influence on muscle, IFC therapy (m. quadriceps femoris), can result in 50% higher activation of the quadriceps compared to that of maximal voluntary contraction (Taradaj J. et al. (2013); Pinfildi CE. et al. (2018)) Youn JI. et al. (2016), found that IFC reduced muscle fatigue and stiffness. Transcutaneously, IFT has been successfully applied to reduce musculoskeletal pain. (Adedoyin et al. (2005)) Musculoskeletal pain, is often associated with fatigue, result of metabolic, energetic and structural changes in the muscles. These changes, are attributed to a lack of oxygen and nutrients supplied by blood vessels, or to altered activity of nerve structures. (Cifrek M. et al, (2009)) Several clinical trials, have shown that IFC is an effective method of pain relief in patients with osteoarthritis for at least 1 week up to 6 months (Itoh K. et al. (2008); Defrin R. et al. (2005); Burch FX. et al. (2008) Adedoyin et al. (2005); Mratskova G. et al. (2021)) In another study, Corrêa J. et al. (2016) recorded a good analgesic effect of IFC in non-specific chronic low back pain (Corrêa J. et al. (2016)). A better analgesic effect of 100Hz frequency in nonspecific low back pain is reported by Almeida N. et al. (2020) and Hussein HM. et al. (2022)) IFC therapy may be effective for reduction of cervical and lumbar spine pain, knee joint osteoarthritis, and postoperative pain. Frequencies in the range of 30-180 Hz are considered to be most effective, with a treatment duration of 20-40 minutes, at a high enough intensity to induce a profound effect in the musculature without causing discomfort (Rampazo & Liebano (2022)).

With regard to the implemented, multi-component rehabilitation program, after completion of the rehabilitation course in the observed group of patients with persistent musculoskeletal symptoms after COVID-19, a fatigue reduction to levels that did not require further intervention beyond prevention activities was found (Mendoza TR. et al. (1999)). There was a reduction in muscle and joint pain levels and improvement in the administered functional tests. On the other hand, it should be mentioned that this study has a number of limitations. The small sample size could have influenced the obtained results. The clinical and functional assessment methods used, also contain an element of subjectivity, which could also affect the results, although these assessment tools are used in routine physiotherapy practice.

CONCLUSION

In the recovery phase post COVID-19, some of the patients had long-time persistent musculoskeletal symptoms (fatigue, myalgia, arthralgia, back pain). These are common reasons for the patients to be referred for outpatient rehabilitation. In order to design a multi-component rehabilitation programme, it is necessary to take into account individual characteristics and comorbidities. The inclusion of physical modalities such as electrotherapy requires accurate assessment of the rehabilitation potential and counterindications. Therapeutic exercises have been proven to be effective in post COVID-19 patients. The results of this study show that the combination of interferential current therapy and therapeutic exercise can effectively reduce back pain, myalgia, arthralgia, and perception of fatigue. On the other hand, this multicomponent program resulted in improvement in functional tests of the studied patients. Due to the small sample size, it is advisable to continue the study in the future, covering a larger number of patients with long-standing musculoskeletal symptoms as part of post-COVID-19 syndrome, in order to design an effective strategy that can efficiently reduce negative health consequences and improve functional activity in these patients.

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