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RESEARCH ARTICLE

NEUROMUSCULAR AND LOW FREQUENCY ULTRASOUND TREATMENT IN CHRONIC AND SUBACUTE NECK PAIN

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ABSTRACT

Neck pain is a major cause of reduced quality of life and a serious public health problem because of its high prevalence and its costs in terms of health care. Specific conservative treatments, both for subacute and chronic phases, include patient education, stretching exercises, pharmacological therapies, intra-articular injections, ultrasound therapy, myofascial manual therapy, electrotherapy, acupuncture and ischemic compression. Aim of this study is to assess the effect of treatment with ultrasound (Us) alone, with manual neuromuscular therapy (Nm) alone and with ultrasound in combination with the manual therapy Neuromuscular (Us-Nm) in subjects with mechanical subacute or chronic neck pain. According to this thirty subjects were randomly assigned to one of three different treatment groups (Us; Nm; Us-Nm). The assessment was performed by the Numeric Pain Rating Scale (NPRS) and Neck Disability Index (NDI). The results of this study showed how all the treated groups had a significant improvement in the subjective feeling of pain and the related disability, at the end of the 4 weeks of treatment (T1); these results showed a stabilization in the midterm follow-up (T2). In group 2 (Nm treatment only) was also found a significant reduction of disability and pain during the time lapse between the end of treatment and the subsequent follow up. These evidences lead us to confirm the effectiveness of both treatments applied both separately or together. However, the treatment with neuromuscular manual therapy appears to be more effective in the long term, inducing a further improvement of all symptoms even after two weeks of discontinuation of treatment.

INTRODUCTION

Neck pain is a major cause of reduced quality of life and a serious public health problem because of its high prevalence and its costs in terms of health care (Murray *et al.,* 2012) (Borghouts *et al.,* 1999) (Hansson *et al.,* 2005). Among the general population, 71% of adults are suffering from neck pain at least once in their lives (Borghouts *et al.,* 1999). It is more common in women than in men (Fejer *et al.,* 2006). The annual prevalence is between 27.1% and 47.8% (Hansson *et al.,* 2004). Neck pain also limits the working ability, leading to a reduction in productivity. The increase in the recourse to health care services involves a large financial burden [Cote *et al.,* 2008) (Maniadakis *et al.,* 2000). Neck pain is considered a major cause of disability worldwide; For this reason, some authors believe that the cervical disability should require greater attention by governments, health professionals and researchers (Hoy *et al.,* 2014). The mechanical neck pain is due to irritation or myofascial dysfunction or cervical facet joints. The diagnosis is to exclusion because the medical scans do not show significant alterations in tissue (Van Der Velde, 2011). Several studies have analyzed the causes of neck pain of myofascial origin, but the etiology related to it is not fully understood (Skillgate *et al.,* 2015). It occurs commonly with myofascial pain (MP), usually caused by myofascial trigger points (MTrPs) (Simons *et al.,* 1999). In the muscles of the neck, trigger points have been associated with radiating pain in the fascial tissue and the skull. The myofascial trigger points (MTrPs) of neck and shoulder muscles are often associated with neck pain, contributing to the symptoms (Muñoz-Muñoz *et al.,* 2012) (Fernández-de-las-Peñas *et al.,* 2007). The muscle most often affected with MTrPs in the neck region is the trapezius (Sciotti *et al.,* 2001) (Meleger *et al.,* 2007), in particular in its upper fibers, for this reason the upper trapezius area is the most painful area in neck and shoulder (Fischer, 1987).

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Other structures responsible for neck pain are the joint's facets (Cooper *et al.,* 2007). The clinical features are often, but not always, pain during palpation over the facet or pain on paraspinal muscles, cervical pain during extension or rotation movements and absence of neurological desease associated (Fukui *et al.,* 1996). For the diagnosis of Facet Syndrome, diagnostic images are usually not useful, if not to exclude other sources of pain such as fractures or cancer. Signs of cervical spondylosis, narrowing of the intervertebral foramen, bony spurs and other degenerative modification have the same prevalence in people with and without neck pain (Friedenberg 1963). Some studies have determined the prevalence of painful joint's facets in patients with neck pain; some authors have shown that blocking the medial branch of the dorsal horn of the spinal column, could lead to very positive results in pain reduction (Cooper *et al.,* 2007). As for the specific treatments, it's possible to work in a conservative way both for subacute and chronic phases, which include patient education, stretching exercises, pharmacological therapies, intra-articular injections, ultrasound (US), myofascial manual therapy, electrotherapy, acupuncture and ischemic compression (Fricton *et al.,* 1990).

In 2012, the Cochrane review showed that myofascial manual therapy, with manipulation and mobilization, is often used in the treatment of neck pain. However, the authors did not considered satisfactory the long-term results about the therapeutic effect and there are very few recommendations for the execution of such therapy in the treatment of neck pain. Therefore, further studies are needed in order to assess the long-term effects of treatment (Gross *et al.,* 2010). Ultrasound therapy is commonly used in the soft tissue pain treatment and management (Hayek *et al.,* 2015). During the session it leads to thermal and non-thermal effects in the tissue. During the absorption of the ultrasonic waves in the tissue and their reflection between the surfaces, the thermal energy is converted into heat. US studies have shown that this mechanism causes a significant increase in the intra-articular temperature. At the same time, US therapy has analgesic effects and increases vascularisation., Furthermore, have been demonstrated positive effects of micro-massage induced by the sound waves at high frequency (Tuncer, 2000). In 2001 a review of the Philadelphia Panel did not show clinically significant benefit of ultrasound therapy in NP (Philadelphia Panel, 2001). Moodley have also shown a beneficial effect of ultrasound therapy in the short and midterm on mechanical neck pain and with a significant increase in the joint R.O.M. (Moodley *et al.,* 1999). The efficacy of treatment with ultrasound and manual therapy of myofascial trigger points (MTrP) neck therefore remains uncertain (Campa-Moran *et al.,* 2015). Experts recommend a multimodal approach since the neck pain is often associated with several disorders and symptoms which do not necessarily always respond to a single treatment (Jull *et al.,* 2010).

MATERIALS AND METHODS

Aim of this randomized controlled trial is to determine the effect of treatment with ultrasound (Us), with manual Neuromuscular therapy (Nm) and with ultrasound in combination with the manual therapy Neuromuscular (Us-Nm) in subjects with mechanical subacute or chronic neck pain.

Thirty patients (12 males and 18 women) with mechanical neck pain in the subacute (30 to 90 days in duration) or chronic phase (> 90 days duration), aged between 48 and 63 years (mean 55, 5 ± 7.5) were recruited. They were randomized into three treatment groups. Participants were recruited from the Rehabilitation and Physical Medicine Unit, University "G. D'Annunzio", Chieti, Italy. Patients were randomly assigned to one of three different treatment groups (Us, Nm, Us-Nm):

- Group 1 (10 patients, Us) made 8 sessions of ultrasound therapy at low frequency (duration: 20 minutes), twice a week for four weeks;
- Group 2 (10 patients, Nm) made 8 sessions of Neuromuscular therapy (duration: 45 minutes), twice a week for four weeks;
- Group 3 (10 patients, Us + Nm) made 8 sessions of ultrasound at low frequency (duration: 20 minutes) followed by neuromuscular manual therapy (duration: 45 minutes).

Inclusion criteria: mechanical neck pain in progress, subacute (30 to 90 days in duration) or chronic (> 90 days duration) phase. Subjects were excluded if they had acute neck pain (<30 days); irradiation in the upper limbs; dizziness; headache; stenosis of the cervical spine; severe comorbidities. The rating scales used for the assessment were the Numeric Pain Rating Scale (NPRS) and Neck Disability Index (NDI). The evaluations were performed before the first treatment session (baseline, T0), after four weeks (at the end of the therapeutic cycle, T1) and two weeks after the last therapy session (follow-up period, T2).

Neck Disability Index (NDI): The Neck Disability Index (NDI) is a self-assessment questionnaire used to determine the incidence of neck pain on the patient's daily life. The NDI has ten questions in the following items: pain intensity, personal care, effort, reading, headaches, concentration, work, driving, sleeping and recreational activities. Each question contains six response options with a score from 0 (no disability) to 5 (total disability). The numeric results of the various sections are then added together. The score is reported on a 0-50 scale, with 0 being the best score possible and 50 the worst. Alternatively, the score may be indicated by 0-100. The rating is often reported as a percentage (0-100%), which includes 5 levels:

0% - 20% - small disability
21% - 40% - moderate disability
41% - 60% - severe disability
61% - 80% - very severe disability
81% - 100% - disability.

Numeric Pain Rating Scale (NPRS): Measuring the subjective intensity of pain. The NPRS is a 11-point scale, from 0 to 10, do "0" = no pain, "10" = most intense pain imaginable. Patients verbally indicate a value that is more in line with the intensity of the pain they have experienced in the last 24 hours. The NPRS has good sensitivity and produces data that can be analyzed statistically. The treatments selected for the study were ultrasound therapy and neuromuscular manual therapy.

Ultrasound therapy: The mechanism of action of the ultrasound therapy is characterized by two main components: an intense pulsation effect on cellular connective and

diathermal effect; a third factor is represented by the chemical effect; in fact the ionization phenomena lead to chemical effects in the body, which is not possible to obtain in any other way. So the application of ultrasound therapy on tissues can give some biological effects:

- **Mechanical:** consisting of micromassage and microcostriction of the cell, with an increase in metabolism and mitosis, through a rhythmic compression and decompression of the tissue;
- **Thermal:** produced from the deep and superficial vasodilatation;
- **Chemicals:** consisting from colloidal flocculation, gases elimination, bacteria destruction, increased skin permeability.

In this trial the treatment with ultrasound (US) was performed at low frequency with SIRIO system (W 1-3 doses / cm²). This device is a low-frequency ultrasound generator (38 KHz +/- 2KHz), managed by a micro-processor, capable of delivering acoustic waves in constant or pulsed mode, and simultaneously to control 100% of the cycle of revolution, allowing, in case of excessive absorption by the handpiece, to immediately lower the power output. The micro-processor can produce acoustic waves in continuous mode, pulsed or continuous and pulsed simultaneously. Sirius is provided with two non-invasive transducers which can be flat or concave; its effectiveness exploits the different effects of its own ultrasound (Mechanical, vibrational, Thermal, cavitation) more vigorously within the tissues thanks to the low emission frequency that determines a greater depth of action. Each session lasted 20 minutes using two types of sensors: flat probe with pulsed emission (10 minutes per session); concave probe with pulsed emission (10 minutes a session). The cervical joint's facets were treated bilaterally.

Neuromuscular Manual Therapy: Neuromuscular therapy is a comprehensive and advanced system of soft tissue manipulation which deals primarily with chronic pain and myofascial pain syndromes. Based on neurophysiological principles, this therapy restores homeostasis of the central nervous system and the musculoskeletal system using various Swedish massage therapy techniques; in particular it is used to effectively treat trigger points in the muscle, in its end, tendons, and ligaments. It is also used to stretch the contracts muscles, chronically shortened, and to balance the coordinated work of the muscle groups, especially when working with patients suffering from postural dysfunction or dysmorphisms. These treatments can also be used to improve the function of the joints and muscles and general biomechanics; it can shorten the healing process through for example the release of endorphins. There are a few drawbacks: the most common include bruising, phlebitis, varicose veins, open wounds and skin infections. In neuromuscular therapy, therapists should first establish what are the areas of soft tissues with chronic muscle shortening and where there are typical suffering areas with trigger points, using techniques such as effleurage, petrissage and friction. Once the region to be treated has been found, they apply more specific techniques such as:

Techniques of stretching as myofascial release, deep effleurage, stretching and deep stretching in order to decrease the chronic tension of the pathologically contracted muscles; pressure on trigger points or clamp tecnique in order to rebalance trigger points in the soft tissues; active stretching inn order to improve R.O.M. in the painful joint. Neuromuscular therapy treats pain and the unpleasant sensation perceived in the surrounding area but also implies an effect on the pain "reported" to regions of the body far from the affected area. A patient with referred pain caused by trigger points may also develop acute symptoms, which may also lead to great disability in performing daily activities. The therapeutic goals of manual therapy are to:

- Identify and isolate the tissue irregularities related to chronic myofascial pain;
- Restore the correct local blood perfusion in the tissue and decrease ischemia, or restore the temporary reduction of blood supply, so that the tissues can start the healing process;
- Reduce hypertonia, ie the excessive muscular tone, and spasm to restore the neurophysiological identity;
- Reduce pain in the dysfunctional tissue;
- Reduce and eliminate the aberrant or excessive stimulation of the affected nerve and normalize the reflex activity of the neuromuscular system;
- Eliminate or reduce the trigger points;
- Increase ROM of the compromised joints;
- Release fascial adhesions or contractures and stretch the chronically shortened muscles, the fascia and other soft tissues (J. Granger, 2011).

Each treatment lasted 45 minutes.

RESULTS

Neck Disability Index (NDI)

The analysis of the results showed significant changes between the pre-treatment assessments (baseline, T0), at the following ones, i.e. T1 (end of treatment) and T2 (mid-term follow-up performed two weeks after the ending) (Table 1). Group 1, treated with low-frequency ultrasound (8 sessions - twice a week for four weeks) on facet joints, showed, as regards the cervical disability, significant differences ($P < 0.001$), both at T1 and T2 compared to baseline. No significant change occurred between T1 and T2 assessment (figure 1):

Group 2, treated with neuromuscular manual therapy (8 sessions - twice a week for four weeks), showed significant differences ($P < 0.001$), both at T1 and T2 compared to baseline. A significant difference was also found comparing the results between T1 and the mid-term follow up (T2) ($p<0.05$) as showed in figure 2. The results of Group 3, treated with ultrasound low frequency applications on the facet joints and neuromuscular manual therapy (8 sessions - twice a week for four weeks) also showed a significant difference ($P < 0.001$), both at T1 and T2 compared to baseline and in the comparison between T1 and the mid-term follow up (T2) ($p<0.05$) as showed in figure 3.

Numeric Pain Rating Scale (BPRS): The analysis of the results showed a significant improvement with regard to the subjective pain between the assessments made before the start of treatment (baseline, T0), at the end of treatment (T1) and two weeks after the last treatment (mid-term follow up, T2) (Table 2).

Table 1. trend of Neck Disability Index (NDI) in the 3 groups

Measure	Groups	Baseline mean (SD)	T1 Mean	T2 Mean	T1 versus Baseline mean difference	P value	T2 versus Baseline mean difference	P value
NDI	Us	52±0,09	13±0,06	12±0,06	-39	<0,001	-40	<0,001
	Nm	39±0,05	10±0,01	6±0,02	-29	<0,001	-33	<0,001
	Us+Nm	28±0,06	10±0,1	8±0,01	-18	<0,001	-20	<0,001

Table 2. trend of NPRS in the 3 groups

Measure	Groups	Baseline mean (SD)	T1 Mean	T2 Mean	T1 versus Baseline mean difference	P value	T2 versus Baseline mean difference	P value
NPRS	Us	7,3±0,82	2,2±1,39	2,1±1,44	-5,1	<0,001	-5,2	<0,001
	Nm	7,8±1,13	3,5±0,97	1,4±1,17	-4,3	<0,001	-6,4	<0,001
	Us+Nm	7,4±1,08	4±0,81	4,2±1,39	-3,5	<0,001	-3,3	<0,001

Group 1, treated with low-frequency ultrasound (8 sessions - twice a week for four weeks) on facet joints, showed, as regards the subjective pain assessment, significant differences (P <0.001), both at T1 and T2 compared to baseline. No significant change occurred between T1 and T2 assessment (figure 4):

Group 2, treated with neuromuscular manual therapy (8 sessions - twice a week for four weeks) showed significant differences (P <0.001) both at T1 and T2 compared to baseline; a significant improvement was also detected in the period between the second evaluation (T1) and the mid-term follow up (T2), as shown in figure 5:

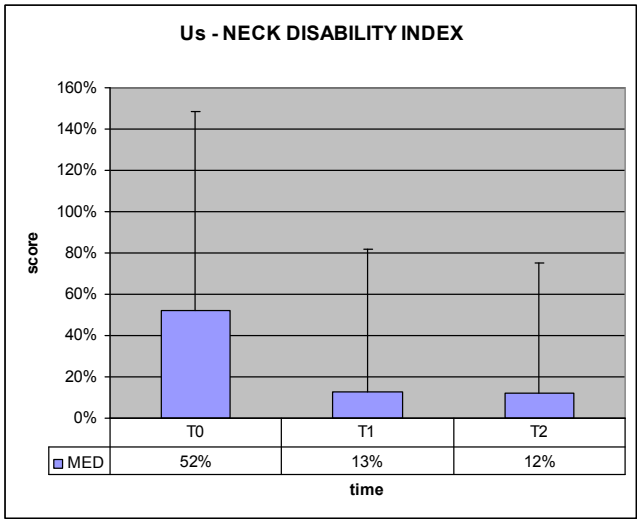

Figure 1. trend of Neck Disability Index results in group 1 (Us – group)

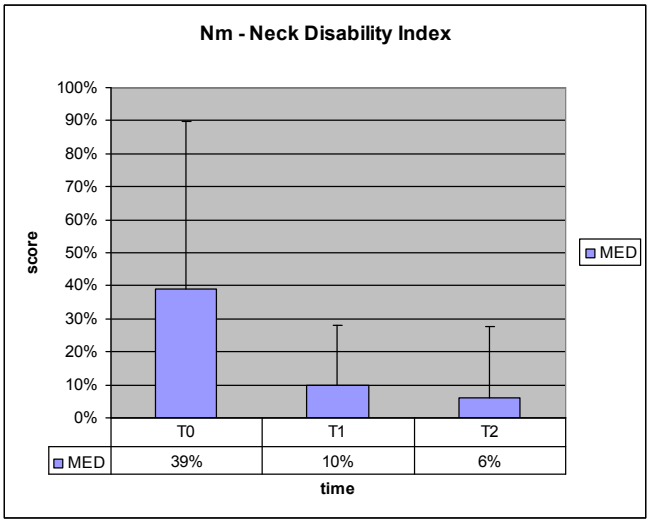

Figure 2. trend of Neck Disability Index results in group 2 (Nm – group)

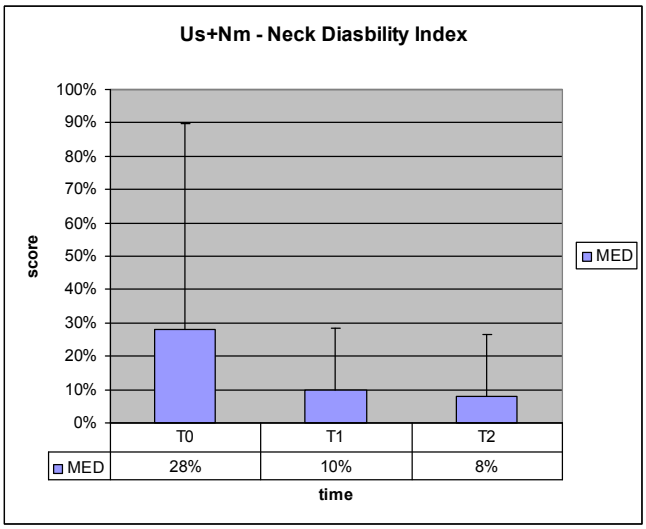

Figure 3. trend of Neck Disability Index results in group 3 (Us+Nm - group)

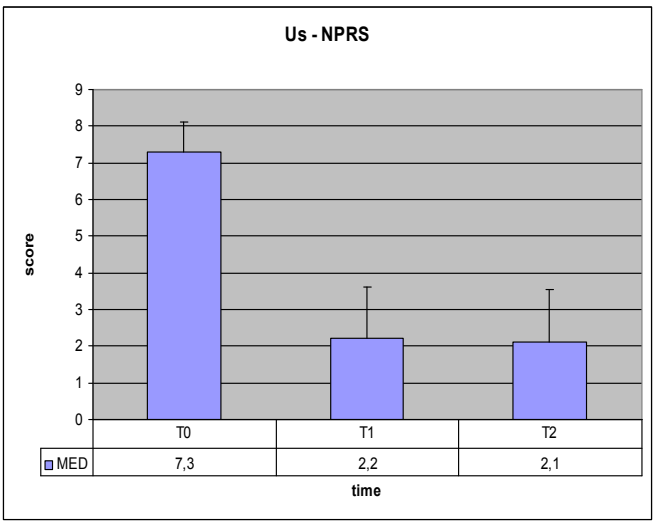

Figure 4. trend of NPRS results in group 1 (Us – group)

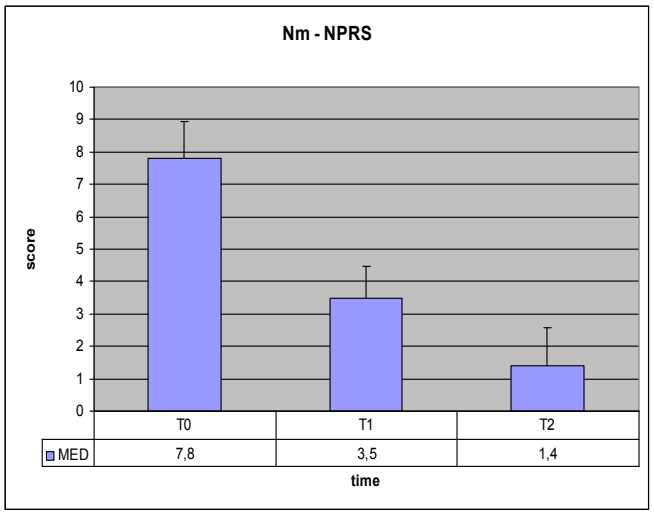

Figure 5. trend of NPRS results in group 2 (Nm – group)

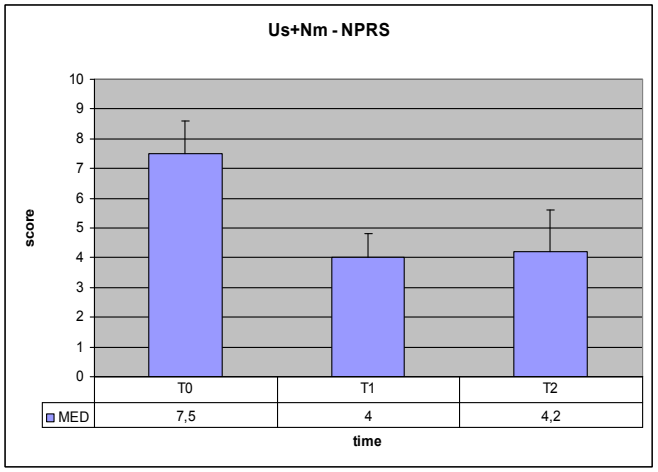

Figure 6. trend of NPRS results in group 3 (Us-Nm – group)

Group 3, treated with 8 sessions of both ultrasound and neuromuscular manual therapy (twice a week for four weeks) showed significant differences (P <0.001) as regards subjective pain both at T1 and T2 compared to baseline, as shown in figure 6.

Discussion and Conclusion

The results of this study showed how all the treated groups had a significant improvement in the subjective feeling of pain and the related disability, at the end of the 4 weeks of treatment (T1); these results showed a stabilization in the mid term follow-up (T2). In group 2 (Nm treatment only) was also found a significant reduction of disability and pain during the timelapse between the end of treatment and the subsequent followup. These evidences lead us to confirm the effectiveness of both treatments applied both separately or together. In fact the treatment of cervical pain with low frequency ultrasound and neuromuscular manual therapy, alone or in combination, appears effective both on cervical pain, of mechanical origin, and onsymptoms related to daily activities in the short term. However, the effectiveness of treatment with neuromuscular manual therapy appears to be more long lasting, inducing a further improvement of all symptoms, even after two weeks of discontinuation of treatment. Jull in a 2010 systematic review (Jull *et al.,* 2010) described the effectiveness of a multimodal therapeutic approach for myofascial pain syndrome, he described how it's difficult to isolate the individual effects of single treatment approaches rather than combined therapies (i.e., mobilisation, manipulation and soft tissue techniques; manipulation or mobilisation plus other physical medicine agents; mobilisation and manipulation plus exercise). Desai (Desai *et al., 2013*) also reviewed the efficacy of various myofascial pain syndrome treatment modalities, including pharmacological therapy, injection-based therapies and physical therapy interventions, assessing subjective pain, pressure threshold pain and range of motion. The evidence found significant benefit with multiple treatments, including diclofenac patch, thiocolchicoside and lidocaine patches. Trigger point injections, ischemic compression therapy, transcutaneous electrical nerve stimulation, spray and stretch, and myofascial release were also efficacious. The authors recommended to plan the treatment in a multimodal way, also including the treatment of underlying and combining pharmacologic therapie with various physical therapeutic modalities, manual myofascial therapy and injection therapies. Further studies with a larger sample are needed to confirm the efficacy of our protocol; however, our findings encourage us to continue in this direction and enable us to hypothesize an ideal treatment program.

Basing on these evidences and considering our significant results, with the mid-term positive effect of neuromuscular manual therapy on the dysfunctional area and on subjective symptoms, we can state that the ideal multimodal rehabilitative approach should consist in a treatment (8 sessions – twice a week) of combined therapy with ultrasound and neuromuscular manual therapy; as a another choice, when it's not possible to recur to this physical therapies, neuromuscular manual therapy, applied at the same frequency (8 sessions – twice a week) could be useful even alone, due to the better results in the long period, if compared to ultrasound therapy. As for the maintenance period we suggest the same multimodal approach consisting in low frequency ultrasound therapy and neuromuscular manual therapy with the frequency of one session a week for two months according to the patient's symptoms, in order to further improve the obtained result and stabilize the clinical condition of the patient even in the long term. Anyway, given that the prolonged application of physical therapies could result in high economic costs for the patient, we feel we can recommend as a second instance, also a maintenance therapy consisting of neuromuscular manual therapy applied alone once a week, by virtue of the best results highlighted for this therapy in the long term on the subjective well-being.

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