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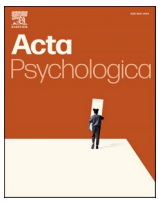

Myofascial release for adults with chronic neck pain and depression

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ABSTRACT

Background: Depression affects a significant portion of the global adult population, with chronic pain patients being particularly susceptible to severe depression. Pain and mental illness contribute to an imbalance in the autonomic nervous system, affecting heart function. Myofascial release promises to improve mental and physical health by addressing fascial dysfunctions.
Objective: This study aims to investigate the influence of myofascial release on emotional states and autonomic nervous system functioning in individuals with chronic neck pain and depression. Additionally, it seeks to evaluate the myofascial release effect on fascial properties, pain intensity and sensitivity, and cervical spine range of motion.
Method: Experimental Study.
Result: The study revealed significant enhancements in the myofascial release group, such as a substantial reduction in pain perception and stiffness, increased range of motion of the cervical spine, heart rate variability, positive affect, and pressure pain threshold. The effect sizes of these improvements ranged from small to large. No significant differences were observed in elasticity and tone.
Conclusion: The findings suggest that myofascial release has a positive impact on individuals with chronic neck pain and depression, particularly in reducing pain intensity. Integrating myofascial release into treatment approaches may be beneficial. However, further research is needed to confirm and expand upon these findings, explore long-term effects, and better understand the clinical significance of certain outcomes.
Trial registration: http://www.osf.io, doi.org/10.17605/OSF.IO/6F5RS

1. Introduction

According to the World Health Organization, depression affects approximately 5 % of the global adult population (WHO, 2023). Notably, patients with chronic pain are particularly susceptible to experiencing severe depression, although it often goes unreported (Agüera-Ortiz, Failde, Mico, Cervilla, & López-Ibor, 2010; Sheng, Liu, Wang, Cui, & Zhang, 2017). Individuals with comorbid pain and depression exhibit elevated symptoms of impaired physical, mental, and social functioning when compared to those suffering from only one of these conditions (IsHak et al., 2018). The neck region is recognized as a high-frequency site for the development of pain, especially the M. Trapezius (descending, transverse, and ascending part) is often restricted in patients who have a high level of stress or neck pain (Lidegaard & Andersen, 2018; Sjörs, Larsson, Dahlman, Falkmer, & Gerdle, 2009; Sollmann et al., 2023). There are pain pathways that affect specific brain regions, which seem to be involved in regulating mood (Sheng et al., 2017). Pain and mental illness contribute to ANS imbalance, impacting visceral functions, particularly the heart (Xhyeri, Manfrini, Mazzalini, Pizzi, & Bugiadrini, 2012). Reduced heart rate variability (HRV), reflecting sympathetic and parasympathetic activity, correlates with adverse physical and mental health (Lesnewich et al., 2019; Pham, Lau, Chen, & Makowsiki, 2021). Studies link depression with decreased short-term HRV (Koenig, Kemp, Beauchaine, Thayer, & Kaess, 2016; Thayer & Lane, 2009). Recent research suggests that myofascial release (MFR) may positively influence HRV (Wójcik & Siatowski, 2023). The abundant presence of fascia, a three-dimensional network of collagen-based connective tissue that extensively permeates the human body, has gained recognition for its multifunctional nature and interactions with bodily systems, impacting health's mechanical and emotional aspects (Bordoni & Marelli, 2017). Dysfunctional changes in fascial tissue, characterized by increased stiffness, decreased elasticity, and changes in innervation, have been observed in individuals with depression and chronic pain (Kondrup, Gaudreault, & Venne, 2022;

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Scientific evidence supports fascial therapy in decreasing pain, restoring optimal length, improving function, and relieving tissue tenderness (McKenney, Elder, Elder, & Hutchins, 2013). Fascial strain can result from trauma, inflammation, infections, malalignment, and structural imbalances, leading to reduced flexibility, increased pain, and limitations in movement (Davis, 2009). MFR, a manual therapeutic intervention developed by Barnes (1997), treats the fascial continuum. MFR produced immediate tissue changes and transient pain reduction in chronic low back pain, as demonstrated by pain intensity and thoracolumbar fascia thickness changes (Devantéry, Morin, Grimard, & Gaudreault, 2023). MFR techniques promise to improve mental health and manage chronic pain (Renoir, Hasebe, & Gray, 2013).

The research hypothesis was whether MFR would significantly impact emotional states, autonomic nervous system (ANS) functioning, fascial properties, pain intensity and sensitivity, and range of motion (ROM) of the cervical spine in individuals with chronic neck pain and depression. The hypothesis posited that individuals receiving MFR would show improvements in these outcome measures compared to those in the placebo control group, as indicated by statistically significant differences between the two groups after the intervention.

2. Method

2.1. Study design

This experimental study was approved by the Research Ethics Committee, Witten-Herdecke, Germany (No. 84/2022), and registered in the OSF registries (https://doi.org/10.17605/OSF.IO/6F5RS). The current report adheres to the Consolidated Standards of Reporting Trials (CONSORT) guidelines, including a 1:1 allocation ratio (Kwakkenbos et al., 2021). All participants provided signed informed consent to participate in the study. The Participants were randomized into two conditions, with one group receiving a myofascial release of the M. Trapezius and the second group receiving a sham laser placebo intervention. In addition to the study protocol, supplementary variables unrelated to the experimental study were collected for further analysis. These additional variables, such as ultrasound measurements, were obtained to explore secondary research questions beyond the scope of the present experimental study.

2.2. Sample size

To determine the appropriate sample size, the G*Power 3.1 software was used. The statistical analysis chosen was a *t*-test, specifically focusing on the distinction between two independent means. A normal distribution was assumed, and the significance level was $p = 0.05$. The effect size of 0.5 was selected based on an a priori assessment that considered prior research findings and the magnitude of the expected differences. This effect size estimation indicated that each group should include 64 patients to attain a statistical power of 80 % (Faul, Erdfelder, Lang, & Buchner, 2007).

2.3. Participants and setting

Eligibility criteria were established to ensure homogeneity within the participant pool and enable meaningful comparisons between the experimental and placebo control groups. Inclusion criteria were as follows: Individuals within the age range of 18 to 70 years. Participants assigned to either group needed a minimum Patient Health Questionnaire-9 (PHQ-9) score of ten. Individuals with a history of neck pain persisting for more than three months, primarily localized in the neck region. The aforementioned information was previously obtained through telephonic inquiries before registration.

Individuals with a history of trauma or sports-related injuries directly linked to neck pain were excluded. Furthermore, individuals experiencing the acute or subacute phase of neck pain were deemed unsuitable for inclusion. Participants exhibiting red flag symptoms, such as a rapid increase in pain intensity, the presence of cancer, or symptoms of vertigo, were also excluded from the study (Lüdtke, Grauel, & Laube, 2020). Finally, those with limited German and/or English proficiency were excluded.

The study was conducted within a physiotherapeutic clinic located in Germany. The clinic served as the site for recruiting participants and conducting data collection. The process of enlisting patients for the study spanned from October 2022 to December 2022, while the time frame of the data collection was from January 2023 to April 2023. In total, 153 participants were initially screened for eligibility. From this group, 128 participants were included in the study, with 64 individuals receiving the intervention and the other 64 assigned to the placebo condition. All patients completed the treatment and the evaluation at the end of the treatment. The data from these 128 participants were subsequently analyzed for the study's outcomes (Fig. 1).

2.4. Randomization

The participants were randomly allocated into two parallel groups: intervention and placebo. This process was executed by an external person not involved in the treatment and examination process to prevent selection bias (Jeehyoung & Wonshik, 2013). Computer-generated numbers were used for simple randomization.

2.5. Intervention

To establish a comparison, the placebo and experimental groups were carefully replicated in procedural aspects, encompassing contextual factors like human interaction and physical contact.

2.6. Patient positioning

In both conditions, the volunteers were prone. The neck was neutral without excessive rotation, flexion, or extension. Additionally, a face gel positioner was used to hold the head in midline and to keep the pressure from the forehead. The arms were located at the armrest, and the shoulders and elbows were in 70-degree flexion below the head to release the upper thoracic muscles.

2.7. Experimental group

To avoid activation of sympathetic activity, the intervention was performed outside the pain threshold, utilizing a minimal amount of pressure of just a few grams (Ajimsha, Al-Mudahka, & Al-Madzhar, 2014). Pain intensity was assessed on a scale ranging from zero to ten, with ten representing unbearable pain and zero indicating the absence of pain. The patient was instructed to signal the therapist when the pain reached a level between three and five on the scale, signaling discomfort (Kumar, Elavarasi, & David, 2016).

A single 12-minute session of MFR was administered as part of the study protocol. The therapist performed MFR passively, involving hands-on technique, while the patient remained relaxed. The initial contact was made at the insertion site of the descending portion of the M. Trapezius and continued towards the origin at the medial third of the superior nuchal line. This procedure was repeated eight times, with each repetition starting from different points at the insertions of the descending, transverse, and ascending parts of the M. Trapezius (Fig. 2). The eight consecutive hooking strokes, applied for 30 s each, were performed with approximately two fingers (2.5 cm) between each stroke. The therapist utilized a “hooking technique” derived from soft tissue massage, specifically developed for treating the fascial layers. During the execution of the strokes, the therapist's wrist was slightly dorsiflexed, and the fingers were moderately flexed. The primary contact and pressure on the tissue were applied through the fingertip of the

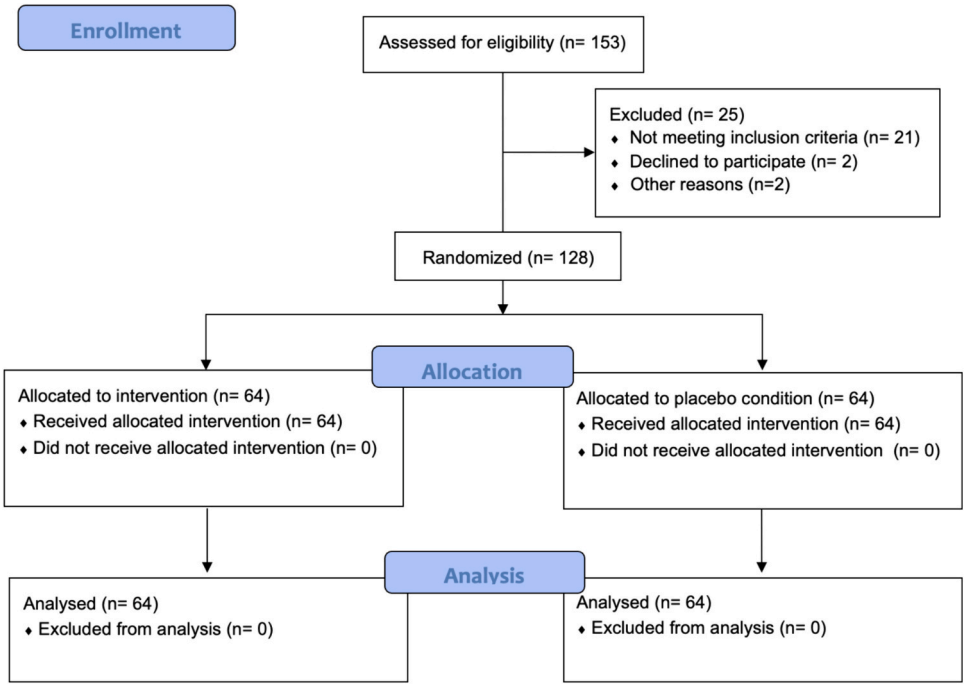

Fig. 1. CONSORT Diagram of Participant flow.

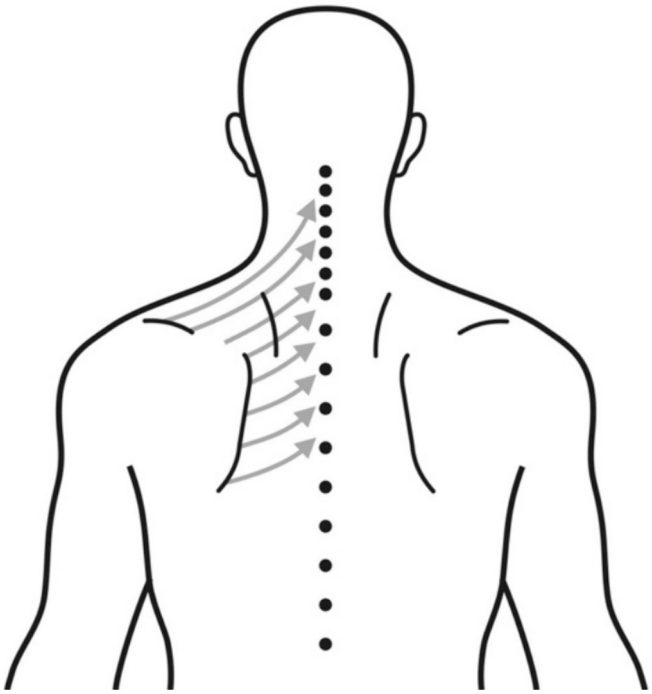

Fig. 2. Application of strokes.

2nd-3rd finger. The patient experienced a non-painful but cutting sensation during the execution of the strokes (Kloster, 2016). The technique was applied bilaterally, starting with the non-affected side.

2.8. Placebo condition

In the placebo condition, participants received a short-term placebo treatment involving sham laser therapy. Implementing a sham laser aligns with established practices within the research field (Fleckenstein et al., 2016; Fleckenstein, Krüger, & Ittner, 2018). The setting and duration of the placebo treatment were similar to those of the intervention group. A commercially available green light laser was utilized. The materials required for the placebo treatment include two pairs of safety goggles and two binders containing information about the application and function of low-level laser therapy placed next to the goggles. The purpose of this setup was to enhance the illusion of an active treatment. A timer was also used to maintain consistency in the duration of the placebo treatment. It was clearly explained to the patient that the safety goggles must be worn due to the high intensity of the bundled light. Once the patient was in a prone position and prepared for the treatment, the case containing the sham laser was opened, signifying the start of the therapy session. During the placebo treatment, the laser was held between the therapist's thumb and index finger, with the laser positioned approximately 2–3 cm above the index fingertip to create slight contact with the patient's skin, exerting no pressure. The therapist gently glided the laser reader across the patient's skin along the same eight lines as in the experimental group, with each line receiving approximately 30 s of contact.

2.9. Measurement instruments

1.) **Patient Health Questionnaire – 9 (PHQ-9):** The PHQ-9 is a widely used instrument for assessing the severity of depression. It consists of nine items that measure symptoms associated with depression. The patient chooses subjectively from a score between 0 (not at all) to 3 (nearly every day), though the result can range from 0 to 27. The scores can be interpreted as follows: mild depression 10–15, severe depression 15–19, and very severe depression 20–27 (Kroenke, Spitzer, & Williams, 2001). A validated German version of the PHQ-9 was used (Löwe, Zipfel, & Herzog, 2002).

2.) **Positive and negative affect schedule (PANAS):** The PANAS is a self-report measure of 10 items designed to assess an individual's positive and negative affect. It is commonly used to evaluate an individual's emotional and psychological well-being. The positive affect subscale measures excitement, enthusiasm, and joy, while the negative affect subscale assesses emotions such

as distress, sadness, and fear. Participants rate the intensity of their experienced emotions on a Likert scale, providing valuable insights into their affective states. The PANAS Questionnaire has demonstrated reliability and validity in measuring affective dimensions across different populations and contexts (Crawford & Henry, 2010; Von Humboldt, Monteiro, & Leal, 2017). It was measured immediately before and after the intervention.

3.) **Visual Analog Scale:** Pain perception was evaluated using a Visual Analog Scale (VAS), which consists of a numerical scale presented as a straight line. The endpoints of the scale are labeled as "no pain" (1) and "pain as bad as it could be" (10). The patient was instructed to indicate the severity of their pain while classifying the pain with a number. The VAS is a widely recognized instrument for assessing and monitoring subjective pain intensity. It has demonstrated validity in detecting both increases and decreases in pain (Euasobhon et al., 2022). The VAS capturing pain intensity over the past three months was assessed through the questionnaire provided to participants before the intervention. Additionally, the VAS score was assessed both before and following the intervention, aiming to examine the immediate pain intensity during this moment and its potential alterations because of the therapeutic intervention.

4.) **Pressure Algometer:** The Pressure Pain Threshold (PPT) was measured by applying a pressure algometer. The sensitivity of the deep muscular tissue of the trapezius was examined. A steadily increasing pressure was applied to the muscle tissue until the patient mentioned a painful sensation by saying, "Now". The pressure algometer is a reliable tool for assessing the effect of a treatment aimed at reducing pain caused by muscle tenderness (Park, Chan, Bog, Jung, & Ho, 2011; Walton, Levesque, Payne, & Schick, 2014). It was measured immediately before and after the intervention.

5.) **Heart Rate Sensor:** The utilization of the Polar H7 heart rate sensor in previous clinical trials has exhibited advantageous outcomes for the measurement of the HRV, leading to its inclusion in the current study (Giles, Draper, & Neil, 2016). HRV is utilized to assess the activity of the autonomic nervous system, specifically, the changes in frequency reflected by the time intervals between heartbeats, known as R-R or interbeat intervals (Lesnewich et al., 2019). Increased HRV indicates good stress management abilities, physical fitness, and emotional flexibility, while decreased HRV may suggest chronic stress, depression, illness, or excessive physical stress, such as overtraining (Brown et al., 2018). Measuring the beat-to-beat values requires tracking small changes in the intervals between successive heartbeats, typically in milliseconds. The Polar H7 is compatible with the smartphone application "Elite HRV" (Perrotta, Jeklin, Hives, Meanwell, & Warburton, 2016) and requires 60 s for HRV monitoring. Although short-term recordings may not capture very low-frequency oscillations, an ultra-short-term measurement period (<5 min) was chosen to minimize the influence of external environmental factors. The HRV Elite app utilizes a proprietary scoring system derived ln(RMSSD), which is then transformed to create a practical 0 to 100 score. According to the HRV Elite manual, this method helps to filter out irregular readings, resulting in a more precise scale where all users fall within the 0 to 100 range. As HRV is highly individual, the score is not fixed to denote "good" or "bad" HRV; higher values generally indicate better HRV. This study specifically aimed to examine the direct effects of therapy. HRV measurements were taken before and after the treatment session (Elite HRV User Manual, 2024).

6.) **Tissue Compliance Meter:** The MyotonPRO was used to determine the stiffness, elasticity, and tone of the fascia of M. Trapezius. The stiffness is defined as the resistance of soft tissue to an external force of deformation (Kisiewicz et al., 2018). Elasticity refers to the biomechanical characteristic of soft tissues to regain their original shape after deformation. A greater decrease in oscillation signifies lower elasticity. The absence of damping is represented by a decrement value of zero (0), which signifies perfect elasticity (MyotonPro USER MANUAL, 2023). The tone is described as oscillation frequency. The oscillation frequency is the level of tonicity observed in superficial skeletal muscles when they are in a passive or resting state, without any voluntary contraction (Ganguly, Kulshreshtha, Almotiri, & Jog, 2021). The wireless device has already been applied in many clinical areas, especially in controlling the success of manual therapy on muscles. Many scientific studies describe it as a reliable measurement tool (Orner, 2016). The measurement was conducted immediately before and after the intervention.

7.) **Digital Goniometer:** The goniometer is a convenient tool for assessing neck mobility. It has demonstrated satisfactory intratester reliability (ICC: 0.7–0.9) and intertester reliability (ICC: 0.8–0.87). The ROM of the cervical spine refers to the maximal extent of joint movement and encompasses both active and passive mobility (Magee, 2014). In this study, neck mobility will be evaluated in a relaxed seated position with the feet placed on the floor (Fernandez-de-las-Penas, Cuadrado, & Pareja, 2006). Given the focus on muscles and fascia, participants will be instructed to actively move their necks to the end ROM in all three planes (Flexion, Extension, Rotation, and Lateral flexion). This approach provides valuable insights into the surrounding structures, whereas passive movements primarily assess joint play. Greater values on the measurement scale indicate increased mobility.

8.) **Credibility/Expectancy Questionnaire (CEQ):** Emerging evidence indicates that patient expectancy plays a crucial role in treatment outcomes. In this study, both patient expectations and treatment credibility were assessed. At the end of the treatment session, expectancy and credibility were assessed with the German version of the credibility/expectancy questionnaire, a reliable tool with high internal consistency and test-retest reliability (Haller, Ostermann, Lauche, Cramer, & Dobos, 2014). The patient responds to six questions using a 9-point numeric rating scale. The scale assessed the patient's beliefs in two dimensions: affective processes related to expectancy and improvements the patient anticipates and credibility, which evaluates the perceived believability, persuasiveness, and logicality of the treatment (Devilly & Brokovec, 2000). A detailed timeline of measurements can be found in Fig. 3.

2.10. Standardized measurement protocol (tissue compliance meter, pressure algometer)

Initially, a tape measure was utilized to determine the midpoint between the spinous process of C7 and the acromion. A small cross was marked at this central point to indicate the precise measurement location on the muscular belly. Subsequently, the respective device was carefully positioned at the marked point for data collection. Both the affected and non-affected sides of the M. Trapezius were included in the measurement process; the non-affected side was measured first.

2.11. Blinding

Patients were informed that they would only receive one of the two treatments under investigation - either manual fascial techniques or laser therapy- and they were not informed whether one would be a placebo. This disclosure was made to compare the effectiveness of these two treatment modalities. A therapist not blinded to the allocated intervention administered the treatment and assessments. The therapist possesses expertise as a manual therapist, specializing in fascial therapy and osteopathy. The qualifications and the training in these fields contribute to the in-depth knowledge and proficiency in therapeutic

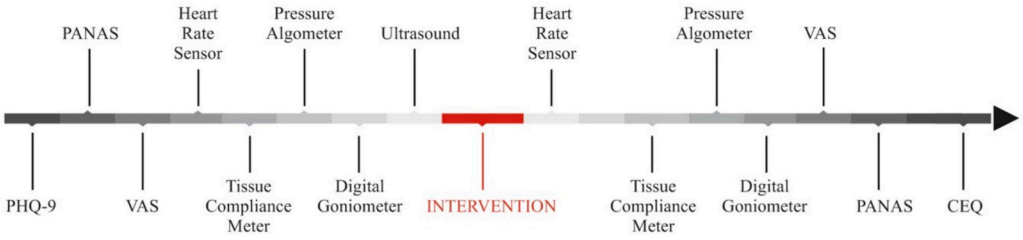

Fig. 3. Timing of measurements.

techniques targeting the musculoskeletal system and fascial structures.

3. Results

The final sample comprised 128 subjects, 77 women and 51 men, all residing in Germany. Independent *t*-tests were conducted to determine the homogeneity of the baseline variables. The analysis revealed that the groups did not significantly differ in age, Body Mass Index (BMI), PHQ-9 scores, marital status, education status, duration of pain, or average pain. However, a significant difference was detected in the frequency of pain occurrence and CEQ scores. Table 1 displays the baseline characteristics of the participants in each group.

Table 1
Descriptive statistics.

Variable	Experimental Group ($n = 64$)	Placebo Control Group ($n = 64$)	*p*-Value
Gender (*n*, %)			
Female	39, 61	38, 59	0.86
Male	25, 39	26, 41	
Age (*M/SD*)	53.61 (12.38)	52.94 (12.69)	0.76
BMI (*M/SD*)	27.27 (5.6)	27.96 (4.31)	0.44
PHQ-9 (*M/SD*)	12.41 (2.64)	12.69 (2.49)	0.54
Marital status (*n*, %)			
Single	11, 17.19	12, 18.75	0.64
Married	44, 68.75	39, 60.9	
Divorced	5, 7.81	8, 12.5	
Widowed	4, 6.25	5 7.8	
Education status (*n*, %)			
Student	1, 1.56	3, 4.69	0.42
Employed	38, 59.38	34, 53.13	
Pensioner	15, 23.44	15, 23.44	
Housewife	3, 4.69	0, 0.00	
Unemployed	1, 1.56	0, 0.00	
Permanently unable to work	6, 9.38	12, 18.75	
How long does pain exist? (*n*, %)			
1/2–1 years	3, 4.69	1, 1.56	0.91
1–2 years	4, 6.25	4, 6.25	
2–5 years	4, 6.25	10, 15.63	
+5 years	53 82.81	49, 76.56	
How often does the pain occur?			
Multiple times a day			
Once a day	37, 57.81	42, 65.63	0.04
Multiple times a week	4, 6.25	14, 21.88	
Once a week	21, 32.81	7, 10.94	
Rare	2, 2.12	0, 0.00	
	0, 0.00	1, 1.56	
CEQ (*M/SD*)			
Utility	8.69(0.77)	7.70(1.02)	<0.001
Logic	8.66(0.72)	7.39(1.08)	<0.001
Confidence in recommending	8.81(0.47)	7.23(1.18)	<0.001
Feeling of improvement	63.98(20.74)	38.44(22.97)	<0.001
Improvement thought to occur	8.22(0.98)	7.14(1.14)	<0.001
Improvement felt to occur	66.27(21.01)	39.84(24.33)	<0.001

BMI = Body Mass Index; PHQ-9 = Patient Health Questionnaire; CEQ = Credibility Expectancy Questionnaire, n = Participants, p-value is significant at 0.05.

We conducted a univariate covariance (ANCOVA) analysis to assess differences in outcome scores between the experimental and placebo control groups following the interventions (Table 2). ANCOVA was chosen to incorporate a covariate and examine whether significant differences existed between the two independent groups on a dependent variable while statistically controlling for a third variable. In our analysis, we included three variables: the dependent variable (post-measurements), the independent variable (group designation), and the covariate (baseline characteristics). Notably, one baseline variable, 'frequency of pain occurrence,' exhibited a significant difference between the groups. Specifically, the control group had a higher proportion of individuals experiencing daily pain compared to the experimental group, which had a higher percentage reporting weekly pain. We included this variable as a covariate in the ANCOVA for each outcome measure to evaluate its potential influence on the results. Even after adjusting for 'frequency of pain' as a covariate, the significant effect of the intervention remained consistent.

Regarding pain perception (VAS), significant differences and large effect sizes were observed between the groups, with the fascial therapy group showing substantially lower pain levels after the intervention than the placebo control group. The intervention significantly affected PPT measurements for both the left and right sides, with post-intervention PPT values significantly higher in the fascial therapy group than in the sham laser therapy group. HRV also showed significant group differences with a small effect size. Participants in the fascial therapy group showed higher HRV than participants in the control group. The Myoton measurements did not reveal significant differences in Tone and Elasticity. However, a significant effect of the intervention was found for stiffness on the left and right sides, with lower stiffness in the fascial therapy group compared to the sham laser therapy group. Furthermore, significant improvements and medium to large effect sizes in ROM were observed in the fascial therapy group, with significant differences between the experimental and placebo control group with higher flexion, extension, rotation to the left, rotation to the right, lateral flexion to the left, and lateral flexion to the right. Additionally, the intervention significantly affected emotional well-being, with higher positive affect (PANAS) scores in the fascial therapy group. No significant differences were observed in negative affect.

4. Discussion

To our knowledge, this is the first study investigating the effects of a fascial intervention with a broad range of outcome measures, including pain, range of motion, HRV, fascial properties, and affect. The findings indicate significant improvements in VAS, ROM of the cervical spine, and emotional well-being for the group receiving MFR. Findings collectively suggest a comprehensive positive impact of the fascial therapy intervention on various physiological and psychological aspects. First and foremost, the substantial decrease in pain perception, as indicated by the VAS, suggests that MFR may be an effective intervention for reducing pain in individuals with chronic neck pain and comorbid depression. Chronic pain often leads to a vicious cycle of increased stress and emotional distress, which can exacerbate both conditions. By effectively reducing pain intensity, myofascial release

Table 2
Differences between experimental and placebo condition.

Variable	Group	Baseline (*M/SD*)	Posttreatment (*M/SD*)	*M* Change from Baseline	*F*	η2	p
VAS	Experimental	5.05(2.12)	2.03(1.81)	−3.02	53.88	0.29	<0.001
	Placebo	6.17(2.05)	5.30(2.90)	−0.87			
PPT left	Experimental	1.54(2.16)	2.03(2.39)	0.49	8.00	0.06	0.005
	Placebo	1.99(2.66)	1.97(2.69)	−0.02			
PPT right	Experimental	1.69(2.38)	2.05(2.41)	0.36	−4.91	0.04	0.03
	Placebo	2.17(2.73)	2.22(2.71)	0.01			
HRV	Experimental	48.17(10.36)	50.67(11.11)	2.5	4.91	0.04	0.03
	Placebo	50.45(10.76)	51.36(10.61)	0.91			
Tone left	Experimental	19.17(2.47)	18.23(2.20)	−0.94	1.63	0.01	0.2
	Placebo	19.50(2.46)	22.64(25.22)	3.14			
Tone right	Experimental	19.01(2.28)	18.13(2.73)	−0.88	1.98	0.02	0.16
	Placebo	19.79(2.50)	19.34(3.21)	−0.45			
Elasticity left	Experimental	2.88(13.22)	1.22(0.19)	−1.66	0.38	0.003	0.54
	Placebo	1.23(0.18)	1.24(0.18)	0.01			
Elasticity right	Experimental	1.30(0.22)	3.18(15.22)	1.88	0.97	0.004	0.46
	Placebo	1.31(0.17)	1.30(0.17)	−0.01			
Stiffness left	Experimental	376.80(75.10)	352.36(61.81)	−24.44	25.96	0.17	<0.001
	Placebo	400.23(75.18)	403.95(70.64)	3.72			
Stiffness right	Experimental	385.16(67.89)	352.22(70.20)	−32.94	12.03	0.88	<0.001
	Placebo	414.15(81.78)	407.54(92.96)	−6.61			
Flexion	Experimental	47.91(14.01)	55.36(13.01)	7.45	15.95	0.11	<0.001
	Placebo	48.17(15.08)	50.88(15.05)	2.71			
Extension	Experimental	49.75(15.83)	55.48(15.33)	5.73	27.23	0.18	<0.001
	Placebo	48.36(13.42)	47.92(12.78)	−0.44			
Rotation left	Experimental	53.44(13.81)	60.11(12.68)	6.67	29.84	0.19	<0.001
	Placebo	55.30(13.76)	55.86(13.25)	0.56			
Rotation right	Experimental	58.42(15.59)	65.14(14.75)	6.72	39.80	0.24	<0.001
	Placebo	56.17(11.97)	56.25(11.43)	0.08			
Lateral flexion Left	Experimental	31.78(10.55)	37.86(10.19)	6.08	43.91	0.26	<0.001
	Placebo	32.47(10.92)	32.56(11.14)	0.09			
Lateral flexion Right	Experimental	30.78(10.89)	37.97(11.40)	7.19	38.55	0.24	<0.001
	Placebo	32.86(11.05)	32.97(10.80)	0.11			
PANAS Positive	Experimental	29.64(5.89)	32.47(6.18)	2.83	15.72	0.11	<0.001
	Placebo	28.31(6.97)	28.44(6.89)	0.13			
PANAS Negative	Experimental	16.22(5.86)	12.81(4.35)	−3.41	2.16	0.02	0.14
	Placebo	16.97(5.38)	13.95(3.97)	−3.02			

VAS = Visual Analog Scale for pain assessment; PPT = Pressure Pain Threshold; HRV = Heart Rate Variability; PANAS Positive: positive affect in the Positive and Negative Affect Schedule; PANAS negative; negative affect in the Positive and Negative Affect Schedule, n = Participants p-value is significant at 0.05.

may offer a promising avenue for breaking this cycle. This, in turn, can lead to improved quality of life for these individuals. These findings align with previous research indicating that pain reduction is a critical factor in enhancing the overall well-being of individuals with comorbid chronic pain and depression (Finan & Smith, 2012). Also, the pressure pain threshold demonstrated a significant difference; the effect size was rather small.

While our study observed an improvement in HRV following myofascial release, with a statistically significant change noted, the effect size was notably small. This underscores the necessity for further research to delve into the potential cumulative effects of repeated myofascial release sessions and their practical implications for individuals dealing with chronic neck pain and depression, particularly in terms of its impact on the ANS. Despite these results, it needs to be considered that only physical touch leads to changes in ANS (Candia-Rivera, Boehme, & Salamone, 2014; Edwards, Young, Cutis, & Johnston, 2018; Wójcik & Siatowski, 2023). Our placebo condition, designed to control for this effect, involved a constant minimal touch with the index finger on the patient's skin, applied consistently throughout the sham-laser application, ensuring consistency in tactile stimulation across groups. Insights from previous studies suggest that cranial osteopathic techniques may also contribute to the enhancement of HRV, indicating their potential efficacy in stress reduction and modulation of HRV (Wójcik & Siatowski, 2023). This nuanced understanding underscores the complexity of interventions targeting the autonomic nervous system and warrants further investigation into the mechanisms underlying their effects.

The observed improvement in ROM of the cervical spine, with significant differences and medium to large effect sizes in various movements, further supports the therapeutic potential of MFR. We found improvements in stiffness; however, there were no significant effects on elasticity and tone. This incongruence raises important questions about the specificity of the effects of MFR on the fascial tissue in individuals with chronic neck pain and depression. The observed improvement in fascial stiffness suggests that MFR may be particularly effective in addressing specific fascial-related issues potentially linked to the pathophysiology of chronic neck pain and depression. These findings align with the notion that pathological changes in fascial tissue, such as increased stiffness, play a role in perpetuating these conditions. Consistent with prior research by Lee and Choi (2017), our study observed improvements in stiffness. Notably, Lee and Choi (2017) observed significant tone alterations but not elasticity. The absence of significant improvements in elasticity and tone may indicate that MFR might not directly affect fascial components or that the study's duration was insufficient to observe changes in these parameters. A noteworthy aspect of the results was the change in affect, measured by positive and negative affect scores using the PANAS questionnaire. While positive affect demonstrated significant improvement within the MFR group, no significant differences in negative affect were observed between the two groups, in line with findings from Michalak et al. (2022). The significant improvement in positive affect within the MFR group is promising and supports the hypothesis that MFR might positively impact emotional well-being.

The placebo effect was examined through the application of CEQ. Overall, the sham laser intervention induced detectable placebo effects. Ratings of Utility (M = 8.69), Logic (M = 7.39), and Confidence in

recommending ($M = 7.23$), indicate that the sham laser intervention was, to the same extent, credible for the participants in the placebo condition and led to expectancies of improvement (ratings of improvement thought to occur: 39.84 %). However, there were significant differences in the credibility ratings of the experimental condition. The fascial intervention was rated as more useful and logical, leading to greater improvement ratings. These results must be interpreted on the background that the assessment of credibility and expectancy was conducted after the interventions and not after the rationale of the intervention was given before the actual intervention. In contrast to previous research using sham laser as a control condition in experiments with laser interventions that found no baseline and post-intervention changes in credibility and expectancy (Fleckenstein et al., 2016; Fleckenstein et al., 2018). The present study's results indicate that the fascial intervention's experience seemed more convincing for participants than the laser intervention, leading to significant differences in credibility and expectancy ratings in our study.

Prior to our study, we initially estimated that we would need 128 participants based on a *t*-test model. However, as we progressed with our statistical analysis, we opted for ANCOVA to address potential confounding variables better. Using G*Power, we recalculated the sample size for ANCOVA and found that 104 participants would suffice (effect size of 0.5, power of 95 %, and α level of 0.05). While our sample size exceeded this calculated value, we believe this adjustment strengthens the reliability of our findings. We made these modifications to enhance the methodological rigor of our study, aiming to ensure robustness in our analysis. Considering sample size requirements and appropriate statistical modeling strategies will be imperative for future research endeavors.

Keeping this limitation in mind, the results of this study suggest several potential therapeutic applications for MFR in the management of comorbid chronic neck pain and depression. Integrating MFR into the treatment protocols for individuals with these conditions could be particularly beneficial. Healthcare providers, including physical therapists and rehabilitation specialists, might consider MFR as an adjunctive therapy to address these complex conditions' physical and emotional aspects. Furthermore, MFR could be employed as part of a multidisciplinary approach to treatment. Integrating it with other evidence-based therapies, such as cognitive-behavioral therapy for depression and exercise-based interventions for chronic pain, might provide a comprehensive and holistic approach to managing comorbid conditions. This multidisciplinary approach would address health's interconnected physical and emotional aspects, ultimately improving the individual's overall well-being.

Nevertheless, further research with more diverse samples is crucial to confirm and expand upon these findings. A more diverse sample, incorporating different demographics and geographical regions, would strengthen the external validity of the results. The short-term follow-up period, focusing on immediate post-intervention outcomes, calls for further investigations assessing the long-term sustainability and durability of the observed benefits. Future studies should explore the long-term effects of MFR, evaluating its sustainability in maintaining pain reduction, improving emotional well-being, and enhancing ANS activity. Furthermore, the effectiveness of the interventions should be considered, as well as whether there is a dose-response relationship between the frequency and duration of MFR sessions. Whether more frequent or extended MFR sessions yield improved pain reduction and emotional well-being outcomes warrants further investigation. Additionally, investigations that delve into the underlying mechanisms by which MFR influences HRV are warranted. Moreover, research assessing the cost-effectiveness of MFR as an adjunctive therapy for comorbid chronic pain and depression could provide valuable insights for healthcare providers and policymakers. In pursuing enhanced clinical outcomes and therapeutic approaches, investigating the interplay between fascial interventions, mental health, and ANS activity remains a promising avenue of inquiry.

5. Conclusion

In conclusion, our study highlights MFR's potential in alleviating symptoms of chronic neck pain, particularly in individuals with concomitant depression. Through a single session of MFR, we observed promising outcomes, including improvements in pain intensity and psychological well-being. However, further research with larger sample sizes and longer intervention durations is warranted to elucidate the long-term effects and mechanisms underlying MFR therapy in this population. Nevertheless, our findings contribute to the growing body of evidence supporting the integration of MFR as an approach to managing chronic neck pain and associated psychological distress.

CRediT authorship contribution statement

Lea Overmann: Writing – original draft, Visualization, Validation, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Robert Schleip:** Conceptualization. **Dennis Anheyer:** Formal analysis. **Johannes Michalak:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare no conflicts of interest related to this research project or its publication. No financial or personal relationships with individuals or organizations could have influenced the conduct of this study or the interpretation of its results.

Data availability

Data will be made available on request.

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