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RESEARCH ARTICLE

Comparison of the Effects of Self-Myofascial Release and Combined Core Stabilization Exercises in Physiotherapy and Rehabilitation Students with Non-Specific Low Back Pain

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Abstract
Objectives: To compare the efficacy of two treatment protocols, core stability exercises combined with the self-myofascial release and only the self-myofascial release on physiotherapy and rehabilitation students sufferin from non-specific low back pain in terms of functional capability and pain. Study Design: Randomized Clinical Trial**.** Methods: 28 (18 females, 10 males) physiotherapy students whose activity VAS was equal or more than 6 (mean age, 26.78 ± 3.66 years) were randomly allocated to 1 of 2 groups. Group 1 received SMFR combined with core exercises while Group 2 received only SMFR. The duration of the study was 5 weeks and each protocol was performed 2 times per week. Evaluations were undertaken in the 1st, 3rd and 5th weeks. Functional capacity was evaluated with Oswestry Scale (ODI), while the pain was measured with the Visual Analogue Scale (VAS). Results: VAS, total ODI and its sub-groups decreased statistically significantly in both groups ($p<0.05$). Statistically significant decreases between groups have been found regarding VAS, total ODI and sub-ODI scores (pain intensity, lifting, walking, sitting, and standing) ($p<0.05$). Conclusions: The self-myofascial release has a clinical effect in reducing pain, and improving function. We may conclude that self-myofascial release combined with core stability exercises seems to be more effective on pain and functional capacity.

Keywords
Self Myofascial Release, Core exercises, Low Back Pain, Functional Status

INTRODUCTION

Low back pain (LBP) is one of the most frequent musculoskeletal problems all around the world. LBP has a variety of categories, but the most common form is non-specific low back pain (NSLBP) (O'Sullivan, 2005). Since NSLBP might affect nearly all ages, this could create several socioeconomic problems in countries (Golob AL and Wipf JE, 2014). According to recent studies, it has been demonstrated that 35 to 50 % of people have NSLBP persisting for more than twelve months (Janwantanakul et al., 2008; Ayanniyi et al.,2010). Recent studies showed that the annual prevalence of NSLBP is found to be 15% to 45% and its point prevalence is approximately %30 (Juul-Kristensen et al., 2004; Sitthipornvorakul et al., 2015). This painful disorder could be caused by mainly traumatic injuries, postural problems, and lumbar-region-based strains. (Allegri et al., 2016) Regarding the risk factors for NSLBP, there are two categories, which are individual and psychosocial. Individual factors are age, gender, fitness level, biomechanical changes, and fascial problems, whereas environmental factors are

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psychological health, economic status, and posture (Hoy et al., 2014).

Among risk factors, poor posture and lack of exercise could be the most predisposing components for NSLBP (Lizier et al., 2012). The posture in a sitting position may lead to increased mechanical stress on the spine and may have an increased static load on the ligaments of the lumbar spine (Akkarakittichoke et al., 2017; Anggiat et al., 2018). Therefore, viscoelastic deformations on fascia (myofascial adhesions) could occur, thus leading to spasms of paraspinal muscles that could trigger metabolic reactions (Plaut, 2022). This accelerates disc degeneration and possibly disc herniation (Beach et al., 2005). Also, during the sustained sitting posture, the amount of lumbar lordosis could decrease and the posterior pelvic tilt may increase, thus possibly leading to the occurrence of pain (Kett et al., 2021). In addition, it has been suggested in studies that individuals, who do not perform exercise sufficiently could be more prone to develop muscle strain, spasms, intervertebral disc injuries, and eventually LBP because the deeply-localized stabilizer muscles could weaken and cannot maintain an optimal stabilization of trunk (Teichtahl et al., 2015; Citko A et al., 2018). A study showed that NSLBP could highly affect certain occupations that necessitate the sitting posture for long periods, such as office workers and university students (Bontrup et al., 2019, Anggiat et al., 2020). Another study also suggested that university students could be more prone to develop such problems because they tend to spend time sitting at the computer and their daily routine lacks regular exercise (Morais et al., 2018). Therefore, like other populations, they develop some postural changes and become more susceptible to pain, myofascial injuries, and loss of functional capacity (FC) (Manchikanti et al., 2014). In the management of LBP, there are several evidence-based effective healing options, namely pharmacological treatments, and physiotherapeutic approaches such as electrotherapy, kinesiotaping, exercises, and manual therapy (Almeida M et al., 2018).

Myofascial release (MFR) is one of the applications of manual therapy and is performed by a physiotherapist or patient himself with a foam roller (Self Myofascial Release) (Barnes, 1997). John F. Barnes stated that MFR is based on the release of all tensions and painful points, and the main goal is to relieve the pain by eliminating the fascia problems associated with mobility (Barnes, 1997). Also, Myers has defined several myofascial meridians (a group of muscles) (Myers TW, 2013). Those meridians are quite fundamental because when one of the muscles found in those chains is injured, it could directly affect other muscle groups located on the corresponding meridian, leading to LBP via tensegretive properties of the fascia (Myers TW, 2013). Therefore, MFR is applied to those meridians to eliminate fascial problems effectively. Moreover, recently conducted studies have suggested that MFR could be quite effective in the management of NSLBP (Cheatham et al., 2015; Wu, Z et al., 2021).

Among exercise procedures, Core stabilization is one of the most recommended techniques to manage the symptoms of NSLBP (Wang et al., 2012). Core stabilization is made up of passive, active, and neural systems. Those muscles are divided into global and core muscles (Panjabi and M. M., 1992). Global muscles provide general stabilization, while core muscles provide segmental stabilization (Gibbons et al., 2001). Global muscles are erector spinae, and abdominal muscles, while core muscles are multifidus, deep rotators, and intertranversarii muscles. With those exercises, they can be strengthened (Gibbons et al., 2001). The basic framework of the core is formed by four elements, namely the pelvic floor muscles, transversus abdominis, paraspinal muscles, and diaphragm (Akuthota V et al., 2008). A study suggested that patients with NSLBP could have delayed activation of Transversus abdominis during movements, hence leading to an insufficient stabilization of the trunk (Hodges et al., 1996). Hides has stated that individuals with LBP are more likely to have poor contraction of multifidus muscles (Hides et al., 2011). It has been suggested that when there is a diminished activation of core muscles, there is an increased burden on the surrounding structures and less control during gait or other movements, resulting in possibly LBP (Hodges et al., 1996; Hides et al., 2011). According to the study by Granacher, this method could allow the back muscles to gain the appropriate strength (Granacher et al., 2014). A systematic review has proposed that core exercises could be effective in decreasing pain compared to normal home exercises, thus increasing FC (Frizziero et al., 2015). According to recent studies, core exercises could have beneficial effects on patients with NSLBP regarding pain and FC, increasing the activation of the aforementioned muscle groups (Ajimsha et al., 2014; Ozsoy et al., 2019). MFR protocol has been recommended with the combination of other manual therapy methods, occupational therapy, and core exercises (Ozsoy et al., 2019). Nevertheless, MFR combined with core exercise protocols has become quite prominent recently and studies had different protocols for comparison of the effectiveness of those interventions, such as „Core exercise versus MFR“ or „MFR combined core exercises versus core exercises alone“ (Meltzer et al., 2017). According to the recent systematic review, both MFR and MFR combined with other interventions seem to be effective in the management of NSLBP, yet there is no consensus between studies regarding MFR protocols, myofascial meridians, and study duration (Akhtar et al., 2017; Majeed A et al., 2019). To our best knowledge, there is no study conducted for the comparison of the effectiveness of SMFR combined with core exercises and SMFR alone on patients with NSLBP regarding pain intensity and FC.

The purpose of this study was to compare the effectiveness of two treatment protocols, which are core stability exercises combined with SMFR and only SMFR. Thus, we aim to compare the effects of both protocols on FC and pain.

MATERIALS AND METHODS

Study design and blinding

This study was randomized and controlled and performed with 32 physiotherapy and rehabilitation students aged 18-30, suffering from NSLBP.University's Ethics Committee approved the study protocol with reference number 202109095. All participants gave their written informed consent, and our study was carried out following the Helsinki Declaration. Due to the pandemic, this study took place online. The randomization was based on the paper selection. Since this was an online study, we selected one paper for each participant. Participants numbered 1 to 16 were selected for the self-myofascial release group combined with core exercises (G1), while participants numbered 17 to 32 were assigned to the self-myofascial release group (G2) only. In group G1, we introduced to our participants both core exercises followed by self-myofascial release exercises; while in G2, patients received only self-myofascial release exercises. At pre-intervention, mid-intervention (3rd week), and post-intervention (at the end of the 5th week) all participants were assessed. Because of our study protocol, we could not perform blinding in this study. The same physiotherapist was in charge of each session.

Participants

Out of 40 volunteers suffering from NSLBP at the beginning, 8 participants were excluded for several reasons. Out of 8 students, 4 participants did not meet the inclusion criteria because they had rheumatismal diseases and scoliosis. The resting 3 students refused to participate in our study for personal reasons. The remaining thirty-two were randomly divided into two groups. (SMFR combined with core exercises group (G1), n=16; and the SMFR group (G2), n=16). However, two participants in the SMFR combined with the core exercises group and two participants in the SMFR group dropped out of the study owing to the pandemic Covid-19.

Thirty-two physical therapy and rehabilitation students from Yeditepe University between the ages of 18 and 35 participated (Average age-Gender; 26, 78 ± 3, 66; F/M: 18/10) in our study. Inclusion criteria were (1) being between in ages of 18-35, (2) being a physiotherapy and rehabilitation student at Yeditepe University, (3) having non-specific low back pain prolonging more than 6 months, (4) having an activity VAS score of more than 6 for pain, and (5) having neither orthopaedic nor neurological problems. Exclusion criteria were (1) the presence of the musculoskeletal condition in 2 months, (2) neurological or vestibular diseases, (3) osteopenia or Osteoporosis, radiculopathy, (4) spondylolysis, (5) scoliosis, (6) rheumatismal or myopathic diseases, (7) taking medications that may affect the balance or the locomotor system, (8) having a history of surgery carried out in the spinal cord and low back area, (9) ongoing inflammation in the body, (10) surgery in 6 months, and (11) pregnancy.

Interventions

The first group received both core stabilization exercises and self-myofascial release techniques, while the second group received only self-myofascial release techniques. During warm-up and cool-down, the participants in G1 performed light jogging, high knee, and modified jumping jack.

Core Stabilization Exercise

The core is made up of many different muscle groups, which are paraspinal muscles, diaphragm, pelvic floor muscles, and abdominal muscles. They are capable of maintaining stability in our body, allowing our distal limbs to move comfortably and freely. When they become weak, we become more prone to developing pain in our spine. It is very important to engage our core muscles efficiently to reduce the risk of injury and optimize stability (Cook et al., 2006; Hibbs et al., 2008). Core stability exercises were introduced to our first group in the study. The main purpose was to strengthen these muscles. In this way, we can eliminate the pain and reduce the risk of recurrence of low back pain. The exercises can be classified into three difficulties, easy, medium, and difficult. If a participant performs the current exercise easily and we increased the difficulty, by moving on to the next movement.

In the first week, participants from G1 performed abdominal draw-in exercises (10x2), supine twist (6x2), plank (10 seconds-1min x 2), side plank (10 seconds-1min x 2), cat stretches (5 times), press-ups (6x2), quadruped opposite arm-leg (8 times for each side) and bridge (10 x2). Gradually, in the second week, we added several other exercises, which are dead bug (8x2), prone cobra (10x1), and semi-curl-up (10x2). Also, the duration of plank and side planks has been step by step increased up to 1 minute. Between the 3rd and 5th weeks, lunge (8 x2), seated Russian twist (8 x2) and supine single leg butt lift (10 x 5-7 seconds for each side) exercises were introduced to our participants.

Self-Myofascial Release (SMFR)

In this study, each participant got a foam roller and a small tennis ball to perform self-myofascial release at home. The foam roller is a popular piece of equipment for self-myofascial release. This tool can apply a sufficient amount of pressure on soft tissues. These tense areas can relax, decreasing pain. We used a standard foam roller (6 ×36 inches) (Beardsley and Škarabot, 2015).

The muscles applied and their durations in the following;

• The self-myofascial release of quadratus lumborum (30-sec x 3 times) with 1 min rest interval

• The self-myofascial release of the thoracolumbar fascia and paravertebral muscles (40 seconds x 3 times) with 1 min rest interval (T12 -L1)

• The self-myofascial release of the psoas muscle (30 seconds x 3 times) with 1 min rest interval

• The self-myofascial release of piriformis muscle +gluteals (30 seconds x 3 times) with 1 min rest interval

Assessments

Before all interventions, all participants filled socio-demographic questionnaire so that we could determine the suitable population for our study. In the study, we measured pain intensity with the Visual Analogue Scale (VAS) and functional capacity with Oswestry Disability Index (ODI). Evaluations have been performed at pre-intervention, mid-intervention (3rd week), and post-intervention (5th week).

Demographic data form

The socio-demographic questionnaire was used to collect personal information about each participant. In the first part, age, gender, occupation, income level, marital status, and education level were recorded. In the second part, the questions are mainly related to health. In particular, these include smoking and alcohol habits, use of medication, activity level, and chronic diseases.

Visual analogue scale (VAS)

The Visual Analogue Scale is an instrument used to determine the degree of pain. We can evaluate the intensity of symptoms. On this scale, there are numbers from 0 to 10. 0 means no pain, while 10 stands for unbearable pain. 5 represents moderate pain. Numbers from 5 to 10 represent severe pain. Numbers from 0 to 5 represent mild pain. In our study, VAS has been measured two times in the first week to show sudden effects. VAS is also divided into 2 parts, activity VAS and resting VAS (Aun C et al., 1986).

Oswestry Disability Index (OID)

The OID is one of the most popular tools for determining the level of function in patients with low back pain. This questionnaire consists of ten different parts, namely pain intensity, self-care, carrying heavy objects, walking, sitting, standing, sleeping, social life, travelling, and degree of change in pain. Each question contains six different answers representing an increasing worsening of symptoms from 1 to 6. In other words, 1 represents no disability, while 6 represents maximum disability. When the patient has answered all the questions, the total score is added. Then the total score is divided by the worst maximum score and multiplied by one hundred. 0-20% represents minimal disability. 20-40% stands for mild disability. 40-60% stands for severe disability. 60-80% stands for very severe disability and finally, 80-100% means the patient may be disabled and bedridden. In our study, in addition to the total ODI score, we have shown the change in each sub-ODI score. Also, we demonstrated the distribution of total ODI in groups according to the severity level of disability at different weeks (Fairbank et al., 1980).

RESULTS

The participant's characteristics are shown in Table 1. No relevant differences were found at the baseline (p>0.05, Table 1).

Table 1. Socio-demographic Features of University Students

	G1 (n= 14) Mean ± SD	G2 (n= 14) Mean ± SD	F	P value
Age (year)	25.92 ± 3.26	27.64 ± 4.06	1.510	.741
Weight (kg)	71.78 ± 16.59	64.00 ± 11.63	2.066	.260
Height (cm)	170.50 ± 7.61	170.64 ± 7.24	0.003	.960
BMI (kg/m^2)	24.62 ± 4.97	21.88 ± 2.82	3.217	.085

*: Mann-Whitney U Test, G1: Core stabilization exercises combined with SMFR, G2: self-myofascial release group, BMI. Body Mass Index, kg: kilogram, cm: centimeter, kg/m^2: kilogram/meter^2

All sudden (T_{0-1}) activity and rest VAS pre-post measurements (pre-study and the end of 1st week) in both groups were not statistically significant (p>0.05, Table 2), except the increase in the rest VAS of G1 (p=.046, Table 2). Statistically significant decreases in all activity and rest VAS between pre-post (T0-3), pre-mid (T_{0-2}) and mid-post (T_{2-3}) measurements were observed in both groups (p<0.05, Table 2), except the rest VAS between pre-mid (T_{0-2}) measurements in G2.

Table 2. Intragroup comparison of activity-rest VAS of groups

		G1 (n= 14) Mean ± SD	z	p value	G2 (n= 14) Mean ± SD	z	P value
A-VAS	**T0**	6.42 ± 0.64	-0.577	.564	6.14 ± 0.36	-1.000	.317
	T1	6.50 ± 0.75			6.21 ± 0.42		
	T0	6.42 ± 0.64			6.14 ± 0.36		
	T2	4.42 ± 0.93	-3.373	**<0.001**	5.50 ± 0.94	-2.264	**.024**
	T2	4.42 ± 0.93			5.50 ± 0.94		
	T3	2.92 ± 0.99	-3.126	**.002**	5.14 ± 1.09	-2.236	**.025**
	T0	6.42 ± 0.64			6.14 ± 0.36		
	T3	2.92 ± 0.99	-3.384	**<0.001**	5.14 ± 1.09	-2.274	**.008**
R-VAS	**T0**	4.42 ± 2.20	-2.000	**.046**	3.85 ± 1.87	0.000	
	T1	4.71 ± 2.43			3.85 ± 1.87		1
	T0	4.42 ± 2.20			3.85 ± 1.87		
	T2	3.07 ± 1.94	-3.126	**.002**	3.57 ± 1.60	-1.027	.305
	T2	3.07 ± 1.94			3.57 ± 1.60		
	T3	1.85 ± 1.65	-3.064	**.002**	3.00 ± 1.75	-2.828	**.005**
	T0	4.42 ± 2.20			3.85 ± 1.87		
	T3	1.85 ± 1.65	-3.316	**<0.001**	3.00 ± 1.75	-2.144	**.032**

*: Wilcoxon Test; Data expressed as mean ± standard deviation. T0: pre-intervention measurement, T1: measurement in 1st week, T2: mid-measurement at 3rd week, T3: post-intervention measurement, A-VAS: Activity visual analogue scale, R-VAS: Resting Visual Analogue Scale, G1: Core stabilization exercises combined with SMFR, G2: self-myofascial release group

Table 3. Intragroup comparison of total and each oswestry disability index subscores of groups at different intervals

		G1 (n= 14) Mean ± SD	Z P value	G2 (n= 14) Mean ± SD	Z P value
	T0	2.42 ± 0.75	-3.207	1.85 ± 0.86	-0.447
	T2	1.57 ± 0.85	**.001**	1.78 ± 0.97	.655
	T2	1.57 ± 0.85	-3.071	1.78 ± 0.97	-2.449
Pain Intensity	**T3**	0.57 ± 0.75	**.002**	1.35 ± 0.92	**.014**
	T0	2.42 ± 0.75	-3.442	1.85 ± 0.86	-2.646
	T3	0.57 ± 0.75	**<0.001**	1.35 ± 0.92	**.008**
	T0	1.21 ± 0.97	-2.121	1.07 ± 0.91	-1.414
	T2	0.78 ± 0.69	**.034**	0.92 ± 0.82	.157
	T2	0.78 ± 0.69	-2.449	0.92 ± 0.82	-2.828
Self-Care	**T3**	0.35 ± 0.49	**.014**	0.35 ± 0.63	**.005**
	T0	1.21 ± 0.97	-2.762	1.07 ± 0.91	-2.887
	T3	0.35 ± 0.49	**.006**	0.35 ± 0.63	**.004**
	T0	1.85 ± 0.94	-2646	1.64 ± 1.15	-1.732
	T2	1.35 ± 0.74	**.008**	1.42 ± 1.15	.083
	T2	1.35 ± 0.74	-2.333	1.42 ± 1.15	-1.633
Lifting	**T3**	0.85 ± 0.77	**.020**	1.14 ± 0.94	.102
	T0	1.85 ± 0.94	-3.071	1.64 ± 1.15	-2.333
	T3	0.85 ± 0.77	**.002**	1.14 ± 0.94	**.020**
	T0	1.71 ± 0.72	-2.588	0.92 ± 0.82	-0.577
	T2	0.85 ± 0.77	**.010**	0.85 ± 0.86	.564
	T2	0.85 ± 0.77	-2.000	0.85 ± 0.86	-1.000
Walking	**T3**	0.57 ± 0.75	**.046**	0.71 ± 0.82	.317
	T0	1.71 ± 0.72	-2.859	0.92 ± 0.82	-1.342
	T3	0.57 ± 0.75	**.004**	0.71 ± 0.82	.180
	T0	1.64 ± 0.74	-2.333	1.42 ± 0.75	-1.732
	T2	1.14 ± 0.36	**.020**	1.21 ± 0.69	.083
	T2	1.14 ± 0.36	-2.646	1.21 ± 0.69	-1.414
Sitting	**T3**	0.64 ± 0.63	**.008**	1.07 ± 0.82	.157
	T0	1.64 ± 0.74	-3.125	1.42 ± 0.75	-2.236
	T3	0.64 ± 0.63	**.002**	1.07 ± 0.82	**.025**
	T0	2.14 ± 0.77	-2.530	1.50 ± 0.85	-1.414
	T2	1.50 ± 0.65	**.011**	1.35 ± 0.84	.157
	T2	1.50 ± 0.65	-2.646	1.35 ± 0.84	-2.000
Standing	**T3**	1.00 ± 0.55	**.008**	1.07 ± 0.82	**.046**
	T0	2.14 ± 0.77	-3.066	1.50 ± 0.85	-2.449
	T3	1.00 ± 0.55	**.002**	1.07 ± 0.82	**.014**

Table 3. Continue

Sleeping	**T0**	0.78 ± 0.89	-2.499	1.00 ± 0.87	-2.236
	T2	0.35 ± 0.74	**.014**	0.64 ± 0.92	**.025**
	T2	0.35 ± 0.74	-1.342	0.64 ± 0.92	-1.414
	T3	0.14 ± 0.36	.180	0.50 ± 0.85	.157
	T0	0.78 ± 0.89	-2.530	1.00 ± 0.87	-2.333
	T3	0.14 ± 0.36	**.011**	0.50 ± 0.85	**.020**
Social Life	**T0**	1.28 ± 0.61	-1.857	0.85 ± 0.66	0
	T2	0.85 ± 0.66	.063	0.85 ± 0.77	1
	T2	0.85 ± 0.66	-1,732	0.85 ± 0.77	-1.414
	T3	0.64 ± 0.74	.083	0.71 ± 0.72	.157
	T0	1.28 ± 0.61	-2.251	0.85 ± 0.66	-1.414
	T3	0.64 ± 0.74	**.024**	0.71 ± 0.72	.157
Travelling	**T0**	1.71 ± 0.61	-2.714	1.28 ± 0.72	-2.236
	T2	1.07 ± 0.26	**.007**	0.92 ± 0.73	**.025**
	T2	1.07 ± 0.26	-2.000	0.92 ± 0.73	-2.000
	T3	0.78 ± 0.57	**.046**	0.64 ± 0.63	**.046**
	T0	1.71 ± 0.61	-2.919	1.28 ± 0.72	-3.000
	T3	0.78 ± 0.57	**.004**	0.64 ± 0.63	**.003**
Degree of change in pain	**T0**	2.21 ± 1.12	-2,588	1.71 ± 0.91	-2.449
	T2	1.35 ± 0.92	**.010**	1.28 ± 0.91	**.014**
	T2	1.35 ± 0.92	-2.530	1.28 ± 0.91	-2.449
	T3	0.78 ± 0.57	**.011**	0.85 ± 0.86	**.014**
	T0	2.21 ± 1.12	-3.133	1.71 ± 0.91	-2.972
	T3	0.78 ± 0.57	**.002**	0.85 ± 0.86	**.003**
Total Oswestry scores	**T0**	16.64 ± 3.62	-3.304	13.28 ± 6.21	-2.728
	T2	10.57 ± 2.65	**<0.001**	11.14 ± 5.70	**.006**
	T2	10.57 ± 2.65	-3.309	11.14 ± 5.70	-2.862
	T3	6.28 ± 3.04	**<0.001**	8.42 ± 5.37	**.004**
	T0	16.64 ± 3.62	-3.309	13.28 ± 6.21	-3.301
	T3	6.28 ± 3.04	**<0.001**	8.42 ± 5.37	**<0.001**

*: Wilcoxon Test, T0: pre-intervention measurement, T2: mid-measurement at 3rd week, T3: post-intervention measurement, G1: Core stabilization exercises combined with SMFR, G2: self-myofascial release group,

In terms of intragroup results for measurements between pre-mid study, all sub-ODI scores in G1 decreased statistically significantly, except social life, while only sleeping, travelling, degree of change in pain and total ODI decreased statistically significantly in G2 ($p<0.05$, Table 3). Regarding the mid-post measurements, all subgroups diminished statistically significantly in the SMFR combined with core exercises group, except sleeping and social life, whereas all scores decreased in the SMFR group, but improvements in pain intensity, self-care, standing and total ODI were statistically significant ($p<0.05$, Table 3). As for the pre-post measurements, all sub-groups of ODI have diminished statistically significantly in G1 ($p<0.05$, Table 3). However, all subgroups except walking and social life decreased statistically significantly in G2 ($p<0.05$, Table 3).

Regarding the intergroup differences, a statistically significant increase in sudden rest VAS was observed (p=.034, Table 4). Similarly, statistically significant decreases in all activity and rest VAS regarding pre-post, and pre-mid measurements between groups were observed ($p<0.05$, Table 4), except the score obtained between mid-post measurements.

Regarding the intergroup results of ODI for pre-mid measurements, only the decreases in pain intensity, lifting, walking, standing, and total ODI were found statistically significant ($p<0.05$, Table 5). As for the mid-post measurements, we have obtained statistically significant improvements in pain intensity, sitting and total ODI ($p<0.05$, Table 5). In terms of the pre-post measurements, statistically significant improvements in pain intensity, walking, sitting, standing and total ODI were observed ($p<0.05$, Table 5).

Table 4 Intergroup comparison of activity-rest VAS of groups

		G1 (n= 14) Mean ± SD	G2 (n= 14) Mean ± SD	z	P value
Δ A-VAS	T_{0-1}	0.14 ± 0.36	0.07 ± 0.26	-0.600	.549
	T_{0-2}	-2.00 ± 0.67	-0.64 ± 0.92	-3.462	**<0.001**
	T_{2-3}	-1.50 ± 1.01	-0.35 ± 0.49	-3.248	**.001**
	T_{0-3}	-3.07 ± 1.85	-1.00 ± 1.03	-3.636	**<0.001**
Δ R-VAS	T_{0-1}	0.28 ± 0.46	0.00 ± 0.00	-2.121	**.034**
	T_{0-2}	-1.35 ± 0.84	-0.28 ± 0.99	-2.726	**.006**
	T_{2-3}	-1.21 ± 1.12	-0.57 ± 0.51	-1.716	.086
	T_{0-3}	-2.57 ± 1.22	-0.85 ± 1.23	-3.202	**.001**

*: Mann-Whitney U Test, Δ: Difference, T0-1: the difference between pre-intervention and measurement in the 1st week,T0-2: the difference between pre-mid measurements (weeks 1-3), T2-3: the difference between mid-post measurements (weeks 3-5), T0-3: the difference between pre-post measurement (weeks 1-5), A-VAS: Activity visual analogue scale, R-VAS: Resting Visual Analogue Scale, G1: Core stabilization exercises combined with SMFR, G2: self-myofascial release group

Table 5. Intergroup comparison of each oswestry disability index subscores of group at different week intervals

		G1 (n= 14) Mean ± SD	G2 (n= 14) Mean ± SD	Z	P value
Δ Pain intensity	T_{0-2}	-0.85 ± 0.53	-0.07 ± 0.61	-3.066	**.004**
	T_{2-3}	-1.00 ± 0.67	-0.42 ± 0.51	-2.241	**.044**
	T_{0-3}	-1.85 ± 0.53	-0.50 ± 0.51	-4.251	**<0.001**
Δ Self-care	T_{0-2}	-0.42 ± 0.64	-0.14 ± 0.36	-1.340	.180
	T_{2-3}	-0.42 ± 0.51	-0.57 ± 0.51	-0.742	.458
	T_{0-3}	-0.78 ± 0.80	-0.71 ± 0.61	-0.126	.900
Δ Lifting	T_{0-2}	-0.50 ± 0.51	-0.22 ± 0.47	-2.111	**.035**
	T_{2-3}	-0.50 ± 0.65	-0.28 ± 0.61	-1.093	.275
	T_{0-3}	-1.00 ± 0.67	-0.50 ± 0.65	-1.933	.053
Δ Walking	T_{0-2}	-0.85 ± 0.94	-0.71 ± 0.47	-2.528	**.011**
	T_{2-3}	-0.28 ± 0.46	-0.00 ± 0.55	-1.394	.163
	T_{0-3}	-1.14 ± 0.94	-0.21 ± 0.57	-2.668	**.008**
Δ Sitting	T_{0-2}	-0.50 ± 0.65	-0.21 ± 0.42	-1.268	.205
	T_{2-3}	-0.50 ± 0.51	-0.14 ± 0.36	-1.987	**.047**
	T_{0-3}	-1.00 ± 0.78	-0.35 ± 0.49	-2.419	**.016**
Δ Standing	T_{0-2}	-0.64 ± 0.84	-0.14 ± 0.36	-2.028	**.043**
	T_{2-3}	-0.50 ± 0.51	-0.28 ± 0.46	-1.140	.254
	T_{0-3}	-1.14 ± 1.02	-0.42 ± 0.51	-2.239	**.025**
Δ Sleeping	T_{0-2}	-0.42 ± 0.51	-0.35 ± 0.49	-0.380	.704
	T_{2-3}	-0.21 ± 0.57	-0.14 ± 0.36	-0.076	.940
	T_{0-3}	-0.64 ± 0.84	-0.42 ± 0.51	-0.524	.600
Δ Social life	T_{0-2}	-0.42 ± 0.75	0.00 ± 0.39	-1.730	.084
	T_{2-3}	-0.21 ± 0.42	-0.14 ± 0.36	-0.485	.628
	T_{0-3}	-0.64 ± 0.84	-0.14 ± 0.36	-1.795	.073
Δ Travelling	T_{0-2}	-0.64 ± 0.63	-0.35 ± 0.49	-1.232	.218
	T_{2-3}	-0.28 ± 0.46	-0.28 ± 0.46	0.000	1
	T_{0-3}	-0.92 ± 0.73	-0.64 ± 0.49	-1.067	.286
Δ Degree of pain change	T_{0-2}	-0.85 ± 0.94	-0.42 ± 0.51	-1.171	.242
	T_{2-3}	-0.57 ± 0.64	-0.50 ± 0.51	-0.183	.855
	T_{0-3}	-1.42 ± 1.08	-0.85 ± 0.66	-1.461	.144
Δ Total Oswestry Score	T_{0-2}	-6.07 ± 3.38	-2.14 ± 2.31	-1.182	**<0.001**
	T_{2-3}	-4.28 ± 1.97	-2.71 ± 2.23	-0.190	**.030**
	T_{0-3}	-10.21± 4.40	-4.85 ± 3.20	-1.199	**.001**

*: Mann-Whitney U Test, T0: pre-intervention measurement, T2: mid-measurement at 3rd week, T3: post-intervention measurement, G1: Core stabilization exercises combined with SMFR, G2: self-myofascial release group,

In addition, we analyzed the correlation of the distribution of total ODI in groups according to the severity level of disability at different weeks (3rd, and 5th). However, we did not find any statistically significant correlations between the SMFR protocols and distribution of total ODI scores according to severity levels (p>0.05, Figure 1). The Distributions of total ODI scores in groups according to the severity level of disability changed as a percentage over 5 weeks. At post-intervention, G1 has a higher percentage (92, 9%) of minimal disability compared to G2 (7, 1%) Even though the percentage of participants with more severe ODI had higher in G1 at pre-intervention, the percentage of participants with a minimal disability was higher in G1 at post-intervention compared to G2 (Figure 1).

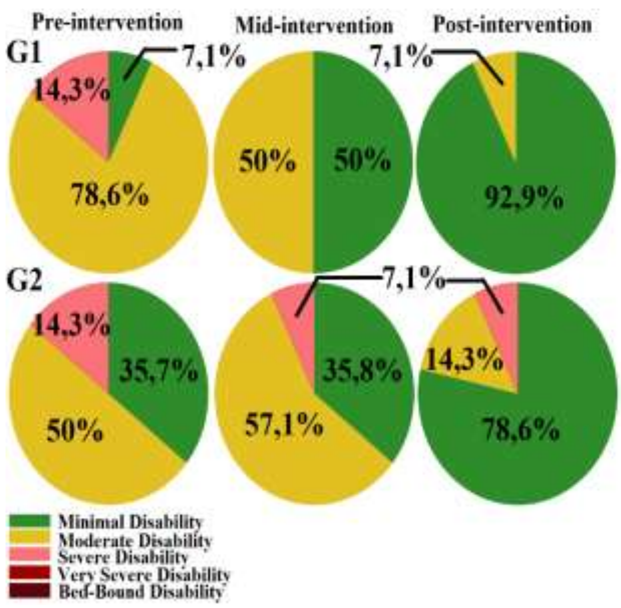

Figure 1. The Distribution of Total ODI score in groups according to the severity level of disability at different weeks

DISCUSSION

The outcome of this study is that core exercise combined with SMFR may have beter short and long-term improvements, in pain intensity and functional status in physiotherapy students with NSLBP than the alone SMFR protocol (p<0.05, Table 4 and 5).

Consistent with our hypothesis, we demonstrated that the core combined with SMFR was more effective to relieve pain and boost the functional status compared to the protocol without core exercises. Nevertheless, the core exercises with SMFR could have adverse effects on pain in the first week.

Özsoy et al compared MFR combined with core exercises and only core exercises for six weeks on 45 elderly with NSLBP for 6 weeks, 3 times. According to the results, the first group had significant improvements in core stability endurance (p=0.031) and spinal mobility (p=0.022) during the post-intervention. However, there were no significant improvements between groups for pain and functional status (p>0.05). Intragroup quality of life, lower back flexibility, pain intensity, and functional status results were significant in the post-intervention (p<0.001). They suggested that MFR combined with core exercises could be more beneficial for the elderly with NSLBP on pain and functional status (Ozsoy et al., 2019). In contrast to Özsoy, we mainly focused on university students with NSLBP. Also, the total duration was shorter, the frequency was lower and each session had the same duration as that of Özsoy. Despite our shorter sessions, we reached significant differences even at the end of 3rd week in each group and between groups in favour of core exercise combined with SMFR, regarding pain and functional status. Therefore, it may be concluded that the combined MFR protocols could be more effective regarding pain and functional status.

A randomized controlled study conducted by Ajimsha et al compared MFR and sham MFR on 80 nurses over 8 weeks, 3 times with chronic LBP, regarding pain and functional status. Group one received MFR, while Group two received sham MFR. Both received specific back exercises. The results showed that the MFR group had significant intra-and intergroup improvements in the eighth, and twelfth weeks for pain and functional status (p< 0.005) (Ajimsha et al., 2014). They suggested that MFR could have better effects on pain and functional status. In contrast, our total number of sessions was fewer. Our duration of exercise was higher, while our duration of MFR was shorter. Also, we measured functional status with ODI and each sub-score of ODI was evaluated separately and showed the distributions of severity levels, which is one of the unique properties of our study. Similarly, we could find significant results between the two groups in favour of core exercise combined with SMFR. Therefore, the representation of change in each sub-ODI score and distribution of severity levels weekly could enhance our understanding of the evaluation of the functional status.

In another study, the effectiveness of MFR and sham MFR were investigated over twelve weeks on 45 participants with LBP. In contrast to Özsoy and Ajimsha, their protocols did not include core exercises. The first group received MFR and the second group received sham MFR twice a week for 2 weeks. MFR was applied on SBL, DFL, and LL. The measurements were made in pre-intervention, in the 2nd and the 12th weeks. The pain intensity was evaluated with the Short-Form McGill Pain Questionnaire (SFMPQ) and VAS, functional status was evaluated with Rolando Morris Questionnaire (RMQ). In the 2nd and 12th weeks, VAS and SFMPQ intragroup differences were significant in both groups ($p<0.01$). In the 12th week, they found significant improvements between groups regarding only SFMPQ ($p=0.04$). Also, in the 12th week, they found significant differences between groups regarding RMQ ($p=0.03$). (Arguisuelas et al., 2017). In 2019, Arguisuelas et al conducted the same protocol on fewer individuals with the flexion-relaxation phenomenon (FRP). They found similar results. Flexion-relaxation was significant between groups in the post-intervention, in favour of the MFR group ($p<0.05$). Those studies of Arguisuelas showed that MFR could have beneficial effects on the Flexion-relaxation phenomenon, functional status, and pain in patients with LBP (Arguisuelas et al., 2019). In contrast, we emphasized 4 myofascial lines and we used SMFR. Similarly, we could find significant improvements even in the 3rd week in and between groups regarding pain and functional status. We might deduce that the utilization of 4 myofascial chains could be more beneficial for patients with LBP.

Seong Yu et al investigated the effectiveness of core exercises and MFR on 40 elderly women regarding pain, flexibility, and balance. Each protocol was performed for 8 weeks (3 times). The first group performed core exercise program. The second group received an MFR of DFL. Participants were evaluated at the pre-and post-intervention. They evaluated pain intensity, balance, and flexibility. According to the results, they found significant intragroup improvements at the post-intervention, regarding pain and flexibility in the MFR group ($p<0.05$). Significant intragroup improvements were found regarding pain and balance in the ADIE group ($p<0.05$). No significant differences were found between groups in the eighth week ($p>0.05$). They concluded that MFR could have positive impacts on pain and flexibility in elderly women, whereas core exercises could benefit more pain and balance (Yu, S. et al., 2016). In contrast, we showed both the short and long-term effects of different SMFR protocols on pain and functional status. Our study had a shorter duration and fewer sessions. Nevertheless, we found significant decreases in pain and improvements in the functional status between groups in the 3rd and 5th weeks in favour of core exercise combined with SMFR. This could be related to the difference in the study protocols. However, we measured neither the lumbar flexibility nor the balance. We could suggest that those parameters should be examined in future studies to assess the functional status efficiently.

In a recent study, the effectiveness of SMFR and Core (Lumbar Stabilization) Exercises (LSE) were evaluated over 6 weeks (3 times/week) on thirty patients with NSLBP. Group one received SMFR of SBL using a lacrosse ball and group two received core exercises. Measurements were done in the pre-and post-intervention using VAS, ODI, trigger point palpation, and ROM. VAS was divided into VAS activity and VAS at rest. According to the results, intragroup VAS activity, VAS at rest, ODI, and ROM in each group improved significantly in the post-intervention ($p<0.05$). They found significant improvements between groups in the post-intervention, in favour of the SMFR group regarding ROM right rotation, ROM left lateral flexion, and trigger point location ($p<0.05$). They concluded that both protocols seem to be effective regarding pain, functional status, and ROM. However, SMFR could be more beneficial for trigger points and Lumbar ROMs (Ling, L. Z. et al., 2022). Similarly, we measured VAS in 2 sections. In contrast, we also showed the acute effects of two protocols on both VAS scores. Regarding sessions, we had fewer sessions compared to this study. Fewer sessions notwithstanding, we demonstrated significant improvements between groups regarding pain and functional status. This could be related to the fact that we compared core exercise combined with SMFR and SMFR. Compared to this study, we demonstrated the distribution of the total ODI according to the severity levels in different weeks (mid-, and post-intervention). Even though we could not find any significant correlation between ODI-intensity levels and the type of protocol in total ODI scores, it might be concluded that the demonstration of those distributions could provide a better chance of monitoring the change in the functional status.

To the best of our knowledge, there are no studies that compared the effectiveness of core exercises combined with SMFR and only SMFR regarding pain and functional capacity. Additionally, the functional status has always been examined using the total ODI or RMQ score without their sub-scores or distribution of ODI scores according to severity levels. Taking into consideration our results, we reported that the representation of each sub-ODI score and the distributions of total ODI scores according to severity levels in two groups might provide a better understanding of following the patient with LBP. In addition, previous studies focused on generally one or two myofascial meridians. No studies were conducted to include the combination of four myofascial meridians (SBL, BFL, DFL, and LL). As a result, it could be deduced that the utilization of those aforementioned four myofascial meridians together could be more effective in the management of LBP.

Our study has some limitations. We examined the five-week results regarding pain and functional capacity, but the follow-up effects remain unknown. The sample size could have been higher. Also, we could not include the measurements for Lumbar ROMs, lumbar flexibility, and depression, due to the pandemic situations. Furthermore, the absence of a blind assessor was another point that caused the bias.

In conclusion, core exercises combined with Self-Myofascial Release and only Self-Myofascial Release have been found effective in decreasing pain and improving the functional capacity in the 3rd and 5th weeks of students with NSLBP. Furthermore, core exercises combined with Self-Myofascial Release can be more effective for reducing pain and improving function.

Declaration of Conflicting Interests

All authors declare no conflicts of interest.

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Ethical Aspect of the Study

The Ethics Committee of Yeditepe University accepted the study protocol on October 19, 2021, under the number 202109095. We acquired written informed consent from all participants and our study was performed by adhering to the Helsinki Declaration.

Author Contributions

Study Design: ETÇ; Data Collection: UD, ETÇ, FS; Statistical Analysis: ETÇ; Data Interpretation: ETÇ, FS; Manuscript Preparation: ETÇ, UD, FS; Final review and editing: ETÇ and FS; Literature Search, ETÇ, UD, FS. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Ajimsha, M. S., Daniel, B., & Chithra, S. (2014). Effectiveness of myofascial release in the management of chronic low back pain in nursing professionals. *Journal of bodywork and movement therapies*, 18(2), 273-281.

Akhtar, M. W., Karimi, H., & Gilani, S. A. (2017). Effectiveness of core stabilization exercises and routine exercise therapy in management of pain in chronic non-specific low back pain: A randomized controlled clinical trial. *Pakistan journal of medical sciences*, 33(4), 1002.

Akkarakittichoke, N., & Janwantanakul, P. (2017). Seat Pressure Distribution Characteristics During 1 Hour Sitting in Office Workers With and Without Chronic Low Back Pain. *Safety and health at work*, 8(2), 212–219.

Akuthota, V., Ferreiro, A., Moore, T., & Fredericson, M. (2008). Core stability exercise principles. *Current sports medicine reports*, 7(1), 39-44.

Allegri, M., Montella, S., Salici, F., Valente, A., Marchesini, M., Compagnone, C., & Fanelli, G. (2016). Mechanisms of low back pain: a guide for diagnosis and therapy. *F1000Research*, 28;5.

Almeida, M., Saragiotto, B., Richards, B., & Maher, C.G. (2018). Primary care management of non-specific low back pain: key messages from recent clinical guidelines. *Medical Journal of Australia*, 208(6), 272-275.

Anggiat, L., Hon, W. H. C., & Baait, S. N. (2018). The incidence of low back pain among university students. Jurnal Pro-Life, 5(3), 677-687.

Anggiat, L., Hon, W. H. C., Sokran, S. N. B. B. M., & Mohammad, N. M. B. (2020). The changes of functional disability in non-specific low back pain among university population after proprioceptive neuromuscular facilitation and McKenzie method. *International Journal of Medical and Exercise Science*, 6(1), 656-667.

Arguisuelas, M. D., Lisón, J. F., Sánchez-Zuriaga, D., Martínez-Hurtado, I., & Doménech-Fernández, J. (2017). Effects of myofascial release in nonspecific chronic low back pain: a randomized clinical trial. *SPINE* 42(9):p 627-634.

Arguisuelas, M. D., Lison, J. F., Domenech-Fernandez, J., Martinez-Hurtado, I., Coloma, P. S., & Sanchez-Zuriaga, D. (2019). Effects of myofascial release in erector spinae myoelectric activity and lumbar spine kinematics in non-specific chronic low back pain: randomized controlled trial. *Clinical Biomechanics*, 63, 27-33.

Aun, C., Lam, Y. M., & Collett, B. (1986). Evaluation of the use of visual analogue scale in Chinese patients. *Pain*, 25(2), 215-221.

Ayanniyi, O., Ukpai, B. O., & Adeniyi, A. F. (2010). Differences in prevalence of self-reported musculoskeletal symptoms among computer and non-computer users in a Nigerian population: a cross-sectional study.*BMC musculoskeletal disorders*,*11*, 177.

Barnes, M. F. (1997). The basic science of myofascial release: morphologic change in connective tissue. *Journal of bodywork and movement therapies*, 1(4), 231-238.

Beach, T. A., Parkinson, R. J., Stothart, J. P., & Callaghan, J. P. (2005). Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine. The spine journal: official journal of the *North American Spine Society*, 5(2), 145–154.

Beardsley, C., & Škarabot, J. (2015). Effects of self-myofascial release: a systematic review. *Journal of bodywork and movement therapies*, 19(4), 747-758.

Bontrup, C., Taylor, W. R., Fliesser, M., Visscher, R., Green, T., Wippert, P. M., & Zemp, R. (2019). Low back pain and its relationship with sitting behaviour among sedentary office workers. *Applied ergonomics*, 81, 102894.

Cheatham, S. W., Kolber, M. J., Cain, M., & Lee, M. (2015). The effects of self-myofascial release using a foam roll or roller massager on joint range of motion, muscle recovery, and performance: a systematic review. *International journal of sports physical therapy*, 10(6), 827.

Citko, A., Górski, S., Marcinowicz, L., & Górska, A. (2018). Sedentary Lifestyle and Nonspecific Low Back Pain in Medical Personnel in North-East Poland. *BioMed research international*, 2018, 1965807.

Cook, G., Burton, L., & Hoogenboom, B. (2006). Pre-participation screening: The use of fundamental movements as an assessment of function–Part 2. *North American journal of sports physical therapy: NAJSPT*, 1(3), 132.

Fairbank, J. C., Couper, J., Davies, J. B., & O'Brien, J. P. (1980). The Oswestry low back pain disability questionnaire. *Physiotherapy*, 66(8),271-273.

Frizziero, A., Pellizzon, G., Vittadini, F., Bigliardi, D., & Costantino, C. (2021). Efficacy of Core Stability in Non-Specific Chronic Low Back Pain. *Journal of functional morphology and kinesiology*, 6(2), 37.

Gibbons, S. G., & Comerford, M. J. (2001). Strength versus stability Part II. Limitations and Benefits, Orthopaedic Division Review.

Golob, A. L., & Wipf, J. E. (2014). Low back pain. *The Medical clinics of North America*, *98*(3), 405–428.

Granacher, U., Schellbach, J., Klein, K., Prieske, O., Baeyens, J. P., & Muehlbauer, T. (2014). Effects of core strength training using stable versus unstable surfaces on physical fitness in adolescents: a randomized controlled trial. *BMC sports science, medicine and rehabilitation*, 6(1), 1-11.

Hibbs, A. E., Thompson, K. G., French, D., Wrigley, A., & Spears, I. (2008). Optimizing performance by improving core stability and core strength. *Sports medicine*, 38(12), 995-1008.

Hides, J., Stanton, W., Mendis, M. D., & Sexton, M. (2011). The relationship of transversus abdominis and lumbar multifidus clinical muscle tests in patients with chronic low back pain. *Manual therapy*, 16(6), 573-577.

Hodges, P. W., & Richardson, C. A. (1996). Inefficient muscular stabilization of the lumbar spine associated with low back pain: a motor control evaluation of transversus abdominis. *Spine*, 21(22), 2640-2650.

Hoy, D., March, L., Brooks, P., Blyth, F., Woolf, A., Bain, C., Williams, G., Smith, E., Vos, T., Barendregt, J., Murray, C., Burstein, R., & Buchbinder, R. (2014). The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. *Annals of the rheumatic diseases*, 73(6), 968–974.

Janwantanakul, P., Pensri, P., Jiamjarasrangsri, V., & Sinsongsook, T. (2008). Prevalence of self-reported musculoskeletal symptoms among office workers. *Occupational medicine (Oxford, England*), 58(6), 436–438.

Juul-Kristensen, B., Søgaard, K., Strøyer, J., & Jensen, C. (2004). Computer users' risk factors for developing shoulder, elbow and back symptoms. *Scandinavian journal of work, environment & health*, 30(5), 390–398.

Kett, A. R., Sichting, F., & Milani, T. L. (2021). The Effect of Sitting Posture and Postural Activity on Low Back Muscle Stiffness. *Biomechanics*, 1(2), 214–224.

Lauridsen, H. H., Hartvigsen, J., Manniche, C., Korsholm, L., & Grunnet-Nilsson, N. (2006). Responsiveness and minimal clinically important difference for pain and disability instruments in low back pain patients. *BMC musculoskeletal disorders*, 7(1), 1-16.

Ling, L. Z., Singh, K., Govind, S., & Wah, Y. C. (2022). Effect of Lumbar Stabilization Exercise and Myofascial Release Therapy in Non-specific Low Back Pain: A Randomized Controlled Trial. *Journal of Positive School Psychology*, 6(3), 4035-4046.

Lizier, D. T., Perez, M. V., & Sakata, R. K. (2012). Exercícios para tratamento de lombalgia inespecífica. *Revista Brasileira de Anestesiologia*, 62, 842-846.

Manchikanti, L., Singh, V., Falco, F. J., Benyamin, R. M., & Hirsch, J. A. (2014). Epidemiology of low back pain in adults. Neuromodulation: *Technology at the Neural Interface*, 17, 3-10.

Majeed A, S., TS, A., Sugunan, A., & MS, A. (2019). The effectiveness of a simplified core stabilization program (TRICCS—Trivandrum Community - based Core Stabilisation) for community - based intervention in chronic non-specific low back pain. *Journal of orthopaedic surgery and research*, 14(1), 1-8.

Meltzer, K. R., Cao, T. V., Schad, J. F., King, H., Stoll, S. T., & Standley, P. R. (2010). In vitro modeling of repetitive motion injury and myofascial release. *Journal of bodywork and movement therapies*, 14(2), 162-171.

Morais, M. L., Silva, V. K. O., & Silva, J. M. N. D. (2018). Prevalence of low back pain and associated factors among physiotherapy students. *BrJP*, 1, 241-247.

Myers, T. W. (2013). Anatomy trains e-book: myofascial meridians for manual and movement therapists. *Elsevier Health Sciences.*

O'Sullivan, P. (2005). Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Manual therapy*, 10(4), 242-255.

Ozsoy, G., Ilcin, N., Ozsoy, I., Gurpinar, B., Buyukturan, O., Buyukturan, B. & Sas, S. (2019). The effects of myofascial release technique combined with core stabilization exercise in elderly with non-specific low back pain: a randomized controlled, single-blind study. *Clinical Interventions in Aging*, 14, 1729.

Panjabi, M. M. (1992). The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *Journal of spinal disorders*, 5, 390-390.

Plaut, S. (2022). Scoping review and interpretation of myofascial pain/fibromyalgia syndrome: An attempt to assemble a medical puzzle. *PloS one*, 17(2), e0263087.

Sitthipornvorakul, E., Janwantanakul, P., & Lohsoonthorn, V. (2015). The effect of daily walking steps on preventing neck and low back pain in sedentary workers: a 1-year prospective cohort study. European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 24(3), 417–424.

Teichtahl, A. J., Urquhart, D. M., Wang, Y., Wluka, A. E., O'Sullivan, R., Jones, G., & Cicuttini, F. M. (2015). Physical inactivity is associated with narrower lumbar intervertebral discs, high fat content of paraspinal muscles and low back pain and disability. *Arthritis research & therapy*, 17(1), 114.

Wang, X. Q., Zheng, J. J., Yu, Z. W., Bi, X., Lou, S. J., Liu, J. & Chen, P. J. (2012). A meta-analysis of core stability exercise versus general exercise for chronic low back pain. *PloS one*, 7(12), e52082.

Wu, Z., Wang, Y., Ye, X., Chen, Z., Zhou, R., Ye, Z. & Xu, X. (2021). Myofascial release for chronic low back pain: A systematic review and meta-analysis. *Frontiers in medicine*, 8, 697986.

Yu, S. H., Sim, Y. H., Kim, M. H., Bang, J. H., Son, K. H., Kim, J. W., & Kim, H. J. (2016). The effect of abdominal drawing-in exercise and myofascial release on pain, flexibility, and balance of elderly females. *Journal of Physical Therapy Science*, 28(10), 2812-2815.