

How to Cite:

El Gendy, M. H., Hekal, H. N., Kadah, M. A., Hussein, H. M., & Ewais, N. F. (2022). Pilate mat exercise versus muscle energy technique on chronic non specific low back pain. *International Journal of Health Sciences*, 6(S5), 3570–3583. <https://doi.org/10.53730/ijhs.v6nS5.9429>

Pilate mat exercise versus muscle energy technique on chronic non specific low back pain

Mohamed Hussien El Gendy PhD.

Professor, Department of basic science for Physical Therapy, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

Hager Nazieh Hekal

Department of basic science for Physical Therapy, Faculty of Physical Therapy, Cairo University, Giza, Egypt and Zifta general hospital, Zifta, Algharbia, Egypt
tel: +201016549132

Email: hager_in@yahoo.com

Mohamed Abdelhaleem Kadah PhD.

Department of, orthopedic surgery, Faculty of Medicine, Cairo University, Giza, Egypt

Hisham Mohamed Hussein PhD.

Department of physical therapy, College of Applied Medical Sciences, University of Ha'il, Ha'il, Saudi Arabia

Najlaa Fathi Ewais

Lecturer of physical therapy, Basic sciences department, Faculty of Physical Therapy, Cairo University, Giza, Egypt

Abstract---Background: Many studies have been performed to evaluate the best physical therapy technique for treating chronic nonspecific low back pain. Pilate exercises and muscle energy techniques showed favorable results in many trials. Yet, no comparisons were conducted to compare their effects. Purpose: To compare between the effects of pilate mat exercise (PME) and Muscle energy technique (MET) on pain intensity, functional disability, trunk range of motion, and flexibility in patients with chronic non specific low back pain. Subjects: seventy-eight patients diagnosed, by their orthopedist, with chronic non specific low back pain participated in this study. Methods: Patients were divided randomly into three groups: *Pilate group*: consisted of 29 patients who received PME and standard treatment, *MET group*: consisted of 29 patients who received MET treatment and standard treatment, *Control group*: consisted of 29 patients who received standard treatment only. Interventions were

performed for 12 sessions (3 sessions/ week) over a period of four weeks. Outcomes were assessed at the beginning and at the end of the fourth week using visual analogue scale for pain intensity, V-sit and reach test (VSR) for flexibility of hamstring and lower back muscles. Roland-Morris Low Back Pain and Disability Questionnaire for functional disability, and (BROM II) device to measures range of motion of the lumbar spine flexion and extension. Results: The studied groups were comparable regarding demographics with small size effect in between the groups. Also, there was no statistically significant difference between the 3 groups regarding trunk range of movement in flexion and extension, VAS and VSR with small size effect. After treatment, there was variable degrees of improvement and statistically significant differences with large size effect regarding ROM, VAS, VSR and Ronald score. Conclusion: Different treatment modalities are effective in treating chronic non-specific low back pain. However, better results were obtained with Pilate Mat exercise technique.

Keywords---Chronic non-specific low back pain, Pilates Mat exercise, Muscle energy technique.

Introduction

Low back pain (LBP) is a major musculoskeletal problem (Pakbazetal., 2019). Approximately 60% to 80% of the population experience more than one episode of LBP in their life (Hussein, Hisham Mohamed; Morsi, AmalAhmed Abdelraoof,2021; Wu et al., 2020). In the majority of these cases the cause could not be recognized hence names non specific (Balagué et al., 2012). Pain in the low back has gained considerable attention within the medical community because of its major socioeconomic impact. It is a leading cause for seeking medical help, deterioration of functional ability, and work absence (Hussien et al., 2017). Many factors contribute to non-specific chronic LBP as obesity, sedentary life style, and genetic factors that have a great effect on pain perception in LBP (Mahdavi et al., 2021). Being one of the major therapeutic intervention, physical therapy techniques have been exposed to multiple investigation to determine the best and cost-effective intervention. The effectiveness of therapeutic exercises has been supported in literature (Chou et al., 2017). However, therapeutic exercises consist of variable techniques such as (PME) and (MET). Pilates exercise was founded first by Joseph Pilates during the 1920s (Caldwell et al., 2015). The prescription of Pilate exercises for patients with chronic back pain had been justified by the fact that this method is based on exercises that emphasize body stretching and strengthening (Eliks et al., 2019). Therefore, the method jointly works isometric strengthening, global stretching, breathing, and proper positioning of the spine promoting a broader body awareness and proprioception (Berdishevsky et al., 2016). According to a systematic review conducted by Patti and others (Patti et al., 2015), PME is an effective pain reliving method in low back pain. Additionally, Lin and colleague found additional beneficial effects in terms of functional level (Lin et al., 2016). The intervention called MET depends on the using of low amplitude muscle contractions against resistance followed by elongation of the

affected tissues, MET aims to normalize soft tissue structures, such as shortened or tight muscles. It can be used to improve joint mobility by influencing the dysfunctional soft tissues and to relax tight tens musculature, spasms, or fibrotic changes. It can help increasing muscle strength, increasing range of motion (ROM) and decreasing edema (Elshinnawy et al., 2019). Although the limited number of high quality studies available to reach conclusive opinion (Franke et al., 2015), MET has been shown to be effective in reducing pain (Phadke et al., 2016), improving ROM, and functional level (Patel et al., 2018). Up to the authors knowledge, no studies were conducted to compare between the effectiveness of PME versus MET in the treatment of chronic non specific LBP. The objective of this study is to compare the PME versus MET on pain, function, ROM, and flexibility in patients with chronic non specific LBP

Methods

Design: Double blinded randomized clinical trial was implemented to investigate the effect of PME and MET on chronic non-specific LBP in comparison to conventional treatment.

Participants (figure 1): Seventy-eight participants with non-specific low back pain were eligible to be enrolled in the study and they were recruited from the faculty of physical therapy outpatient clinic, Cairo University (Cairo, Egypt).

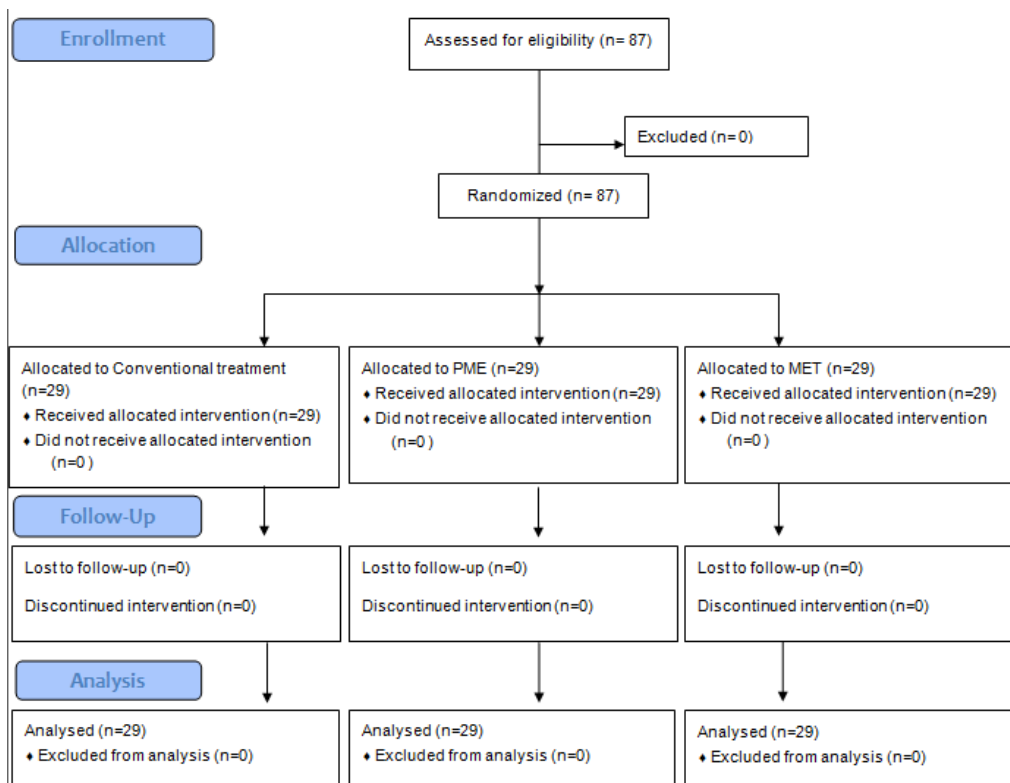


Figure (1): Study flow chart

Inclusion criteria: patients on both genders with age more than 18 years were included. All participants had normal body mass index (BMI) and were diagnosed as chronic non specific LBP patients.

Exclusion criteria: Patients with previous back surgery, lumbar disc herniation, spinal deformities, Neuro-musculoskeletal problems as hip arthrodesis or arthroplasty and spondylolisthesis, patients with history of cardiovascular disease, diabetes mellitus and rheumatoid arthritis, Pregnant women and patients with osteoporosis were excluded.

Enrolled participants were randomized into 3 groups:

Control Group: received traditional treatment only for 12 sessions (3 sessions/week) over a period of four weeks.

Pilate Group: received PME for 12 sessions (3 sessions/week) over a period of four weeks.

MET Group: received MET treatment for 12 sessions (3 sessions/week).

Sample size: Sample size was calculated using G*Power (version 3.0.10). F test MANOVA within and between interaction effects was selected. Considering a power of 0.8 an alpha level of 0.05 (2tailed) and effect size of 0.34, three groups and response variables of four, a generated sample size of at least 29 participants per group was required and total sample size of 87 subjects.

Randomization and allocation: Randomization was simply performed by giving every participant an identification number; these numbers were randomized into 3 groups.

Blinding: Double blind study in which doctors and patients did not know the method of randomizing was used.

Interventions: During the first meeting, the assessor described the purpose of the study and answered any questions raised by the patients. Then patients classified into 3 groups; Control Group, Pilate Group and MET Group.

Standard treatment for Control group: will include Electrical heat pack a comfortable treatment plinth was used so that the patient was in a relaxed prone lying position and put Electrical heat pack above lower back. Patients performed stretching from a sitting position, subjects were asked to keep their pelvis neutral while extending one knee to the point at which they complained of a feeling of discomfort or tightness in the hamstring muscles or felt to lose the neutral pelvic position. Subjects had to maintain this position for 30 seconds. Stretching was repeated 3 times per session. Other treatment modality is Stretch of lower back muscles this exercise was performed in kneeling sitting position, Keeping knees about hip width apart, First, the patient was asked to place his hands on his thighs. Then, slide his hands down his thighs on to the floor in front of him supporting his weight as the trunk moves down toward the floor. The back of the patient was completely relaxed and rested on his thighs the patient was asked to hold this position for 30 seconds and was repeated 3 times per session. Strengthening exercise for abdominal muscles is also performed while the patients assumed crook lying. One set of 10 repetitions was performed during the

first week. Exercise repetitions were increased according to the tolerance of the patient. The therapist stabilized both feet of the patient, and the patient was asked to cross his hands over the chest and raise his head and shoulders of the bed then relax.

Procedures for Pilate group: The Pilate group was receiving PME in addition to standard treatment. These include Bridging by Lie supine with the knees bent, legs parallel approximately hip distance apart, arms relaxed at the sides with palms down, and the pelvis in a neutral position, Lateral bridging (Shoulder Bridge). Knees are bent and feet on the floor about hip distance apart and parallel. Extend arms along sides, and press the backs of arms into the mat. Pilate Plank (front support) from a quadruped position with the hands directly under the shoulders and fingers facing forward, establish a neutral spine and draw the shoulder blades down and back. Then, inhale as one leg extends to the plank position keeping the pelvis as still as possible.

Procedures for MET: MET were applied for two muscles; Hamstring and Erector Spinae. For each muscle after positioning, the patient was asked to apply 20% force against therapist resistance and hold that contraction for 7-10 seconds and after that relax for 5 seconds and when patient exhale, therapist takes muscle to new restriction barrier. Hold this position for 30 seconds at the end barrier as an end-stretch with 3 repetitions.

Outcome:

1-Pain intensity: For measuring the pain level, each patient was instructed to rate the current level of pain by placing (X) sign a cross the horizontal VAS line. The distance in millimeters from the lower limit was measured using a ruler. VAS was assessed before and after the treatment program as 1:2 mild, 3:6 moderate and 7:10 severe.

2-Functional Disability: Patients were asked to read the list of 24 sentences and place a tick against appropriate sentence based on how they feel each sentence describes them. If the sentence does not describe their symptoms today, patients are asked to leave the space next to the sentence blank. Participants were asked to tick next to the sentence if they were sure it describes them today. The Roland-Morris Disability Questionnaire (RMDQ) is scored by adding up the number of items the patient has ticked. Scores can vary between 0-24. Greater levels of disability are reflected by higher scores.

3-Range of Motion: Measurements with the universal inclinometer need to be with the patient in an upright position. Palpate and mark S1 and T12. Mark on bare skin when possible. This avoids the marks moving with the patient's clothing. Center the two inclinometers over the palpation marks and zero with your finger by spinning the dial (zero would then be at the bottom of the inclinometer). Have the patient flex forward as far as possible. Note the reading on each inclinometer. The reading on the upper inclinometer is total lumbar flexion. The reading on the lower inclinometer is sacral flexion. The difference between the reading at S1 and T12 is true lumbar flexion. Repeat flexion protocol for extension having the patient extends back for full extension instead of flexing forward.

Statistical analysis: All data were tabulated in the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA). Categorical data were expressed as number and percent. Normally distributed data were expressed as mean and standard deviation. Chi-square was used to test categorical data between the groups. Student t-test was used to compare normally distributed data between 2 groups. Analysis of Variance (ANOVA) test was used to compare normally distributed data between more than 2 groups. Repeated measures ANOVA test was used to test the effect of treatment per each group. Post hoc tests were used to conduct the subsequent pairwise comparisons. The results will be considered significant when the probability of error is less than 5% ($p < 0.05$).

Results

The study included 87 patients with age ranges from 20 to 60 years. The majority of the included patients were females (60 patients) with mean BMI 22.48 ± 1.5 Kg/m². There was no statistically significant difference between the studied groups regarding baseline demographics including age, sex and BMI. Also, range of movement of the trunk in flexion and extension, VAS and VSR were comparable between the studied groups (*table 1*).

Table (1): Demographics differences between the studied groups

	Control group	PME group	MET group	P*
Age (years) mean±SD	40.38±9.36	39.3±10.97	42.58±11.7	>0.05
Weight (kg)	63.2±8.2	59.67±7.6	60.7±7.9	
Height (cm)	154±4.2	157.23±3.1	152.76±4.5	
Body mass index (Kg/m ²) mean±SD	22.5±1.64	22.3±1.69	22.65±1.4	
ROM (trunk flexion) mean±SD	40.34±3.9	39.3±5.4	39.48±6.03	
ROM (trunk extension) mean±SD	11.03±2.06	11.7±2.4	11.7±2.4	
VAS (mm) mean±SD	78.27±8.5	74.09±14.86	74.7±9.01	
VSR (cm) mean±SD	1.13±0.69	0.93±0.4	1.17±0.7	

PME: Pilates Mat exercise; MET: Muscle Energy Technique; ROM: Range of motion; VAS: Visual analogue scale; VSR: V-sit and reach test; Level of significance < 0.05 ; * Multivariate analysis of variance test

After treatment completion, range of movement of trunk flexion improved significantly in the 3 groups especially in Pilates Mat group with statistically significant difference ($p > 0.05$). range of trunk movement in extension improved significantly in the 3 groups ($p > 0.05$) but improvement was the lowest among control group. VAS and VSR showed statistically significant improvement in the 3 groups after treatment especially in PME group ($p > 0.05$) (*table 2*).

Table (2): Within-groups comparison regarding characteristics pre and post treatment:

Outcome	Groups	M ₀	M ₁
ROM (trunk flexion) mean±SD	Conventional	40.34±3.9	45.17±4.3 ^a
	PME	39.3±5.4	48.96±6.17 ^a
	MET	39.48±6.03	44.66±5.8 ^a
ROM (trunk extension) mean±SD	Conventional	11.03±2.06	14.3±3.2 ^a
	PME	11.7±2.4	18.55±3.74 ^a
	MET	11.7±2.4	18.79±3.44 ^a
VAS (mm) mean±SD	Conventional	78.27±8.5	63.5±11.95 ^a
	PME	74.09±14.86	37.79±17.37 ^a
	MET	74.7±9.01	56.72±17.3 ^a
VSR (cm) mean±SD	Conventional	1.13±0.69	0.3±0.1 ^a
	PME	0.93±0.4	0.75±0.4 ^a
	MET	1.17±0.7	0.54±0.2 ^a

PME: Pilates Mat exercise; MET: Muscle Energy Technique; ROM: Range of motion; VAS: Visual analogue scale; VSR: V-sit and reach test; M₀: measures at baseline; M₁: measures after treatment; Level of significance<0.05; ^a M₁ differs significantly from M₀

The between-group comparisons showed similarity between all groups at baseline measurements ($p > 0.05$) with small size effect regarding ROM, medium effect of size regarding VAS between control and PME and also control and MET (d : 0.34; 0.4 resp.) and medium effect of size regarding VSR between control and PME (d :0.4) and also PME and MET (d : 0.4). After treatment, trunk range of movement in flexion was significantly better in PME group when compared to control group and MET group with large effect of size (d : 0.7) ($p>0.05$). trunk range of movement in extension showed better improvement in PME and MET groups than control group with large effect of size (d : 1.2, 1.35 resp.) ($p>0.05$). VAS improved significantly in PME group when compared to control and MET with large effect of size (d : 1.72, 1.09 resp.) ($p>0.05$). On the other hand, VSR decreased in the 3 groups however VSR in PME group was significantly higher than the other 2 groups ($p>0.05$) while the other 2 groups were comparable inspite of the large effect of size (d : 1.5; $p<0.05$) (table 3). Regarding Roland Morris Disability percent, the percent was significantly higher among PME (66.06±16.4) and MET groups (61.89±17.3) than control group (51.7±15.59) ($p>0.05$) with large effect of size between PME and control (d : 1.03) and MET and control (d : 0.9)

Table (3): Between groups mean difference comparison

Outcomes	Time	Control-PME (95% CI) <i>Cohen's d</i>	Control-MET (95% CI) <i>Cohen's d</i>	PME-MET (95% CI) <i>Cohen's d</i>
ROM (trunk flexion)	M ₀	(-2.24, 4.3) 0.22	(-2.4, 4.14) 0.16	(-3.4, 3.1) 0.03
	M ₁	(-7.23, -0.34) 0.71*	(-2.9, 3.96) 0.09	(0.8, 7.75) 0.7*

ROM (trunk extension)	M ₀	(-2.13, 0.75) 0.29	(-2.13, 0.75) 0.29	(-1.4, 1.4) 0.00
	M ₁	(-6.4, -2.06) 1.2*	(-6.65, -2.3) 1.35*	(-2.4, 1.9) 0.07
VAS (mm)	M ₀	(-2.8, 11.21) 0.34	(-3.4, 10.56) 0.4	(-7.66, 6.3) 0.04
	M ₁	(15.85, 35.59) 1.72*	(-3.07, 16.66) 0.4	(-28.79, -9.06) 1.09*
VSR (cm)	M ₀	(-0.28, 0.69) 0.4	(-0.52, 0.45) 0.05	(-0.73, 0.24) 0.4
	M ₁	(-0.87, -0.023) 1.5*	(-0.66, 0.18) 1.5	(-0.218, 0.63) 0.7*
Roland Morris (%)	M ₁	(-24.6, -4.08) 1.03	(-20.4, 0.09) 0.9	(-6.09, 14.4) 0.23

PME: Pilates Mat exercise; MET: Muscle Energy Technique; ROM: Range of motion; VAS: Visual analogue scale; VSR: V-sit and reach test; M₀: measures at baseline; M₁: measures after treatment; *Level of significance<0.05

Discussion

The study included 87 patients who were referred with low back pain. After exclusion of any causes, pain was determined as unspecified chronic low back pain. The patients' age ranged from 20 to 60 years and mean age 40.75±10.69 years. This is similar to prevalence report by Shmagel et al., and he also found positive correlation between increased age and incidence of LBP (**Shmagel et al., 2016**). This comes in hand also with reports stated that low back pain is one of the common health problems that 50–80% of adults experience at some point in their life. It is believed that adults of working age are the most vulnerable group of LBP, which is ranked as the highest cause of disability than any other condition globally (**Grimmer et al., 2000**), (**Rubin, 2007**), (**Hoy et al., 2010**). Low back pain in the current study was more prevalent among females (68.95%). This is in agreement with Grimmer et al., who found that unspecified low back pain is more common among young females (**Grimmer et al., 2000**) and (**Solem, 2015**) who performed a survey on the prevalence of ULBP and found that it was more common among females. Shmagel et al., also showed that LBP is more pronounced among females (55.5%) (**Shmagel et al., 2016**). In contrary to the current study, many other reports found that the prevalence of LBP is more common among males (**Kuijer et al., 2015**), (**Beaudet et al., 2013**) and (**Spijker-Huiges et al., 2015**). This may be related to the type of patients included in their study as their studies were performed mainly on workers and they related the LBP to the nature of their work. Our previous results regarding age and sex are consistent with estimates for all-chronicity LBP from US national surveys (**Deyo et al., 2006**), (**Deyo et al., 1987**). Body mass index of the included patients was high (35.48±1.57). This is with what was reported by Shmagel et al., who associated incidence of LBP with BMI more than 30 (**Shmagel et al., 2016**). Shiri et al., also found the same association (**Shiri et al., 2010**). A systematic literature review from 2000 for all-chronicity LBP found a weak positive association between LBP and obesity, emphasizing that a strong

relative risk above 2 was not reported in any of the reviewed epidemiologic studies (**Lebouef et al., 2000**). The patients were randomized to different 3 techniques for treatment of LBP. The patients in the 3 groups were comparable regarding age, sex and BMI. Also they were comparable regarding LBP characteristics (range of movement either in extension or flexion, visual assisted scale and V set and reach test. Standard stretching technique was beneficial on treating low back pain. It improved trunk range of movement in flexion and extension, visual assisted scale and V set and reach test. This comes in agreement in the result of meta-analysis by Slade et al., which included 13 randomized clinical trials after exclusion of useless and bias trials and concluded that trunk strengthening is effective for reducing pain and improving function (**Slade & Keating, 2006**). Also, Kankaanpaa et al., and Mannion et al., found that physical stretching techniques were beneficial in treating patients with unspecified low back pain (**Kankaanpaa et al., 1999**), (**Mannion et al., 2000**). Another study showed that manual stretching exercises for back, hamstring and iliopsoas muscles and strengthening exercises for abdominal muscle and postural instructions for activities of daily living were beneficial in decreasing pain (reflected by improvement of VAS and VSR) and improving functional activities (ROM) in people with chronic low back pain (**Kang et al., 2019**). On the other hand, more recent studies showed inferiority of the physical muscle stretching in treating low back pain (**Franca et al., 2012**), (**Halbertsma et al., 1999**). Both studies reported improvement in VAS and VSR however it was less than 50% and they considered it as unsatisfactory improvement. Regarding Pilate exercise, there was significant improvement of range of movement, VAS scale and VSR test after Pilate exercise. These results were confirmed by Llewellyn et al., who found that Pilates based exercise can be administered safely and is well tolerated by the majority of patients with nonspecific chronic LBP and his study included 13 patients (**Llewellyn et al., 2017**). Patti et al., in his meta-analysis concluded that Pilates method is very effective in treating low back pain (**Patti et al., 2016**). The analysis included results of 29 randomized clinical trial. Valenza et al., also reported effective pain reduction after Pilates exercise among 27 patients (**Valenza et al., 2017**). Gladwell et al., reported that Pilates was found to be superior to the controls and improvements were seen in this group's general health, sports functioning, flexibility, proprioception and they experienced less pain (**Gladwell et al., 2006**). Efficacy of Pilates exercise on LBP was approved in many other studies (**Lim et al., 2008**), (**Mallin and Murphy, 2013**), (**Kucukcakir et al., 2013**). A meta-analysis by Cruz-Ferreira et al., reported improvement of pain after Pilates exercise but no effect was found on range of movement (**Cruz-Ferreira et al., 2011**). Marshall et al., reported reduction 30% in VAS after treatment by Pilates (**Marshall et al., 2013**). On contrary to the current study, Donzelli et al., did not find favorable outcome among LBP patients who received Pilates exercise treatment (**Donzelli et al., 2006**). Same finding was reported by (**Pereira et al., 2012**) with no significant effect of Pilates exercise. Also, Wells et al., couldn't approve the efficacy of Pilates and he related that to the insufficient number and poor methodology (**Wells et al., 2012**). Regarding Muscle energy technique, there was significant improvement in trunk range of movement, VAS and VSR after MET. This is similar to the results of reports by (**Selkow et al., 2009**), (**Shipy, 2012**), (**Deepali and Siddhartha, 2014**) and (**patal et al., 2018**). This is against what was reported by **Pillay et al., 2005 and Salvador et al., 2005 and Bindra et al., 2012** who did not find

statistically significant difference between pre and post treatment among the included patients treated with MET. Also, Day & Nitz found minimal non-significant improvement with MET in treating LBP (**Day & Nitz, 2012**). Franke et al., confirmed the previous results (**Franke et al., 2016**). Post-treatment and the degree of changes in trunk range of movement in flexion and extension, VAS scale and VSR test were better in Pilates exercise group than the other 2 methods. This comes in hand with Patti et al., who confirmed superiority of Pilates over the other techniques in treating LBP (**Patti et al., 2016**). Galdwell et al., also reported better improvement in VAS with Pilates in comparison to physical exercise (**Galdwell et al., 2006**). Da Fonseca et al., showed significant improvement in Pilates group than no Pilates group (**Da Fonseca et al., 2009**). Against what was reported in the current study, Rydeard et al., found superiority of stretching muscle exercise over Pilates exercise among female patients with LBP (**Rydeard et al., 2006**). Curnow et al., did not find significant difference between Pilates and other methods in treating LBP (**Curnow et al., 2009**). On the other hand, MET showed superiority to conventional treatment but to some extent comparable results to Pilates exercise in our results. This comes in hand with Selkow et al., who stated that MET had better results than conventional therapy (**Selkow et al., 2009**). Also, **Phadke et al.**, found that Muscle energy technique was better than stretching technique in improving pain and functional disability in people with mechanical pain (**Phadke et al., 2018**). But, **Fryer et al., 2011** found that MET had low success rate in comparison to conventional methods. Roland Morris percent was higher significantly among Pilates then MET groups than control group which reflect better pain control in these groups. The study had the advantage of being performed on large sample size in comparison to most of the published studies. Also, the patients received different 3 techniques. To the best of our knowledge, this is the first study to compare Pilates to MET in treating low back pain directly as most of the studies compared either techniques with physical exercise or no intervention. Also, we analyzed the effect of each modality separately before comparing each other which help in avoiding selection and randomization bias.

Conclusion

This preliminary study included relatively large sample size of population who suffered from chronic non-specific low back pain and randomized to receive different 3 types of treatment showed that different degrees of improvement occurred to all participants in the 3 groups with better improvement with Pilates Mat Exercise technique then Muscle energy techniques than conventional treatment.

Limitations

The study included limited number of population which limits the findings. The demographics of the current study may affect the outcome and limit the generalizability as most of included patients were females and maximum age was 60 years. The therapist may affect the technique and inter-personal variations may present which affects the study findings. Further and more extended studies are needed to confirm our results.

Conflicts of interest

No conflict

Acknowledgments

None

References

- Atya, A. M. (2013). The validity of spinal mobility for prediction of functional disability in male patients with low back pain. *Journal of Advanced Research*, 4(1), 43–49. <https://doi.org/10.1016/j.jare.2012.01.002>
- Balagué, F., Mannion, A. F., Pellisé, F., & Cedraschi, C. (2012). Non-specific low back pain. *Lancet (London, England)*, 379(9814), 482–491. [https://doi.org/10.1016/S0140-6736\(11\)60610-7](https://doi.org/10.1016/S0140-6736(11)60610-7)
- Baltaci, G., Un, N., Tunay, V., Besler, A., & Gerçeker, S. (2003). Comparison of three different sit and reach tests for measurement of hamstring flexibility in female university students. *British Journal of Sports Medicine*, 37(1), 59–61. <https://doi.org/10.1136/BJSM.37.1.59>
- Barros, G., McGrath, L., & Gelfenbeyn, M. (2019). Sacroiliac Joint Dysfunction in Patients With Low Back Pain. *Federal Practitioner: For the Health Care Professionals of the VA, DoD, and PHS*, 36(8), 370–375. <https://pubmed.ncbi.nlm.nih.gov/31456628/>
- Berdishevsky, H., Lebel, V. A., Bettany-Saltikov, J., Rigo, M., Lebel, A., Hennes, A., Romano, M., Bialek, M., M'hango, A., Betts, T., de Mauroy, J. C., & Durmala, J. (2016). Physiotherapy scoliosis-specific exercises - a comprehensive review of seven major schools. *Scoliosis and Spinal Disorders*, 11(1), 1–52. <https://doi.org/10.1186/s13013-016-0076-9>
- Caldwell, K., Adams, M., Quin, R., Harrison, M., & Greeson, J. (2015). Pilates, mindfulness and somatic education. *Journal of Dance & Somatic Practices*, 5(2), 141–153. https://doi.org/10.1386/JDSP.5.2.141_1
- Chou, R., Deyo, R., Friedly, J., Skelly, A., Hashimoto, R., Weimer, M., Fu, R., Dana, T., Kraegel, P., Griffin, J., Grusing, S., & Brodt, E. D. (2017). Nonpharmacologic therapies for low back pain: A systematic review for an American College of physicians clinical practice guideline. *Annals of Internal Medicine*, 166(7), 493–505. https://doi.org/10.7326/M16-2459/ASSET/IMAGES/LARGE/M162459FF1_FIGURE_LITERATURE_SEARCH_AND_SELECTION.JPEG
- Delgado, D. A., Lambert, B. S., Boutris, N., McCulloch, P. C., Robbins, A. B., Moreno, M. R., & Harris, J. D. (2018). Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. *Journal of the American Academy of Orthopaedic Surgeons. Global Research & Reviews*, 2(3), e088. <https://doi.org/10.5435/JAAOSGLOBAL-D-17-00088>
- Donzelli, S., Di Domenica, F., Cova, A. M., Galletti, R., & Giunta, N. (2006). Two different techniques in the rehabilitation treatment of low back pain: A randomized controlled trial. *Europa Medicophysica*, 42(3), 205–210. <https://pubmed.ncbi.nlm.nih.gov/17039216/>
- Eliks, M., Zgorzalewicz-Stachowiak, M., & Zeńczak-Praga, K. (2019). Application of Pilates-based exercises in the treatment of chronic non-specific low back pain: State of the art. *Postgraduate Medical Journal*, 95(1119), 41–45. <https://doi.org/10.1136/postgradmedj-2018-135920>

- Elshinnawy, A. M., Abd Elrazik, R. K., & Mohamed Abd Elatief, E. E. (2019). The effect of Muscle Energy Techniques versus cross (X) technique kinesio taping to treat chronic low back dysfunction. *Https://Doi.Org/10.12968/Ijtr.2017.0038, 26(2)*. <https://doi.org/10.12968/IJTR.2017.0038>
- Franke, H., Fryer, G., Ostelo, R., & Kamper, S. J. (2015). Muscle energy technique for non-specific low-back pain. *Cochrane Database of Systematic Reviews, 2*. <https://doi.org/10.1002/14651858.CD009852.pub2>
- Gladwell, V., Head, S., Hagggar, M., & Beneke, R. (2006). Does a Program of Pilates Improve Chronic Non-Specific Low Back Pain? *Journal of Sport Rehabilitation, 15(4)*, 338–350. <https://doi.org/10.1123/JSR.15.4.338>
- Grimmer, K., & Williams, M. (2000). Gender-age environmental associates of adolescent low back pain. *Applied Ergonomics, 31(4)*, 343–360. [https://doi.org/10.1016/S0003-6870\(00\)00002-8](https://doi.org/10.1016/S0003-6870(00)00002-8)
- H Hussein, E Kamel, R. K. (2019). Association between pain intensity and obesity in patients with chronic non-specific low back pain. *Bioscience Research, 16(4)*, 3579–3583.
- Halbertsma, J. P. K., Mulder, I., Göeken, L. N. H., & Eisma, W. H. (1999). Repeated passive stretching: Acute effect on the passive muscle moment and extensibility of short hamstrings. *Archives of Physical Medicine and Rehabilitation, 80(4)*, 407–414. [https://doi.org/10.1016/S0003-9993\(99\)90277-0](https://doi.org/10.1016/S0003-9993(99)90277-0)
- Helen, L. (2017). The Effect of a Pilates Exercise Programme on Perceived Functional Disability and Pain Associated with Non-Specific Chronic Low Back Pain. *MOJ Yoga & Physical Therapy, 2(1)*. <https://doi.org/10.15406/MOJYPT.2017.02.00013>
- Hussein, Hisham Mohamed; Morsi, Amal Ahmed Abdelraoof, N. A. (2021). The immediate effect of sustained natural apophyseal glide on postural stability and pain in individuals presenting with flexion-dominant chronic low back pain: A randomized single-blinded placebo-controlled trial. *Journal of Back and Musculoskeletal Rehabilitation, in press(in press)*, 1–8.
- Hussien, H. M., Abdel-Raouf, N. A., Kattabei, O. M., & Ahmed, H. H. (2017). Effect of Mulligan Concept Lumbar SNAG on Chronic Nonspecific Low Back Pain. *Journal of Chiropractic Medicine, 16(2)*, 94–102. <https://doi.org/10.1016/j.jcm.2017.01.003>
- Kang, T. W., & Kim, B. R. (2019). The Effects of Stretching and Strengthening Exercise on the Pain, Pelvic Tilt, Functional Disability Index, and Balance Ability of Patients with Chronic Lower Back Pain. *The Journal of Korean Physical Therapy, 31(1)*, 7–12. <https://doi.org/10.18857/jkpt.2019.31.1.7>
- Kankaanpää, M., Taimela, S., Airaksinen, O., & Hänninen, O. (1999). The efficacy of active rehabilitation in chronic low back pain: Effect on pain intensity, self-experienced disability, and lumbar fatigability. *Spine, 24(10)*, 1034–1042. <https://doi.org/10.1097/00007632-199905150-00019>
- Lin, H. T., Hung, W. C., Hung, J. L., Wu, P. S., Liaw, L. J., & Chang, J. H. (2016). Effects of pilates on patients with chronic non-specific low back pain: A systematic review. *Journal of Physical Therapy Science, 28(10)*, 2961–2969. <https://doi.org/10.1589/jpts.28.2961>
- MacDermid, J. C., Arumugam, V., Vincent, J. I., Payne, K. L., & So, A. K. (2015). Reliability of three landmarking methods for dual inclinometry measurements of lumbar flexion and extension. *BMC Musculoskeletal Disorders, 16(1)*. <https://doi.org/10.1186/S12891-015-0578-2>

- Mahdavi, S. B., Riahi, R., Vahdatpour, B., & Kelishadi, R. (2021). Association between sedentary behavior and low back pain; A systematic review and meta-analysis. *Health Promotion Perspectives, 11*(4), 393–410. <https://doi.org/10.34172/hpp.2021.50>
- Mannion, A. F., Müntener, M., Taimela, S., & Dvorak, J. (1999). A randomized clinical trial of three active therapies for chronic low back pain. *Spine, 24*(23), 2435–2448. <https://doi.org/10.1097/00007632-199912010-00004>
- Mayorga-Vega, D., Merino-Marban, R., & Viciano, J. (2014). Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: A meta-analysis. *Journal of Sports Science and Medicine, 13*(1), 1–14.
- Page P. 2012. Current concepts in muscle stretching for exercise and rehabilitation. *International journal of sports physical therapy, 7*(1), 109–119.
- Pakbaz, M., Hosseini, M. A., Aemmi, S. Z., & Gholami, S. (2019). Effectiveness of the back school program on the low back pain and functional disability of Iranian nurse. *Journal of Exercise Rehabilitation, 15*(1), 134–138. <https://doi.org/10.12965/jer.1836542.271>
- Patel, V. D., Eapen, C., Ceepee, Z., & Kamath, R. (2018). Effect of muscle energy technique with and without strain-counterstrain technique in acute low back pain — A randomized clinical trial. *Hong Kong Physiotherapy Journal, 38*(01), 41–51. <https://doi.org/10.1142/S1013702518500051>
- Patti, A., Bianco, A., Paoli, A., Messina, G., Montalto, M. A., Bellafiore, M., Battaglia, G., Iovane, A., & Palma, A. (2015). Effects of pilates exercise programs in people with chronic low back pain: A systematic review. *Medicine (United States), 94*(4), 1–9. <https://doi.org/10.1097/MD.0000000000000383>
- Patti, A., Bianco, A., Paoli, A., Messina, G., Montalto, M. A., Bellafiore, M., Battaglia, G., Iovane, A., & Palma, A. (2016). Pain perception and stabilometric parameters in people with chronic low back pain after a pilates exercise program: A randomized controlled trial. *Medicine (United States), 95*(2), 1–7. <https://doi.org/10.1097/MD.0000000000002414>
- Payares, K., Lugo, L. H., & Restrepo, A. (2015). Validation of the Roland Morris Questionnaire in Colombia to Evaluate Disability in Low Back Pain. *Spine, 40*(14), 1108–1114. <https://doi.org/10.1097/BRS.0000000000000963>
- Phadke, A., Bedekar, N., Shyam, A., & Sancheti, P. (2016). Effect of muscle energy technique and static stretching on pain and functional disability in patients with mechanical neck pain: A randomized controlled trial. *Hong Kong Physiotherapy Journal, 35*, 5–11. <https://doi.org/10.1016/j.hkpj.2015.12.002>
- Rydeard, R., Leger, A., & Smith, D. (2006). Pilates-based therapeutic exercise: effect on subjects with nonspecific chronic low back pain and functional disability: a randomized controlled trial. *The Journal of Orthopaedic and Sports Physical Therapy, 36*(7), 472–484. <https://doi.org/10.2519/JOSPT.2006.2144>
- Selkow, N. M., Grindstaff, T. L., Cross, K. M., Pugh, K., Hertel, J., & Saliba, S. (2009). Short-term effect of muscle energy technique on pain in individuals with non-specific lumbopelvic pain: a pilot study. *The Journal of Manual & Manipulative Therapy, 17*(1), 14E–18E. <https://doi.org/10.1179/JMT.2009.17.1.14E>
- Shiri, R., Karppinen, J., Leino-Arjas, P., Solovieva, S., & Viikari-Juntura, E. (2010). The association between obesity and low back pain: A meta-analysis. *American Journal of Epidemiology, 171*(2), 135–154. <https://doi.org/10.1093/aje/kwp356>

- Shmagel, A., Foley, R., & Ibrahim, H. (2016). Epidemiology of Chronic Low Back Pain in US Adults: Data From the 2009-2010 National Health and Nutrition Examination Survey. *Arthritis Care & Research*, 68(11), 1688-1694. <https://doi.org/10.1002/acr.22890>
- Slade, S. C., Ther, M. M., & Keating, J. L. (2006). Trunk-Strengthening Exercises for Chronic Low Back Pain: A Systematic Review. *Journal of Manipulative and Physiological Therapeutics*, 29(2), 163-173. <https://doi.org/10.1016/J.JMPT.2005.12.011>
- Solem, R. C. (2015). Limitation of a cross-sectional study. In *American Journal of Orthodontics and Dentofacial Orthopedics* (Vol. 148, Issue 2, p. 205). <https://doi.org/10.1016/j.ajodo.2015.05.006>
- Djuraev, A. M., Alpisbaev, K. S., & Tapilov, E. A. (2021). The choice of surgical tactics for the treatment of children with destructive pathological dislocation of the hip after hematogenous osteomyelitis. *International Journal of Health & Medical Sciences*, 5(1), 15-20. <https://doi.org/10.21744/ijhms.v5n1.1813>
- Stratford, P. W., & Riddle, D. L. (2016). A Roland Morris Disability Questionnaire Target Value to Distinguish between Functional and Dysfunctional States in People with Low Back Pain. *Physiotherapy Canada. Physiotherapie Canada*, 68(1), 29-35. <https://doi.org/10.3138/PTC.2014-85>
- Suryasa, I. W., Rodriguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. *International Journal of Health Sciences*, 6(1), i-v. <https://doi.org/10.53730/ijhs.v6n1.5949>
- Supreet Bindra, Mithilesh Kumar, Pankaj Preet Singh, J. S. (2012). A Study on the Efficacy of Muscle Energy Technique as Compared to Conventional Therapsy in Chronic Low Back Pain Due to Sacroiliac Joint Dysfunction. *Indian Journal of Physiotherapy and Occupational Therapy.*, 6(1), 200-203.
- Wu, A., March, L., Zheng, X., Huang, J., Wang, X., Zhao, J., Blyth, F. M., Smith, E., Buchbinder, R., & Hoy, D. (2020). Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017. *Annals of Translational Medicine*, 8(6), 299-299. <https://doi.org/10.21037/ATM.2020.02.175>