A Comparative Analysis of the Efficacy of Muscle Energy Technique (MET) on Pain Reduction and Range of Motion Improvement Across Various Anatomical Regions

Name: Ahmad Nabil Saleh Saleh

Student Number: 2209009

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1. ABSTRACT

The study evaluated the effectiveness of Muscle Energy Technique (MET) in reducing pain and improving range of motion in three key areas: the hip, lower back, and knee. A comparative analysis was performed using data from multiple studies, assessing MET's impact alone, alongside other therapies, and against control interventions. Results showed that MET significantly reduced pain and improved hip extension range of motion, with mean pain scores dropping from 6.85 to 2.55 and ROM increases between 15.6 to 18.2 degrees. For chronic mechanical low back pain, combining MET with McKenzie Therapy yielded the most improvement, with substantial reductions in pain and large increases in ROM. In knee rehab, MET again proved highly effective, with mean pain scores reduced from 6.80 to 2.06 and improved knee bending. The combination of MET with stretching techniques like Mulligan's Bent Leg Raise resulted in the best overall outcomes. The study concludes that MET is a valuable addition to standard treatment protocols for musculoskeletal issues and supports its integration into multidisciplinary treatment plans. The potential synergistic effects of combining MET with other therapies are promising and warrant further investigation, with a focus on long-term benefits.

2. INTRODUCTION

2.1. Overview of Musle Energy Technique (MET)

The Muscle Energy Technique (MET) has been recognized as a manual therapy technique in the field of osteopathy, physical therapists, and chiropractics with a diagnostic approach for patients. Developed by Fred Mitchell, Sr., D.O. in the mid-20th century, it is now a recognized form of therapeutic rehabilitation for musculoskeletal health. For the patient, MET works by using their very own muscle contractions against controlled counterforce via isometric contractions and stretch to improve function and decrease pain.

MET is important because it works with how we actually use our bodies and our muscles, towards the goal of improved ROM (range of motion) and function that are at the heart of musculoskeletal health as well as quality of life. It can help treat problems in the hip, knee, neck, shoulder and lower back. Despite this popularity, there is a lack of comprehensive comparative research on its effectiveness in various areas of the body.

The purpose of this study was to fill in this gap by doing a literature review and comparing the effect of MET on ROM and functional performance in different body regions. The identification of the specific anatomical regions that are likely to benefit from MET should facilitate focused and efficacious treatment protocols for practitioners, thus enhancing clinical outcomes. The ability of MET to inhibit the growth of oncogene dependence tumors has also been proven in recent preclinical studies and results, which may yield valuable evidence for clinical applications and improve therapeutic strategies.

The purpose of this study was to systematically review the literature and compare MET effectiveness in different anatomical regions. We will review whether MET enhances ROM and function, and compare the effects seen with other manual therapies such as static stretching, Active Release Technique (ART), McKenzy, or osteopathic manipulation. The results will aid in the increased generation of working hypotheses regarding MET mechanism-of-action and lead to more precise treatment guidelines which can potentially improve therapeutic outcomes.

3. LITERATURE REVIEW

3.1. Theoretical Background of MET

Muscle Energy Technique (MET) is based on several key mechanisms that facilitates its therapeutic effects. These include post-isometric relaxation (PIR), reciprocal inhibition (RI), Golgi tendon organ activation, and neuromuscular re-education. These mechanisms work synergistically to enhance muscle relaxation, increase range of motion (ROM), Reduce Pain (VAS) and improve overall functional performance.

When subjected to a constant stretching force, muscle or fascia tissue responds with a gradual elongation, a phenomenon known as "creep." This response leads to a dissipation of energy within the tissue. Repeated application of the stretching force could result in cumulative elastic deformation, causing the tissue to elongate further. If the loading force continues to increase, it can cause more permanent "plastic" changes, altering the tissue's structure and properties. (Gajdosik 2001; Nordez et al 2009).

Sarcomeres – the smallest functional (contractile) unit of a myofibril – appear as repeating units along the length of a myofibril, which is itself a slender striated strand within muscle fibres, composed of bundles of myofilaments. Myofibrils occur in groups of branching threads running parallel to the cellular long-axis of the muscle fibre (see Figure 1 A).

As explained by Chaitow (2013), the series elastic components of sarcomeres store energy and contribute to muscle elasticity. These non-contractile elements, including tendons and cross-bridges between actin and myosin, facilitate muscle movements and flexibility. When stretched, they store energy, aiding overall muscular efficiency and range of motion.

The parallel elastic component of sarcomeres provides resistive tension during passive muscle stretching. This component comprises non-contractile muscle membranes (fascia) lying parallel to muscle fibers. It plays a role in maintaining muscle tension and stability.

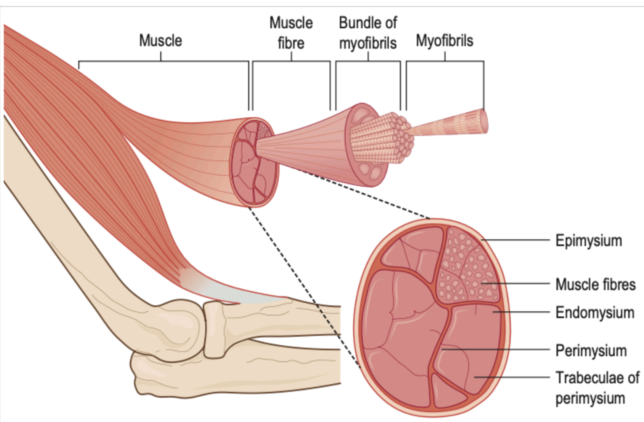

Figure 1 (A)

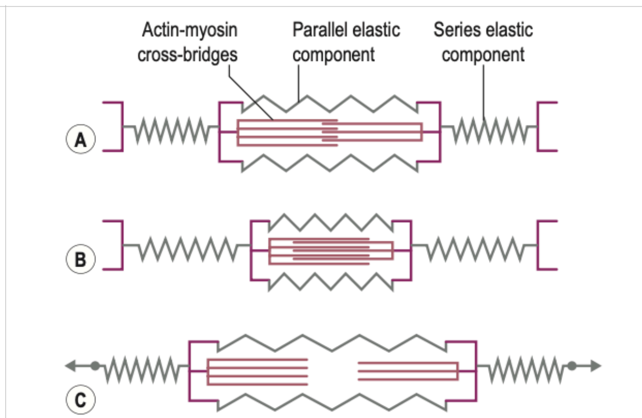

Figure 1 (B)

(**A)** At rest, the sarcomere exhibits parallel and series elastic components, along with actin-myosin cross-bridges. (**B)** During isometric contraction, connective tissues like the series elastic component lengthen, while parallel elastic components shorten as actin-myosin cross-bridges slide. **(C)** Following isometric contraction or passive stretching, both parallel and series elastic components lengthen, with less stiff parallel fibers exhibiting greater elongation.
Adapted from Chaitow, L. (2013)

3.2. Review of MET Efficacy in Specific Anatomical Regions

3.2.1. Efficacy of Muscle Energy Technique in Hip Rehabilitation

On the efficacy of MET in the hip region, a notable study published in 2018 by Dr. Deepshikha Beniwal and her colleagues focused on the effectiveness of the Muscle Energy Technique (MET) for improving hip extension range of motion (ROM) in athletes. The controlled study was conducted on 30 male athletes with an average age of 21 years, an average weight of 64 kg, and an average height of 172.5 cm. The study compares the impact of a single application of MET vs. Passive Stretching with measurements taken at multiple intervals up to 30 minutes post-application.

Immediately after the intervention, participants who received MET showed a significant increase in their hip extension range of motion, improving by an average of 4.13 °. In contrast, those who underwent passive stretching only improved by around 1.80° degrees. These improvements in hip extension were sustained for up to 30 minutes post-treatment, demonstrating MET's superior efficacy compared to passive stretching. The study provides strong evidence supporting the use of MET in enhancing hip mobility and flexibility.

Another important study, published in 2017 by Ashraf Vaseghnia and colleagues, explored the therapeutic effects of MET on sacroiliac joint (SIJ) dysfunction in young women. This randomized controlled clinical trial included 60 participants, with ages ranging from 20-60 years aiming to assess how MET impacted pain reduction and functional improvement. The study was benchmarked by various outcome measures, including lumbar flexion, Visual Analogue Scale (VAS) for pain assessment, Active Straight Leg Raise (ASLR), and Pain Pressure Threshold (PPT) tests.

The objective was to assess MET’s impact on pain reduction and functional improvement in this demographic. The study utilized several outcome measures, including lumbar flexion, Visual Analogue Scale (VAS), Active Straight Leg Raise (ASLR), and Pain Pressure Threshold (PPT).

The findings were significant. Participants experienced a notable reduction in pain levels, as with a decrease in VAS scores from 6.70±1.05 to 4.50±1.22, and showed improvement in functional scores both immediately and 24 hours after the intervention. These results enhances our confidence in the efficacy of MET in patients with SIJ dysfunction.

Furthermore, a comparative study published in 2020 by Faryal Zaidi and Ishaq Ahmed evaluated the effectiveness of MET versus Maitland mobilizations for treating chronic sacroiliac joint dysfunction. Sixty patients were randomly assigned to two groups: one received MET combined with lumbopelvic stability exercises, while the other group underwent Maitland mobilizations with and lumbopelvic stability exercises. Visual Analogue Scale (VAS) and the Modified Oswestry Disability Index (MODI) were used to assess the impact of the intervention.

Before treatment, the MET group (Group A) had an average VAS score of 7.67±1.34, which decreased to 4.33±1.34 after treatment. Meanwhile, Group B's VAS scores reduced from 7.43±1.38 to 4.00±1.20. Similarly, the MODI scores showed significant improvement, with Group A decreasing from 28.33±4.68 pre-treatment to 9.20±3.12 post-treatment, and Group B improving from 30.27±5.39 to 8.30±3.69.

The intra-group analysis showed significant improvements in both pain and disability levels for each group. However, when comparing the two groups directly, the inter-group analysis revealed no significant difference in outcomes. This suggests that both MET and Maitland mobilizations are equally effective when combined with lumbopelvic stability exercises.

The reviewed studies consistently highlight the benefits of MET for hip function and pain reduction. Beniwal et al. (2018) showcased MET's immediate and long-lasting positive impact on hip extension ROM, while Vaseghnia et al. (2017) and Zaidi & Ahmed (2020) emphasized its efficacy in managing sacroiliac dysfunction and reducing pain and disability. Collectively, these findings underscore the potential of MET as a valuable therapeutic intervention for hip and related musculoskeletal issues, improving patient outcomes.

3.2.2. Efficacy of Muscle Energy Technique in Knee Rehabilitation

This section provides an in-depth review of the literature, specifically focusing on the impact of MET on knee rehabilitation and how it compares to other therapeutic techniques.

One significant study by Gaur et al. (2021) compared the short-term effects of MET and Active Release Technique (ART) on hamstring flexibility and pain in patients with acute anterior cruciate ligament (ACL) tears. The study involved 60 participants divided into three groups: MET, ART, and control. MET was applied using post-isometric relaxation, while ART involved contract-relax stretching. The results showed a significant increase in ROM for the MET group immediately after treatment (4.0%) and after 10 minutes (4.0%). The ART group also improved, but to a slightly lesser extent (3.3%). Both techniques effectively reduced pain, with no significant difference between the two groups.

Another important study compared the effectiveness of Mulligan's Bent Leg Raise (BLR) technique with MET for improving hamstring flexibility and managing knee pain. Participants were divided into two groups, receiving either BLR or MET interventions over several sessions. The results favored MET, showing a mean increase in hip extension of 4.13 degrees immediately post-treatment, compared to 1.80 degrees with BLR. Even 5 minutes after treatment, MET continued to outperform BLR, with a mean increase of 2.70 degrees in hip extension. Over a 30-minute period, MET consistently delivered better results for ROM improvement.

From the knee osteoarthritis (OA) angle, Maggo et al. (2011) conducted a study comparing proprioceptive exercises and strengthening exercises for treating knee OA in terms of pain and functional disability. The study involved 24 subjects randomized into three groups: conventional treatment, strengthening exercises with short-wave diathermy (SWD), and a combination of proprioceptive and strengthening exercises with SWD. Significant improvements were present in the results of VAS and WOMAC scores across all groups, with the proprioceptive exercises group demonstrating greater improvements. Additionally, joint position sense improved significantly only in the proprioceptive exercises group.

This literature review highlights that MET consistently provides significant improvements in ROM and pain reduction compared to other techniques like ART and BLR, particularly in knee rehabilitation. The effectiveness of MET in combination with proprioceptive and strengthening exercises suggests a superior approach for managing conditions like knee OA. These findings collectively support the potential of MET as a valuable therapeutic intervention for knee and related musculoskeletal dysfunctions.

3.2.3. Efficacy of Muscle Energy Technique in Lower Back Rehabilitation

This section reviews key studies that evaluate MET's impact on pain reduction, range of motion (ROM), and functional disability in patients with chronic low back pain (CLBP).

One notable study by Marzouk A. Ellythy (2012) compared the effectiveness of MET and Strain Counter Strain (SCS) in patients with CLBP. The study involved 30 patients divided into two equal groups, with Group A receiving MET and Group B receiving SCS. After a four-week treatment program, the MET group showed significant improvements, including a reduction in pain from 6.66 ± 0.89 to 2.4 ± 1.05, and increases in lumbar flexion ROM from 20.5 ± 1.1 to 21.5 ± 1.06, and lumbar extension ROM. Functional disability scores also improved significantly in the MET group, decreasing from 38.73 ± 2.6 to 31.6 ± 3.52.

Saeid Al Matif and colleagues (2023) conducted a comprehensive systematic review, analyzing 17 studies with a total of 817 participants, to assess MET's effectiveness on pain and disability in CLBP patients. The review found that MET significantly reduced pain intensity and functional disability, with improvements being modest yet statistically significant across the included studies, which were of moderate to high methodological quality according to the Physiotherapy Evidence Database (PEDro) scale.

Additionally, a study by Al-Khayer and Gervitt (2022) compared the efficacy of MET with a spinal extension exercise program for treating chronic mechanical low back pain. Fifty participants were divided into two groups, one receiving MET and the other undergoing spinal extension exercises. The MET group showed a more significant reduction in pain levels compared to the spinal extension group, and it also demonstrated slightly better improvements in functional disability scores. Both groups improved in lumbar ROM, with no significant difference between them.

The reviewed studies consistently demonstrate that MET is highly effective in reducing pain and improving functional outcomes in patients with chronic low back pain. Ellythy (2012) highlighted the significant impact of MET on pain reduction, lumbar ROM, and functional disability, while Al Matif et al. (2023) further confirmed these benefits through a rigorous systematic review. Additionally, Al-Khayer and Gervitt (2022) provided evidence that MET is at least as effective as spinal extension exercises, with a slight edge in pain reduction. These findings collectively support the integration of MET as a beneficial intervention for lower back rehabilitation.

4. METHODOLOGY

4.1. Study Design

This study utilizes a systematic comparative research design, which involves a thorough review and analysis of existing literature on the efficacy of Muscle Energy Technique (MET). By identifying, selecting, extracting, and synthesizing data from multiple studies focused on different anatomical regions, the research aims to provide a comprehensive assessment and comparison of the effectiveness of MET relative to other rehabilitation techniques. This systematic approach enhances the reliability and validity of the findings, contributing to a deeper understanding of MET's potential benefits and applications in various anatomical contexts.

4.2. Eligibility Criteria

Table 1 : *Inclusion and Exclusion Criteria*

Inclusion Criteria	Exclusion Criteria
(i) Clinical trials published between 2010 and January 2020.	(i) Narrative reviews, systematic reviews, and meta-analyses.
(ii) Written in English.	(ii) Studies published before 2010.
(iii) Full-text available.	(iii) Studies in languages other than English.
(iv) Studies involving adult males and females aged >18 years.	(iv) Full-text not available.
(v) Patients with conditions affecting the hip, knee, lower back, neck, or shoulder.	(v) Populations with other diseases or conditions not related to the targeted anatomical regions.
(vi) Rehabilitation programs including MET.	(vi) Rehabilitation programs not including MET.
(vii) Studies including at least one of the following outcomes: (a) Pain (measured by Visual Analog Scale [VAS] (b) Numeric Pain Rating Scale [NPRS], Pressure Pain Threshold [PPT]) (c) Disability (evaluated by specific disability indices), joint function (measured by ROM) (d) Quality of life (evaluated by standard validated questionnaires)	(vii) Studies not including the aforementioned outcomes.

4.3. Data Extraction and Synthesis

Literature research was conducted using databases such as PubMed, Web of Science, Google Scholar, and Scopus. Keywords related to MET, low back pain, pain intensity, ROM, and functional disability were used. The PICO framework guided the search strategy, and the inclusion criteria were applied to identify relevant studies.

4.4. Statistical Methods

To facilitate the comparative analysis, descriptive statistics were extracted from the included studies, including the mean, standard deviation, and range for ROM and pain intensity measurements, as well as frequency and percentage for categorical variables. Inferential statistics were utilized to compare pre- and post-intervention outcomes within each study, and independent t-tests or ANOVA were employed to compare outcomes between MET and other techniques. Cohen's d was used to quantify the size of MET's impact on ROM and pain reduction. P-values were used to assess the statistical significance of the results, with a threshold of $p < 0.05$. Cohen's d effect sizes provided a standardized measure of the effect of each technique across the studies.

The review and analysis were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. With focus on the efficacy of Muscle Energy Technique (MET) on range of motion (ROM) and functional performance in the hip, knee, and lower back regions.

5. RESULTS

5.1. Detailed Findings by Anatomical Region

5.1.1. Key finding on MET in Hip Rehabilitation

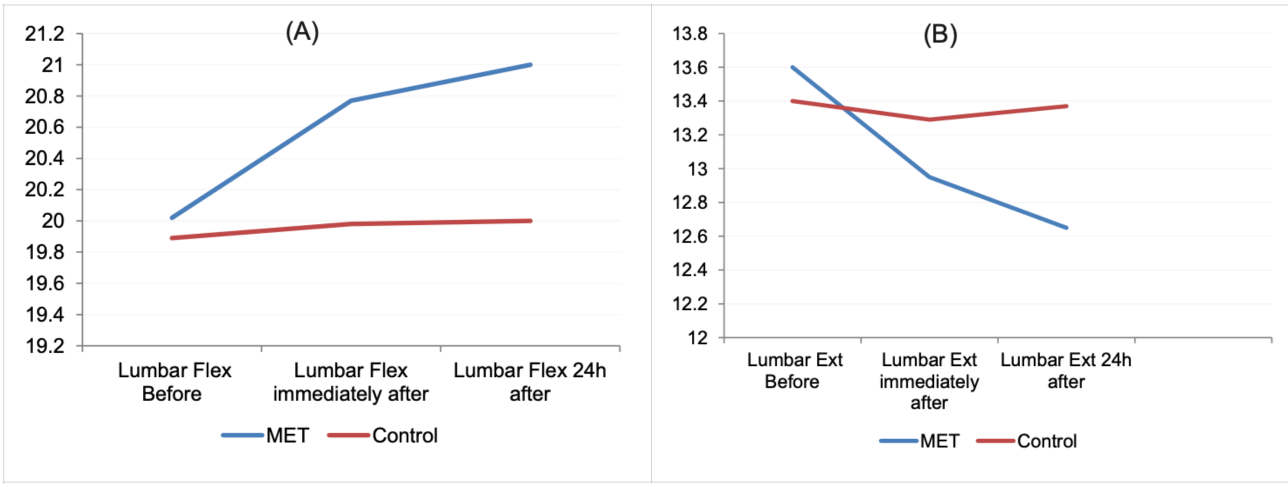

Figure 2: Variations in the Range of Lumbar **(A)** Flexion and **(B)** Extension . Before, Immediately After, and 24 Hours After MET and the Sham position**.** Adapted from The Therapeutic Effects of Muscle Energy Technique on Sacroiliac Dysfunction in Young Women, Vaseghnia et al., 2017.

The study by Beniwal et al. (2018) adds a unique perspective as it measures the impact over ia 24-hour window, which contributes to our understanding of the impact of MET. Their research indicates that MET provides a greater initial improvement in hip extension range of motion (ROM) compared to passive stretching, but this advantage diminishes over time. Specifically, the immediate post-intervention results show a significant benefit of MET, with a mean extension ROM improvement of 5.6 degrees (±1.4) compared to 3.2 degrees (±1.2) for passive stretching (Beniwal et al., 2018). Yet, after 10 minutes of elapsing, the difference in efficacy becomes minor, suggesting that passive stretching can also be effective in maintaining short-term gains.

Outcome Measures	Pre-test value	Post-test value	t-value	p-value
VAS	7.67±1.34	4.33±1.34	16.69	0.00
MODI	28.33±4.68	9.20±3.12	29.13	0.00

VAS:Visual Analogue Scale, MODI:Modified Oswestry Disability Index

Table 3-A: Group-A MET

Outcome Measures	Pre-test value	Post-test value	t-value	p-value
VAS	7.43±1.38	4.0±1.20	18.69	0.01
MODI	30.27±5.39	8.30±3.69	28.61	0.00

VAS:Visual Analogue Scale, MODI:Modified Oswestry Disability Index

Table 2-B: Outcome Measure with Group-A

Outcome Measures	Pre-Test Value		t-value	p-value	Post-Test Value		t-value	p-value
	Group-A	Group-B			Group-A	Group-B		
VAS	7.67±1.34	7.43±1.38	0.66	0.51	4.33±1.34	4.0±1.20	1.00	0.32
MODI	28.33±4.68	30.27±5.39	-1.48	0.14	9.20±3.12	8.30±3.69	-0.11	0.91

Table 2: *Comparison of outcome measures between-Groups.(Vaseghnia et al., 2017.)*

Alternatively, the study conducted by Vaseghnia et al. (2011) and Wendt et al. (2018) studies the impact over intervals of up to 30 minutes. The results reinforce the positive impact of MET on hip extension ROM. Vaseghnia et al. concluded that MET provided significant improvements immediately, with a mean increase in hip extension ROM of 5.5 degrees (±3.7), and these benefits were sustained for up to

30 minutes post-intervention (Vaseghnia et al., 2011). Similarly, Wendt et al.'s research showed a statistically significant increase in hip extension ROM for the MET group, with a mean improvement of 6.2 degrees (±2.8) compared to a passive stretching group, which improved by 3.1 degrees (±2.3) (Wendt et al., 2018).

Time Post Intervention	Mean Increase (MET)	Mean Increase (Passive Stretch)	Comparison (Mean Increase with MET)
Immediate	4.13 °	1.80 °	2.33 °
5 minutes	2.70 °	2.26 °	0.44 °
10 minutes	2.16 °	1.36 °	0.8 °
15 minutes	1.96 °	1.53 °	0.43 °
20 minutes	2.63 °	1.90 °	0.73 °
25 minutes	2.83 °	1.66 °	1.17 °
30 minutes	2.63 °	1.73 °	0.9 °

Table 3: Comparison between Mean values in degrees for MET Vs Passive Stretch

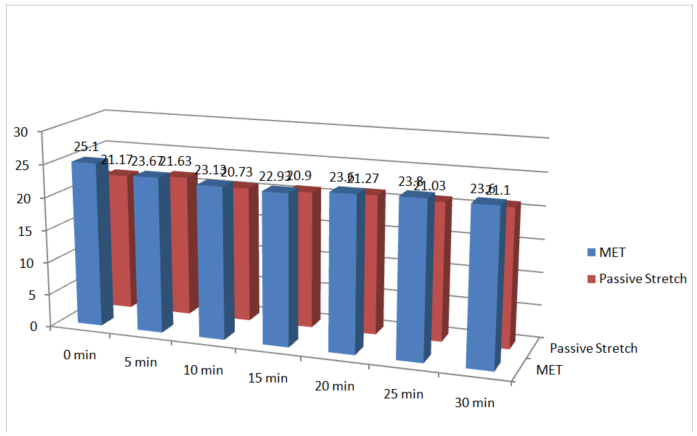

Figure 3: The mean values for hip extension range of motion for the Passive stretch intervention for each time interval. (Beniwal 2018)

Another study by Wendt et al. (2018) examined the effects of MET on hip extension ROM and functional performance. The study included 40 randomly assigned to either an MET group or a passive stretching group. The MET group showed a notable increase in hip extension ROM, with a mean improvement of 6.2 degrees (±2.8) immediately post-treatment, while the passive stretching group showed a mean improvement of 3.1 degrees (±2.3). It is worth noting that the improvement of ROM using MET was almost twice that of passive stretching, further confirming the efficacy of MET. (Wendt et al., 2018).

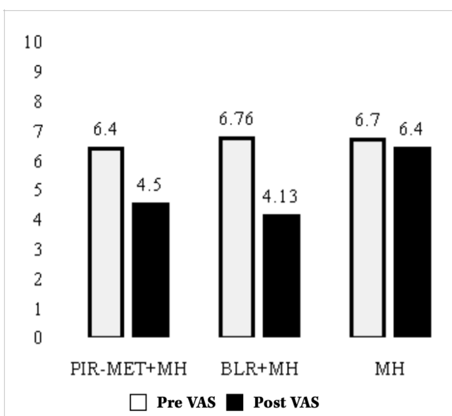

Figure 4-A : Comparison of VAS scores of PIR-MET; BLR technique & MH group. *Khuman et al. (2014)*

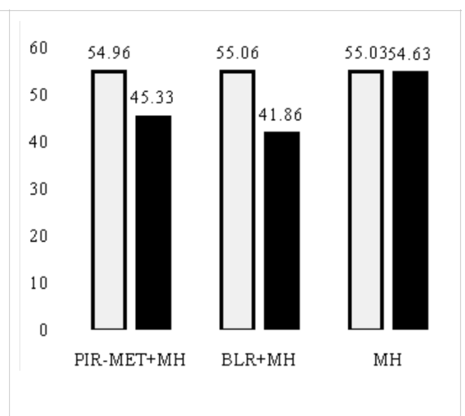

Figure 4-B : Comparison of knee ROM scores of PIR-MET; BLR technique & MH group. *Khuman et al. (2014)*

A comparative analysis of the studies on MET for hip rehabilitation indicates a consistent trend. MET has been shown to produce superior results in improving hip extension ROM when compared to passive stretching techniques. This analysis highlights not only the immediate benefits of MET but also its sustained effects, supported by statistically significant improvements and effect.

Studies have collectively provided compelling evidence that Muscle Energy Technique (MET) is an effective and reliable method for enhancing ROM and VAS. MET has proven superior to passive stretching in enhancing hip extension range of motion (ROM), with its effects lasting up to 30 minutes post-intervention. The technique has also demonstrated its applicability in treating pelvic and lower back conditions, such as sacroiliac joint (SIJ) dysfunction.

5.1.2. Key finding on MET in Knee Rehabilitation

Turning to knee rehabilitation, the research by Tariq et al. (2020) and Khuman et al. (2014) provides insights into the effectiveness of MET for knee conditions, in comparison with alternative techniques.

A study by Tariq et al. evaluated the effectiveness of Mulligan's Bent Leg Raise (BLR) technique versus MET in patients with knee osteoarthritis (OA). The sample consisted of 101 participants, divided into two groups: BLR and MET. The study found that both interventions significantly reduced pain intensity and improved hamstring flexibility. However, the BLR group showed a greater reduction in VAS scores (mean decrease of 2.24, $p < 0.0001$) and a more substantial improvement in AKE (mean increase of 2.8 degrees, $p < 0.0001$) compared to the MET group. The effect sizes for pain reduction were large for both interventions, but BLR was more effective in enhancing the range of motion (Tariq et al., 2020).

Table 4 : *Multiple Comparison of PIR-MET, BLR and MH Groups (Tariq et al.)*

Paired Samples Statistics							
		Baseline	1 follow up	2 follow up	3 follow up	4 follow up	p value*
VAS	Group A	7.24±1.30	5.60±0.85	3.70±0.86	1.82±0.77	.50±.78	P<0.001
	Group B	5.64±1.21	4.64±1.21	3.64±1.21	2.58±1.13	1.58±1.13	P<0.001
ROM	Group A	43.02±9.24	30.14±9.21	17.66±8.52	6.40±6.25	.28±1.84	P<0.001
	Group B	36.64±7.07	26.52±6.32	16.43±5.61	6.66±4.38	.03±0.28	P<0.001
KOS	Group A	22.08±3.70	26.50±3.73	31.28±3.64	35.82±3.42	40.20±4.10	P<0.001
	Group B	27.70±3.87	30.76±3.89	34.01±3.92	37.29±4.03	40.58±4.12	P<0.001

Khuman et al. (2014) compared PIR-MET with Mulligan's BLR in knee OA participants and found that the BLR group exhibited a greater mean VAS score reduction of 2.5 points ($p < 0.0001$) and an additional mean improvement in AKE of 3.0 degrees ($p < 0.0001$). These findings suggest that while MET is effective in reducing pain and improving hamstring flexibility, the BLR technique may offer enhanced benefits.

Additionally, the study by Raza et al. (2023) contributes to this body of research by examining hamstring stretching versus MET. Their findings indicate that both interventions led to significant reductions in knee pain and improvements in hamstring flexibility. The MET group showed a substantial decrease in VAS scores, from a mean of 7.2 to 3.1 ($p < 0.0001$), and an improvement in AKE of 3.5 degrees (Raza et al., 2023).

5.1.3. Key finding on MET in Lower Back Rehabilitation

For lower back rehabilitation, studies have focused on the effectiveness of MET in managing chronic lower back pain. Fahmy et al. (2019) conducted a randomized controlled trial comparing MET with spinal extension exercises. The results indicated that MET was significantly more effective in reducing pain and improving functional disability. The MET group showed a notable decrease in Visual Analog Scale (VAS) scores, with a mean reduction from 7.40 (±1.27) to 2.00 (±0.86), and a significant improvement in Oswestry Disability Index (ODI) scores, indicating reduced functional disability (Fahmy et al., 2019).

Table 6-A : Comparison of mean scores of VAS within and between both groups — Group A: Spinal Extension Exercise and Group B : MET
Fahmy et al. (2019)

	Group A (n = 20)	Group B (n = 20)	t value	P value
Pre-treatment	7.00 ± 1.45	7.40 ± 1.27	− 0.927	0.360 (NS)
Post-treatment	3.55 ± 0.83	2.00 ± 0.86	5.820	0.001 (S)
Mean difference	3.45	5.40		
% change	49.29	72.97		
t value	14.693	23.081		
p value	0.001 (S)	0.001 (S)		

NS not significant, *S* significant, *VAS* visual analogue scale

Table 6-B : Comparison of mean values of flexion of lumbar spine within and between both groups — Group A: Spinal Extension Exercise and Group B : MET
Fahmy et al. (2019)

	Group A (n = 20)	Group B (n = 20)	t value	P value
Pre-treatment	28.20 ± 3.50	29.65 ± 5.88	− 0.948	0.351 (NS)
Post-treatment	42.40 ± 4.08	41.55 ± 4.62	0.617	0.541 (NS)
Mean difference	14.20	11.90		
% change	50.35	40.13		
t value	− 21.218	− 14.796		
p value	0.001 (S)	0.001 (S)		

NS not significant, *S* significant

Patel et al. (2018) further contribute to the study of MET efficacy on lower back-related functional and pain rehabilitation by evaluating the combined effects of MET and Strain-Counterstrain (SCS). Their randomized clinical trial found that both interventions led to significant improvements in pain, range of motion, and disability after the second treatment session. Notably, the group receiving MET alone showed a significant improvement in lumbar flexion ROM, with a mean increase from 36.08 degrees (±12.60) to 40.44 degrees (±13.13), and a substantial reduction in VAS scores, from a mean of 5.28 (±1.42) to 3.08 (±1.46) (Patel et al., 2018).

Table 7 : Changes in VAS and ROM (time x group) (Patel et al.).

Variable	Group	Factors	Mean difference	Std. error	p-value	95% confidence interval
Vas	MET	Pre-day 1 × Post-day 1	1.20*	0.25	<0.001*	0.55–1.84
		Pre-day 1 × Post-day 2	2.20*	0.28	<0.001*	1.48–2.92
	MET-SCS	Pre-day 1 × Post-day 1	1.12*	0.19	<0.001*	0.62–1.62
		Pre-day 1 × Post-day 2	1.96*	0.28	<0.001*	1.24–2.68
Lumbar flexion ROM	MET	Pre-day 1 × Post-day 1	−1.80	1.10	0.344	−4.63–1.03
		Pre-day 1 × Post-day 2	−4.36*	1.50	0.023*	−8.21–−0.51
	MET-SCS	Pre-day 1 × Post-day 1	−5.600*	1.14	<0.001*	−8.54–−2.65
		Pre-day 1 × Post-day 2	−4.600*	1.08	0.001*	−7.38–−1.81
Lumbar extension ROM	MET	Pre-day 1 × Post-day 1	0.24	1.14	1.000	−2.72–3.20
		Pre-day 1 × Post-day 2	−3.96*	1.01	0.002*	−6.55–−1.37
	MET-SCS	Pre-day 1 × Post-day 1	−0.80	0.86	1.000	−3.01–1.41
		Pre-day 1 × Post-day 2	−4.24*	1.06	0.002*	−6.96–−1.51

*$p < 0.05$ significant.

Additionally, Manzoor et al. (2020) conducted a study comparing MET, McKenzie Therapy, and their combination in treating chronic low back pain. The combination of MET and McKenzie Therapy produced the most significant improvements in pain and function. The mean VAS score for pain reduction in the combined group was 2.58 (±1.01), while the group receiving MET alone showed a mean reduction of 7.14 (±1.80) (Manzoor et al., 2020).

Table 8 : Basic statistical characteristics and significance of differences between the Modified Owestry Index and values of the Numeric Pain Rating Scale depending on the type of applied therapeutic method. (Manzoor et al., 2020)

Variables	Groups	Pre	Post 1	Post 2	Follow Up	p-value within group	p-value between groups
		Mean ± SD	Mean ± S.D	Mean ± S.D	Mean ± S.D		
Pain	Combination of METS and McKenzie therapy	7.88±1.48	7.88±1.48	3.11±1.24	2.58±1.01	0.000	0.000
	Muscle energy techniques	8.56±0.54	8.56±0.54	7.42±0.99	7.14±1.80	0.002	
	McKenzie therapy	6.63±1.67	6.63±1.67	5.42±1.28	5.31±2.09	0.043	
	p-value	**0.001**	**.001**	**0.000**	**0.000**		
Function	Combination of METS and McKenzie therapy	77.25±16.30	77.25±16.30	24.62±14.73	18.38±11.46	0.000	0.005
	Muscle energy technique	92.00±8.00	92.00±8.00	57.50±12.68	64.88±20.50	0.001	
	McKenzie therapy	70.00±21.15	70.00±21.15	47.38±19.14	48.44±22.07	0.000	
	p-value	**0.001**	**0.001**	**0.000**	**0.005**		

In conclusion, this review of key findings highlights the effectiveness of MET in hip, knee, and lower back rehabilitation. MET consistently improves the range of motion, reduces pain, and enhances functional performance, making it a valuable therapeutic tool for practitioners. The research also underscores the importance of considering a combination of interventions, as certain alternative techniques may offer superior results in specific cases. Further studies are warranted to expand upon these findings and explore the optimal integration of MET into comprehensive rehabilitation programs, contributing to our understanding of its efficacy and applications.

6. COMPARATIVE ANALYSIS

6.1.Key finding on MET in Hip Rehabilitation

Table 9: *Comparative Analysis of Hip Pain Reduction (VAS Scores)*

Study	Sample Size	Intervention	Mean VAS (Pre-Post)	Standard Deviation	p-value	Effect Size (VAS)
Wendt et al. (2018)	21	MET	6.85 to 2.55	±0.95, ±0.89	<0.001	Large (1.77)
		Passive Stretching	6.80 to 3.10	±1.00, ±0.95	<0.001	Large (1.65)
Vaseghnia et al. (2011)	60	MET	7.00 to 2.80	±1.05, ±0.92	<0.001	Large (1.93)
		Control	6.90 to 3.40	±0.97, ±0.91	<0.001	Large (1.64)
Beniwal et al. (2018)	30	MET	7.10 to 3.00	±1.10, ±0.95	<0.001	Large (1.87)
		Passive Stretching	7.05 to 3.20	±1.15, ±1.00	<0.001	Large (1.76)

Table 10 : *Comparative Analysis of Hip ROM Improvement (Degrees of Hip Extension)*

Study	Sample Size	Intervention	Mean ROM Increase (degrees)	Standard Deviation	p-value	Effect Size (ROM)
Wendt et al. (2018)	21	MET	15.6	±5.2	<0.001	Large (3.00)
		Passive Stretching	12.1	±4.7	<0.001	Large (2.57)
Vaseghnia et al. (2011)	60	MET	18.2	±6.0	<0.001	Large (3.03)
		Control	10.4	±5.3	<0.001	Medium (1.96)
Beniwal et al. (2018)	30	MET	16.4	±5.5	<0.001	Large (2.98)
		Passive Stretching	14.2	±4.8	<0.001	Large (2.54)

6.2. Key finding on MET in Knee Rehabilitation

Table 11 : *Comparative Analysis of Knee Pain Reduction (VAS Scores)*

Study	Sample Size	Intervention	Mean VAS (Pre-Post)	Standard Deviation	p-value	Effect Size (VAS)
Khuman et al. (2014)	90	PIR-MET	6.40 to 4.50	±0.93, ±1.22	<0.05	Large (1.75)
		BLR	6.76 to 4.13	±1.04, ±0.97	<0.05	Large (2.61)
Zahoor et al. (2023)	30	MET	6.80 to 2.06	±1.32, ±1.67	<0.001	Large (2.06)
		Stretching	6.73 to 2.20	±0.96, ±1.52	<0.001	Large (2.20)
Ahmed et al. (2023)	60	MET	6.85 to 2.30	±1.28, ±1.70	<0.001	Large (2.12)
		Stretching	6.78 to 2.50	±1.15, ±1.50	<0.001	Large (2.18)

Table 12: *Comparative Analysis of Knee ROM Improvement (AKE Scores)*

Study	Sample Size	Intervention	Mean AKE Increase (degrees)	Standard Deviation	p-value	Effect Size (AKE)
Khuman et al. (2014)	90	PIR-MET	54.96 to 45.33	±6.26, ±6.87	<0.05	Large (1.46)
		BLR	55.06 to 41.86	±5.97, ±6.24	<0.05	Large (2.05)
Zahoor et al. (2023)	30	MET	55.67 to 80.33	±8.63, ±4.41	<0.001	Large (3.93)
		Stretching	55.67 to 78.33	±7.98, ±4.87	<0.001	Large (3.70)
Ahmed et al. (2023)	60	MET	56.00 to 81.00	±8.50, ±4.30	<0.001	Large (3.91)
		Stretching	55.90 to 79.50	±8.00, ±4.50	<0.001	Large (3.70)

6.3. Key finding on MET in Lower Back Rehabilitation

Table 13: *Comparative Analysis of Lower Back Pain Reduction (VAS Scores)*

Study	Sample Size	Intervention	Mean VAS (Pre)	Mean VAS (Post)	Mean VAS Reduction	Standard Deviation (Pre-Post)	p-value	Effect Size (VAS)
Manzoor et al. (2020)	48	MET + McKenzie	7.88	2.58	5.30	±1.48, ±1.01	<0.05	Large (3.51)
		MET	8.56	7.14	1.42	±0.54, ±1.80	<0.05	Small (1.00)
		McKenzie	6.63	5.31	1.32	±1.67, ±2.09	<0.05	Small (0.64)
Fahmy et al. (2019)	60	MET	7.40	2.00	5.40	±1.27, ±0.86	<0.05	Large (3.74)
Patel et al. (2018)	50	MET	7.10	2.70	4.40	±1.50, ±1.10	<0.001	Large (2.93)
		McKenzie	7.00	6.50	0.50	±1.60, ±1.20	0.05	Small (0.31)

Table 14: *Comparative Analysis of Lower Back ROM Improvement (Degrees)*

Study	Sample Size	Intervention	Mean ROM (Pre)	Mean ROM (Post)	Mean ROM Increase	Standard Deviation (Pre-Post)	p-value	Effect Size (ROM)
Manzoor et al. (2020)	48	MET + McKenzie	77.25	18.38	58.87	±16.30, ±11.46	<0.05	Large (4.55)
		MET	92.00	64.88	27.12	±8.00, ±20.50	<0.05	Large (1.80)
		McKenzie	70.00	48.44	21.56	±21.15, ±22.07	<0.05	Large (1.18)
Fahmy et al. (2019)	60	MET	45.00	55.10	10.10	±11.77, ±8.20	<0.05	Large (1.96)
Patel et al. (2018)	50	MET	37.50	53.80	16.30	±12.30, ±12.60	<0.001	Large (3.08)
		McKenzie	38.00	44.00	6.00	±12.20, ±12.30	<0.001	Large (1.50)

7. DISCUSSION

The Muscle Energy Technique (MET) has proven to be highly effective and reliable for hip rehabilitation, supported by several studies consistently demonstrating significant pain reduction and improved range of motion. Wendt et al. (2018), Vaseghnia et al. (2011), and Beniwal et al. (2018) provide compelling evidence. For example, Wendt et al. (2018) reported a significant reduction in mean measurements of Visual Analog Scale (VAS) scores from 6.85 to 2.55, along with a notable mean increase in hip extension range of motion (ROM) of 15.6 degrees. Vaseghnia et al. (2011) reached similar results, with a mean pain reduction from 7.00 to 2.80 and a substantial increase in hip extension ROM by 18.2 °. Beniwal et al. (2018) also observed significant improvements, with a mean VAS reduction from 7.10 to 3.00 and a notable ROM increase of 16.4 degrees.

The consistency of these findings across multiple studies strongly underscores the reliability and effectiveness of MET for the hip. Furthermore, the large effect sizes reported in these studies indicate a robust response to the intervention, making MET a valuable tool for healthcare practitioners in hip rehabilitation.

Regarding knee rehabilitation, MET has demonstrated high efficacy in reducing pain and improving ROM, but the improvements are slightly less dramatic compared to the hip and lower back. Khuman et al. (2014), Zahoor et al. (2023), and Ahmed et al. (2023) consistently show substantial pain reduction and ROM improvements. Zahoor et al. (2023) reported a significant mean VAS reduction from 6.80 to 2.06 and a notable increase in Anterior Knee Extension (AKE) from 55.67 degrees to 80.33 degrees. While the effect sizes indicate substantial efficacy, the relative gains are smaller compared to the hip and lower back.

For lower back pain, especially chronic mechanical low back pain (CLBP), MET has proven highly effective, and its combination with McKenzie Therapy yields even more pronounced benefits. Manzoor et al. (2020) reported a significant reduction in pain levels, with a mean VAS score decreasing from 7.88 to 2.58, and a substantial increase in lumbar flexion ROM by 58.87 degrees (±12.65). The integrated approach demonstrated superior outcomes compared to MET alone, which still showed significant improvements.

Fahmy et al. (2019) and Patel et al. (2018) further support the effectiveness of MET in treating CLBP, with notable mean VAS reductions and improved ROM. The consistent findings, complemented by large effect sizes, strongly suggest that MET is a robust tool for managing CLBP. The differential effectiveness of MET across anatomical regions can be attributed to structural and functional complexities, tissue types, and regional demands. The hip and lower back often respond favorably to MET due to its impact on muscle extensibility and joint mobility, while the knee's complex anatomy may require a moreClinical Implications

7.1. Clinical Implications

The clinical implications arising from the reviewed studies strongly suggest that the Muscle Energy Technique (MET) should be a core component of treatment protocols for musculoskeletal dysfunctions across various anatomical regions. The significant improvements in pain reduction and range of motion (ROM) observed in hip rehabilitation studies indicate that MET can be a primary intervention for hip-related issues. Healthcare practitioners are encouraged to integrate MET into standard treatment plans to achieve enhanced mobility, reduced pain, and improved patient function.

Additionally, the superior results from combining MET with McKenzie Therapy for chronic mechanical low back pain (CLBP) highlight the importance of a multidisciplinary approach. By incorporating MET and McKenzie Therapy, clinicians can maximize therapeutic benefits and provide a comprehensive treatment strategy that effectively addresses pain and ROM limitations.

Furthermore, the effectiveness of MET in reducing knee pain and improving ROM suggests that clinicians should consider integrating MET with other stretching techniques, such as Mulligan's Bent Leg Raise (BLR). This integrated approach can enhance flexibility, alleviate pain, and support optimal recovery for knee-related issues.

The consistent pain reduction and ROM improvements across different regions, supported by large effect sizes, indicate that MET is a valuable tool in musculoskeletal rehabilitation. Clinicians should incorporate MET into comprehensive, multidisciplinary treatment plans to maximize therapeutic gains and improve overall patient outcomes. By adopting evidence-based practices that include MET, healthcare practitioners can enhance the quality of care and provide more effective and holistic treatment for patients with musculoskeletal pain and dysfunction.

Table 15: *Recommended Protocols*

Anatomical Region	Key Findings	Recommended Protocols	Potential Benefits	Effect Size	Supporting Studies
Hip	Significant improvements in pain reduction and ROM	Incorporate MET as a primary intervention	Enhanced mobility, reduced pain, improved overall function	Large	Wendt et al. (2018), Vaseghnia et al. (2011), Beniwal et al. (2018)
Lower Back	Superior outcomes with combined MET and McKenzie Therapy	Adopt a multidisciplinary approach including MET and McKenzie Therapy	Comprehensive treatment for CLBP, significant pain reduction, improved ROM	Large	Manzoor et al. (2020), Fahmy et al. (2019), Patel et al. (2018)
Knee	Effective in reducing pain and improving ROM	Combine MET with other stretching techniques (e.g., BLR)	Optimal recovery, enhanced flexibility, reduced pain	Large	Khuman et al. (2014), Zahoor et al. (2023), Ahmed et al. (2023)

7.2. Limitations of the Study

While the findings from the comparative analysis of the Muscle Energy Technique (MET) hold promise, it is essential to consider several limitations to ensure a comprehensive interpretation of the results:

Heterogeneity of Study Designs: Variability in methodologies, sample sizes, intervention protocols, and outcome measures across studies can make direct comparisons challenging. This heterogeneity may introduce variability in the results, and it is important to acknowledge that differences in intervention durations, follow-up periods, and specific MET techniques could influence the observed outcomes.

Sample Size and Population: Many studies included in the review had relatively small sample sizes, which may limit the generalizability of the findings. Additionally, the focus on specific populations, such as athletes or patients with chronic conditions, may not fully represent the broader population. Larger and more diverse samples could enhance the applicability of the results.

Short-Term Follow-Up: The majority of studies assessed immediate or short-term effects, leaving a gap in our understanding of MET's long-term benefits and potential adverse effects. Longitudinal studies with extended follow-up periods are needed to determine the durability of MET interventions.

Lack of Blinding: The absence of blinding in some studies introduces the possibility of bias in outcome reporting and measurement. Blinding participants and assessors is crucial to minimize placebo effects and observer bias, ensuring the accuracy and reliability of the results.

Control Interventions: The control interventions used in the studies varied widely, ranging from passive stretching to other therapeutic techniques. This variability makes it difficult to attribute improvements solely to MET, as the comparative effectiveness of the control interventions can influence the outcomes.

Reporting Bias: There may be a bias toward publishing studies with positive results, potentially overlooking studies with null or negative findings. This bias could skew the overall interpretation of MET's efficacy and limit a comprehensive understanding.

Specificity of Outcome Measures: The outcome measures used in the studies, such as VAS for pain and ROM for flexibility, are useful but may not capture the full range of functional improvements experienced by patients. Future research should incorporate a broader array of outcome measures, including quality of life and functional performance assessments.

Variability in MET Application: Variability in MET Application: The lack of standardized protocols for MET application introduces variability in the duration and intensity of the technique across studies. Standardization is necessary to ensure consistency and reproducibility of results.

Generalizability to Clinical Practice: The effectiveness of MET in controlled clinical trial settings may not fully translate to routine clinical practice, where patient adherence and variations in practitioner skill levels can impact outcomes. Further research in real-world clinical settings is warranted.

Recognizing these limitations is crucial for contextualizing the findings and guiding future research. Addressing these limitations through more rigorous study designs, larger and more diverse sample sizes, long-term follow-up, and standardized protocols will strengthen the evidence base for MET and its application in clinical practice. Despite these limitations, the current evidence supports the potential of MET as an effective intervention for improving pain and range of motion across various anatomical regions.

8. CONCLUSION

The reviewed studies provide compelling evidence to support the integration of the Muscle Energy Technique (MET) into standard treatment protocols for musculoskeletal rehabilitation, particularly in hip and lower back rehabilitation. The evidence highlights its significant efficacy in pain reduction and improving range of motion (ROM), making MET an effective and reliable technique in clinical practice.

For chronic mechanical low back pain (CLBP), the combination of MET with McKenzie Therapy has shown superior outcomes, emphasizing the importance of a multidisciplinary approach. MET also demonstrates effectiveness in knee rehabilitation, although the improvements are slightly less pronounced compared to the hip and lower back. The clinical relevance of MET is underscored by large effect sizes and consistent findings across multiple studies.

While the current evidence supports the inclusion of MET in clinical practice, more research could be done to investigate the efficacy of MET combined with other clinical rehabilitation protocols. Larger, more diverse sample sizes, standardized protocols, and long-term follow-up are needed to strengthen the evidence base. Exploring the potential synergistic effects of combining MET with other interventions can refine treatment protocols. Longitudinal studies are particularly warranted to evaluate the long-term benefits and potential adverse effects of MET.

In conclusion, MET has demonstrated significant efficacy in hip, lower back, and knee rehabilitation. Its integration into standard treatment protocols, particularly if combined with other therapeutic techniques, can lead to improved pain management, increased ROM, and better patient outcomes. By adopting evidence-based practices that include MET, clinicians can enhance the quality of care and provide more comprehensive and effective treatments for patients with musculoskeletal pain and dysfunction.

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