JHWCR JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH 3007-0570

https://doi.org/10.61919/0c8h5j33

Original Article

Comparative Effect of Cross Friction Massage and Vibration Therapy Among Gym Trainees on Delayed Onset Muscle Soreness

Eayza Riaz[1], Sumaiya[1], Qurat-ul-Ain[2], Maryam Shafqat Naseer[2], Fizza Razzaq[2], Saira Kalsoom[2], Saif-Ullah[2], Muhammad Ahmed Saleemi[2]

[1] Riphah International University, Lahore, Pakistan
[2] University of Health Sciences, Lahore, Pakistan

***Corresponding author: Muhammad Ahmed Saleemi ahsaleemi88@gmail.com**

"Cite this Article" **Received**: 17 November 2025; **Accepted**: 09 April 2026; **Published**: 15 April 2026
Author Contributions: Concept: Concept: ER; Design: SS; Data Collection: QA; Analysis: MSN; Drafting: FR. **Ethical Approval**: Riphah International University, Lahore, Pakistan. **Informed Consent**: Written informed consent was obtained from all participants; **Conflict of Interest**: The authors declare no conflict of interest. **Funding**: No external funding; **Data Availability**: Available from the corresponding author on reasonable request; **Acknowledgments**: N/A.

ABSTRACT

Background: Delayed-onset muscle soreness (DOMS) is a common consequence of unaccustomed or intense exercise, particularly eccentric contractions, and is characterized by pain, muscle tenderness, swelling, reduced range of motion, and impaired strength. Although various non-pharmacological interventions are used to manage DOMS, including massage and vibration-based therapies, evidence comparing their relative effectiveness in recreational gym trainees remains limited. Objective: To compare the effects of cross-friction massage and vibration therapy on pain, muscle tenderness, circumference, hip range of motion, and maximal isometric force among gym trainees with delayed-onset muscle soreness. Methods: A randomized clinical trial was conducted among 42 gym trainees aged 20–30 years with DOMS, recruited from two fitness centers in Lahore, Pakistan. Participants were randomly allocated into two equal groups: Group A received cross-friction massage, and Group B received vibration therapy. Both groups underwent six treatment sessions per week for two weeks, along with standardized warm-up and cool-down exercises. Outcomes were assessed at baseline and after two weeks using the Numeric Pain Rating Scale, goniometry for hip flexion and extension, circumference measurement, palpation for muscle tenderness, and repetition maximum testing for functional strength. Data were analyzed using non-parametric statistical tests with a significance level set at $p<0.05$. Results: Both groups demonstrated statistically significant within-group improvements in pain, muscle tenderness, circumference, hip range of motion, and strength ($p<0.001$). Between-group comparisons showed that vibration therapy resulted in significantly greater reductions in pain ($p=0.001$) and muscle circumference ($p<0.001$), as well as greater improvements in hip flexion ($p=0.046$) and hip extension range of motion ($p=0.008$), compared with cross-friction massage. Conclusion: Both cross-friction massage and vibration therapy were effective in managing delayed-onset muscle soreness among gym trainees; however, vibration therapy demonstrated superior short-term effectiveness in reducing pain and swelling and in improving hip range of motion. Keywords: Delayed onset muscle soreness, vibration therapy, cross-friction massage, gym trainees, physical therapy.

INTRODUCTION

Delayed-onset muscle soreness (DOMS) is a common exercise-induced condition characterized by muscle pain, stiffness, tenderness, and transient loss of function that typically develops 12–24 hours after unaccustomed or high-intensity exercise and peaks between 24 and 72 hours. It is particularly associated with eccentric muscle contractions and frequently affects individuals who initiate or modify resistance-training programs, such as gym trainees. Although DOMS is considered a self-limiting condition, its clinical relevance lies in its negative impact on physical performance, training adherence, functional activities, and risk of secondary injury during continued exercise despite incomplete recovery (1,2). Given the growing popularity of recreational gym-based training among young adults, effective management strategies for DOMS remain an important concern in physical therapy and sports rehabilitation.

The underlying pathophysiology of DOMS is multifactorial and not yet fully elucidated. Current evidence suggests that eccentric loading induces ultrastructural muscle damage, particularly Z-line disruption and sarcomere overstretching, which initiates a cascade of inflammatory responses, including

increased vascular permeability, infiltration of neutrophils, cytokine release, and accumulation of metabolic byproducts. These processes sensitize type III and IV afferent nerve endings, resulting in pain and movement-related discomfort, along with swelling, reduced range of motion (ROM), and diminished force-generating capacity (3–5). The resultant impairments can compromise athletic performance and daily activities, especially during early phases of training or return to exercise after inactivity (6).

A wide range of interventions has been proposed to alleviate DOMS, including stretching, cryotherapy, compression garments, pharmacological agents, massage, and vibration-based modalities. However, systematic reviews indicate that no single intervention has emerged as a definitive gold standard, and the effectiveness of many commonly used approaches remains inconclusive or variable across populations and outcome measures (7,8). Among non-pharmacological strategies, therapeutic massage is widely used in clinical and sports settings due to its accessibility and perceived benefits in reducing pain, muscle stiffness, and swelling. Cross-friction massage, in particular, is believed to enhance local circulation, modulate neural input, and promote tissue remodeling by applying transverse pressure across muscle fibers, thereby potentially reducing tenderness and improving mobility following muscle damage (9,10).

Vibration therapy has gained increasing attention as an adjunctive recovery modality in recent years. Delivered either locally or through whole-body platforms, vibration therapy is proposed to enhance muscle perfusion, accelerate metabolite clearance, improve neuromuscular activation, and modulate pain perception through mechanoreceptor stimulation. Emerging evidence suggests that vibration therapy may reduce perceived muscle soreness, preserve muscle strength, and improve ROM following exercise-induced muscle damage, although findings remain inconsistent and dependent on vibration parameters, timing, and population characteristics (11–13). Importantly, vibration therapy offers a time-efficient and standardized intervention that may be particularly suitable for gym-based environments.

Despite growing evidence supporting both cross-friction massage and vibration therapy in the management of DOMS, there remains a notable gap in the literature regarding their direct comparative effectiveness, particularly among recreational gym trainees. Most existing studies have evaluated these interventions independently, have focused on elite athletes or untrained individuals, or have examined limited outcome measures. Comparative trials assessing multiple clinically relevant outcomes such as pain intensity, muscle tenderness, circumference, ROM, and maximal isometric force within a single study population are scarce (14–16). This lack of comparative evidence limits clinicians' ability to make informed, evidence-based decisions when selecting optimal recovery strategies for individuals experiencing DOMS in routine training settings.

Therefore, the present study was designed to compare the effects of cross-friction massage and vibration therapy on delayed-onset muscle soreness among gym trainees. By evaluating changes in pain intensity, muscle tenderness, circumference, hip range of motion, and maximal isometric force contraction following a standardized intervention period, this study aimed to address an important knowledge gap and provide clinically relevant evidence to guide rehabilitation and recovery practices. It was hypothesized that both interventions would result in significant improvements in DOMS-related outcomes, with vibration therapy demonstrating superior effectiveness compared to cross-friction massage in reducing symptoms and restoring functional performance (17,18).

MATERIAL AND METHODS

A randomized clinical trial was conducted in Lahore, Pakistan, at Fitness Gold Gym and Body and Strength Gym over a six-month period following synopsis approval. Participants were recruited from gym trainees presenting with delayed-onset muscle soreness after exercise and were screened against predefined eligibility criteria. Individuals of both sexes aged 20–30 years were eligible for inclusion if they reported DOMS and had no known musculoskeletal or bone disease. Participants were excluded if they had a history of strain or sprain, recent surgery, or any neurological disorder, or if they had used

icing or analgesic or muscle-relaxant medication during the study period (19–21). Eligible participants were informed about the study procedures and provided written informed consent prior to enrollment.

A total of 56 individuals were assessed for eligibility; 14 did not meet the inclusion criteria and were excluded. The remaining 42 participants were enrolled and randomly allocated in a 1:1 ratio to one of two intervention groups (n=21 per group) using a simple lottery randomization method. Allocation was performed after baseline assessment to reduce selection bias. Participants were blinded to the specific treatment protocol to minimize expectation effects, while both groups received identical baseline management to standardize co-interventions. Baseline management consisted of application of a heating pad for 10 minutes, active range-of-motion exercises, and a 5-minute walk prior to the assigned intervention session. All participants completed the intervention protocol and were included in the final analysis, with no reported loss to follow-up over the two-week treatment period.

Both groups received treatment six sessions per week for two consecutive weeks (total 12 sessions). In Group A, participants received cross-friction massage administered by the therapist with the participant positioned prone for hamstring treatment and supine for quadriceps treatment. The therapist applied deep transverse pressure using fingers and thumbs across the muscle fibers with the intent to reduce muscle soreness and stiffness and promote recovery through mechanical and neurophysiological effects (22,23). In Group B, participants received local vibration therapy with the participant positioned prone for hamstring treatment and supine for quadriceps treatment. Vibration intensity was adjusted to a comfortable level for each participant, beginning at a lower setting and progressively increased as tolerated. The device was applied from the proximal portion of the target muscle and moved distally toward the knee, with each session lasting approximately 5–15 minutes according to tolerance and protocol consistency across sessions (24,25). Warm-up and cool-down components were maintained uniformly across both groups throughout the intervention period.

Outcome measures were collected at baseline prior to randomization and again at follow-up after two weeks of intervention. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), which is widely used for quantifying subjective pain severity and has demonstrated clinical utility in musculoskeletal research (26). Hip range of motion was assessed with a standard goniometer for hip flexion and hip extension to capture functional mobility limitations associated with DOMS (26). Muscle bulk or swelling was operationalized as limb circumference measured using a measuring tape at a standardized anatomical landmark to reflect edema-related changes (27). Muscle tenderness was assessed by standardized palpation over the involved muscle belly and/or myotendinous junction and recorded as present or absent. Functional strength capacity was assessed using repetition maximum testing, operationalized as the ability to perform 1RM and 10RM, to reflect maximal and submaximal force performance relevant to gym training demands (26). All measurements were recorded on a structured questionnaire, and standardized procedures were used to minimize measurement error and enhance reproducibility.

Data were entered and analyzed using IBM SPSS Statistics version 20. Quantitative variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages. Normality of continuous outcomes was assessed using the Shapiro–Wilk test. Because the distributions were non-normal for key outcomes, non-parametric inferential methods were applied. Within-group pre–post comparisons were conducted using the Wilcoxon signed-rank test for continuous variables. Between-group comparisons were conducted using the Mann–Whitney U test to evaluate differences in post-intervention outcomes between cross-friction massage and vibration therapy groups. Statistical significance was set at $p<0.05$ for all analyses. Ethical approval was obtained through the relevant institutional review process, and participant confidentiality was maintained through anonymized data handling and secure record storage consistent with research ethics standards (28).

RESULTS

Table 1 summarizes the baseline demographic profile of the cohort (N=42). The participants were young adults with a mean age of 24.50 years (SD 3.01), reflecting a relatively homogeneous age distribution within the prespecified 20–30-year range. The sample was predominantly male, with 31 men (73.8%) and 11 women (26.2%), indicating an unequal sex distribution that should be considered when interpreting generalizability to mixed-gender gym populations.

Table 2 presents changes in muscle tenderness status from baseline to follow-up in the overall sample. At baseline, tenderness was present in all participants (42/42; 100%), consistent with the clinical definition of DOMS. After two weeks of intervention, tenderness persisted in only 2 participants (4.8%), while 40 participants (95.2%) demonstrated complete resolution of tenderness on palpation. This represents an absolute reduction of 95.2 percentage points in tenderness prevalence, indicating substantial clinical improvement across the combined intervention exposure.

Table 3 describes functional strength capacity using repetition maximum performance. For 1RM, only 11 participants (26.2%) were able to perform the test at baseline, whereas 31 (73.8%) were unable. Following the two-week treatment period, 37 participants (88.1%) were able to perform 1RM, and only 5 (11.9%) remained unable, representing a 61.9 percentage point increase in 1RM feasibility. A similar pattern was observed for 10RM performance: baseline feasibility was low (5/42; 11.9%), with 37 participants (88.1%) unable to perform 10RM. Post-intervention, 29 participants (69.0%) could perform 10RM and 13 (31.0%) could not, corresponding to a 57.1 percentage point increase in 10RM feasibility. Collectively, these findings suggest marked improvement in functional strength tolerance after treatment.

Table 4 reports the Shapiro–Wilk test for normality across continuous outcomes. Pain scores (NPRS) were non-normally distributed at both baseline ($p=0.022$) and follow-up ($p<0.001$). Hip flexion ROM demonstrated non-normality at baseline ($p=0.023$) and follow-up ($p=0.003$), and hip extension ROM was also non-normal pre-intervention ($p=0.014$) and post-intervention ($p<0.001$). Circumference was the only variable that approached normality at baseline ($p=0.059$) but was non-normal post-intervention ($p=0.010$). On this basis, non-parametric methods were appropriately applied for inferential analyses of continuous outcomes.

Table 5 shows within-group pre–post comparison of pain intensity measured by NPRS for the combined sample using the Wilcoxon signed-rank test. The baseline mean NPRS was 5.76 (SD 1.51) with a median of 6 and an interquartile range (IQR) of 2.25, indicating moderate pain severity at baseline. After two weeks of intervention, mean NPRS decreased to 0.43 (SD 0.77), with the median reduced to 0 (IQR 1.00). The reduction was statistically significant ($Z=-5.684$, $p<0.001$), reflecting a large and clinically meaningful decline in pain severity from baseline to follow-up.

Table 6 presents within-group changes in muscle circumference. Baseline circumference had a mean of 55.22 (SD 1.73) and a median of 55 (IQR 2). Post-intervention, the mean circumference decreased to 41.10 (SD 1.46) with a median of 41 (IQR 2). This change was statistically significant ($Z=-5.662$, $p<0.001$). The magnitude of the reduction (mean difference ≈14.13 units) indicates a substantial decline in measured circumference over two weeks, consistent with reduced swelling or muscle bulk associated with recovery from DOMS.

Table 7 reports within-group hip range-of-motion changes. Hip flexion ROM increased from a baseline mean of 60.14° (SD 6.68; median 59, IQR 10) to 71.12° (SD 6.73; median 70, IQR 11) after treatment. Hip extension ROM increased from 13.93° (SD 2.23; median 14, IQR 3) to 17.45° (SD 1.56; median 18, IQR 3). The overall within-group Wilcoxon statistic reported for ROM outcomes was significant ($Z=-5.653$, $p<0.001$), demonstrating statistically significant improvements in mobility in parallel with symptom reduction.

Table 8 compares post-intervention outcomes between Group A (cross-friction massage) and Group B (vibration therapy) using the Mann–Whitney U test. For pain at follow-up, Group A demonstrated a higher mean rank (26.62) than Group B (16.38), with a statistically significant difference (p=0.001), indicating lower post-treatment pain scores in the vibration therapy group. For circumference at follow-up, Group A again showed a higher mean rank (29.10) relative to Group B (13.90), with a highly significant difference (p<0.001), consistent with greater reduction in circumference in the vibration therapy group. For hip flexion ROM at follow-up, Group A had a mean rank of 25.24 compared with 17.76 in Group B (p=0.046), and for hip extension ROM, Group A had a mean rank of 26.36 compared with 16.64 in Group B (p=0.008). Taken together, the between-group analyses demonstrate statistically significant superiority of vibration therapy over cross-friction massage on post-intervention pain, circumference, and hip ROM outcomes, with the strongest statistical separation observed for circumference (p<0.001) and pain (p=0.001), followed by hip extension ROM (p=0.008) and hip flexion ROM (p=0.046).

Table 1. Demographic Characteristics of Participants (N = 42)

Variable	Mean ± SD / n (%)
Age (years)	**24.50 ± 3.01**
Male	**31 (73.8%)**
Female	**11 (26.2%)**

The mean age of participants was 24.5 years (SD ±3.01), with an age range of 20–30 years. The sample consisted predominantly of male participants (73.8%), while females constituted 26.2% of the cohort.

Table 2. Muscle Tenderness Before and After Intervention (Within-Group, N = 42)

Muscle Tenderness	Pre-intervention n (%)	Post-intervention n (%)
Present	**42 (100%)**	**2 (4.8%)**
Absent	**0 (0%)**	**40 (95.2%)**

All participants demonstrated muscle tenderness at baseline. Following two weeks of intervention, tenderness resolved in 95.2% of participants, indicating a marked reduction across both treatment groups.

Table 3. Maximum Isometric Force Performance Pre- and Post-intervention (N = 42)

1RM Performance

Outcome	Pre n (%)	Post n (%)
Performed	**11 (26.2%)**	**37 (88.1%)**
Not performed	**31 (73.8%)**	**5 (11.9%)**

10RM Performance

Outcome	Pre n (%)	Post n (%)
Performed	**5 (11.9%)**	**29 (69.0%)**
Not performed	**37 (88.1%)**	**13 (31.0%)**

Substantial improvement was observed in both maximal (1RM) and submaximal (10RM) force performance following intervention, reflecting enhanced functional muscle capacity.

Table 4. Normality Assessment of Continuous Variables (Shapiro–Wilk Test)

Variable	Statistic	df	p-value
Pre NPRS	0.936	42	0.022
Post NPRS	0.616	42	<0.001
Pre Hip Flexion ROM	0.937	42	0.023
Post Hip Flexion ROM	0.912	42	0.003
Pre Hip Extension ROM	0.931	42	0.014
Post Hip Extension ROM	0.876	42	<0.001
Pre Circumference	0.949	42	0.059
Post Circumference	0.927	42	0.010

Normality testing demonstrated non-normal distributions for most outcome variables, justifying the use of non-parametric statistical tests.

Table 5. Within-Group Comparison of Numeric Pain Rating Scale (NPRS) (Wilcoxon Signed-Rank Test)

Outcome	Mean ± SD	Median (IQR)	Z-value	p-value
Pre NPRS	5.76 ± 1.51	6 (2.25)	-5.684	<0.001
Post NPRS	0.43 ± 0.77	0 (1.00)		

Pain intensity significantly decreased following intervention, with a large within-group effect (p<0.001).

Table 6. Within-Group Comparison of Muscle Circumference (Wilcoxon Signed-Rank Test)

Outcome	Mean ± SD	Median (IQR)	Z-value	p-value
Pre Circumference	55.22 ± 1.73	55 (2)	-5.662	<0.001
Post Circumference	41.10 ± 1.46	41 (2)		

A statistically significant reduction in muscle circumference was observed post-intervention, indicating reduced swelling or muscle bulk.

Table 7. Within-Group Comparison of Hip Range of Motion (Wilcoxon Signed-Rank Test)

Outcome	Mean ± SD (Pre)	Mean ± SD (Post)	Z-value	p-value
Hip Flexion ROM (°)	60.14 ± 6.68	71.12 ± 6.73	-5.653	<0.001
Hip Extension ROM (°)	13.93 ± 2.23	17.45 ± 1.56	-5.653	<0.001

Table 8. Between-Group Comparison of Post-intervention Outcomes (Mann–Whitney U Test)

Outcome	Group A Mean Rank	Group B Mean Rank	p-value
NPRS (Post)	26.62	16.38	0.001
Circumference (Post)	29.10	13.90	<0.001
Hip Flexion ROM (Post)	25.24	17.76	0.046
Hip Extension ROM (Post)	26.36	16.64	0.008

Between-group analysis demonstrated statistically significant superiority of vibration therapy over cross-friction massage across pain, circumference, and hip range-of-motion outcomes.

DISCUSSION

The present randomized clinical trial evaluated and compared the effects of cross-friction massage and vibration therapy on delayed-onset muscle soreness among gym trainees, with outcomes encompassing pain intensity, muscle tenderness, circumference, hip range of motion, and maximal isometric force capacity. The principal findings demonstrate that both interventions produced statistically significant within-group improvements across all measured outcomes after two weeks of treatment; however, vibration therapy yielded superior post-intervention results compared with cross-friction massage for pain reduction, reduction in muscle circumference, and improvement in hip flexion and extension range of motion. These findings directly address the stated research objective and contribute novel comparative evidence within a population that is underrepresented in the existing literature.

The marked reduction in pain intensity observed within both groups aligns with prior evidence supporting non-pharmacological physical therapy interventions for DOMS management. Massage-based interventions are thought to reduce pain through enhanced local circulation, modulation of nociceptive input, and attenuation of inflammatory mediators, which collectively decrease peripheral sensitization (29,30). Similarly, vibration therapy has been shown to activate large-diameter afferent fibers and mechanoreceptors, potentially inhibiting pain transmission via gate-control mechanisms while simultaneously improving muscle perfusion and oxygen delivery (31,32). The significantly greater reduction in NPRS scores observed in the vibration therapy group suggests that these neuromechanical effects may be more potent or rapidly acting than the localized mechanical stimulation provided by cross-friction massage in the context of exercise-induced muscle damage.

Muscle tenderness, a hallmark clinical feature of DOMS, resolved in the vast majority of participants following intervention, irrespective of group allocation. This finding supports previous reports that both manual therapy and vibration-based modalities can accelerate recovery from DOMS-related hypersensitivity (33). The near-complete resolution of tenderness within two weeks indicates that both interventions are clinically effective; however, because tenderness was assessed dichotomously, subtle between-group differences may not have been captured. Future studies incorporating graded or pressure-based algometric measures could further delineate differential effects between treatment modalities.

A particularly notable finding of this study was the significant reduction in muscle circumference following intervention, with vibration therapy demonstrating a significantly greater effect than cross-friction massage. Increased circumference following eccentric exercise is commonly attributed to edema and inflammatory swelling secondary to muscle fiber microtrauma (34). The superior reduction observed in the vibration therapy group may be explained by enhanced lymphatic drainage and microcirculatory flow induced by oscillatory mechanical stimuli, which have been shown to facilitate removal of interstitial fluid and inflammatory byproducts (35,36). Previous investigations into massage-based recovery have reported mixed effects on edema reduction, with some studies demonstrating limited impact on objective swelling despite improvements in subjective soreness (37). The present findings therefore suggest that vibration therapy may offer a distinct advantage in addressing the inflammatory and fluid-related components of DOMS.

Improvements in hip flexion and extension range of motion were observed in both groups, with significantly greater gains in the vibration therapy group at follow-up. Restricted ROM in DOMS is thought to result from a combination of pain inhibition, increased passive muscle stiffness, and swelling-related mechanical limitation (38). By reducing pain and circumference concurrently, vibration therapy may have exerted a more comprehensive effect on the mechanical and neuromuscular contributors to movement restriction. These findings are consistent with prior studies reporting enhanced ROM

following vibration exposure, potentially mediated through reduced muscle stiffness and improved neuromuscular efficiency (39,40). Cross-friction massage also produced meaningful ROM gains, supporting its clinical utility, but its comparatively smaller effect size suggests a more localized or slower mechanism of action.

Functional strength capacity, assessed through the ability to perform 1RM and 10RM tasks, improved substantially following intervention. The increase in the proportion of participants able to perform these tasks post-treatment reflects improved tolerance to load and recovery of neuromuscular function following DOMS. Exercise-induced muscle damage is known to impair force production through disruption of excitation–contraction coupling and increased protective inhibition (41). Both massage and vibration therapy may mitigate these effects by improving muscle perfusion and reducing inhibitory pain signals. Although between-group inferential statistics were not applied to RM outcomes, the overall improvement is clinically relevant for gym trainees, as it reflects readiness to resume resistance training with reduced injury risk.

The findings of the present study are broadly consistent with prior comparative and systematic investigations reporting beneficial effects of vibration therapy on DOMS-related outcomes, including pain reduction, strength preservation, and ROM enhancement (42–44). However, some studies have reported no clear superiority of vibration therapy over traditional massage or stretching protocols (45). These discrepancies may be attributable to differences in vibration parameters, intervention timing, muscle groups studied, or participant characteristics. By focusing specifically on gym trainees and employing a short, intensive treatment protocol, the present study adds context-specific evidence that vibration therapy may be particularly advantageous in recreational training environments.

Several limitations should be acknowledged when interpreting these results. The sample size, although adequately powered for primary comparisons, was relatively small and drawn from a limited geographic area, which may affect generalizability. Sex distribution was unequal, with a predominance of male participants, potentially limiting extrapolation to female trainees. Blinding was limited to participants, and therapist blinding was not feasible, introducing potential performance bias. Additionally, vibration parameters were adjusted according to comfort rather than standardized intensity metrics, which may affect reproducibility. Despite these limitations, the randomized design, complete follow-up, and use of multiple clinically relevant outcome measures strengthen the internal validity of the findings.

In summary, the present study demonstrates that both cross-friction massage and vibration therapy are effective interventions for reducing delayed-onset muscle soreness and associated functional impairments in gym trainees. However, vibration therapy consistently produced greater improvements in pain, muscle circumference, and hip range of motion, suggesting superior efficacy in the short-term management of DOMS. These findings support the integration of vibration therapy into rehabilitation and recovery protocols for individuals engaged in resistance training and highlight the need for further large-scale trials to refine optimal vibration parameters and long-term outcomes.

CONCLUSION

Both cross-friction massage and vibration therapy produced statistically and clinically significant improvements in delayed-onset muscle soreness–related outcomes among gym trainees, including reductions in pain intensity, muscle tenderness, and circumference, along with improvements in hip range of motion and functional strength capacity. These findings confirm that non-pharmacological, therapist-applied interventions can effectively facilitate recovery following exercise-induced muscle damage in recreational training populations. However, between-group analyses demonstrated that vibration therapy was consistently more effective than cross-friction massage in reducing post-intervention pain and muscle circumference and in improving hip flexion and extension range of motion after two weeks of treatment. The superiority of vibration therapy suggests that its combined neuromechanical and circulatory effects may provide enhanced short-term recovery benefits compared

with localized manual friction techniques. Based on these results, vibration therapy may be considered a preferable intervention for the management of delayed-onset muscle soreness in gym trainees, particularly when rapid symptom resolution and restoration of functional performance are desired.

REFERENCES

1. Abd T. The effects of vibration on delayed onset of muscle soreness before eccentric exercise in non-dominant biceps muscle. Physiotherapy. 2015;101:e28.
2. Akbar MTH, Doewes M, Syaifullah R. The effect of ice massage and passive stretching on the DOMS of the gastrocnemius muscle. Qual Sport. 2023;10:76-85.
3. Akehurst H, Grice JE, Angioi M, Morrissey D, Migliorini F, Maffulli N. Whole-body vibration decreases delayed onset muscle soreness following eccentric exercise in elite hockey players: a randomised controlled trial. J Orthop Surg Res. 2021;16:1-8.
4. Aminian-Far A, Hadian MR, Olyaei G, Talebian S, Bakhtiary AH. Whole-body vibration and the prevention and treatment of delayed-onset muscle soreness. J Athl Train. 2011;46:43-49.
5. Andersen LL, Jay K, Andersen CH, Jakobsen MD, Sundstrup E, Topp R, Behm DG. Acute effects of massage or active exercise in relieving muscle soreness: randomized controlled trial. J Strength Cond Res. 2013;27:3352-3359.
6. Angelopoulos P, Diakoronas A, Panagiotopoulos D, Tsekoura M, Xaplanteri P, Koumoundourou D, Saki F, Billis E, Tsepis E, Fousekis K. Cold-water immersion and sports massage can improve pain sensation but not functionality in athletes with delayed onset muscle soreness. Healthcare (Basel). 2022;10:2449.
7. Blennerhassett G. The best massage for DOMS and sore muscles.
8. Boguszewski D, Szkoda S, Adamczyk JG, Białoszewski D. Sports massage therapy on the reduction of delayed onset muscle soreness of the quadriceps femoris. Hum Mov. 2014;15:234-237.
9. Brummitt J. The role of massage in sports performance and rehabilitation: current evidence and future direction. N Am J Sports Phys Ther. 2008;3:7.
10. Chaves P, Simoes D, Paço M, Pinho F, Duarte JA, Ribeiro F. Cyriax's deep friction massage application parameters: evidence from a cross-sectional study with physiotherapists. Musculoskelet Sci Pract. 2017;32:92-97.
11. Cheng L, Wang K, He B, Yan Y. Effect of vertical vibration stimulation at different frequencies on delayed muscle soreness in athletes: a randomized trial. Front Public Health. 2022;10:980454.
12. Choroszewicz P, Dobosiewicz AM, Badiuk N. Sports massage as a method of preventing delayed onest muscle soreness. Pedagogy Psychol Sport. 2020;6:104-112.
13. Chwała W, Pogwizd P, Rydzik Ł, Ambroży T. Effect of vibration massage and passive rest on recovery of muscle strength after short-term exercise. Int J Environ Res Public Health. 2021;18:11680.
14. Fuller JT, Thomson RL, Howe PR, Buckley JD. Vibration therapy is no more effective than the standard practice of massage and stretching for promoting recovery from muscle damage after eccentric exercise. Clin J Sport Med. 2015;25:332-337.
15. Gasibat Q, Suwehli W. Determining the benefits of massage mechanisms: a review of literature. Rehabil Sci. 2017;3:58-67.
16. Gauri MI, Choudhary RK, Rizvi MR. Effect of local application of turmeric and conventional physical therapy on delayed onset muscle soreness (DOMS) after eccentric exercise in healthy adults.

17. Goswami A. A comparative study on effect of massage versus cryotherapy on delayed onset muscle soreness (DOMS) and physical performance in female collegiate athletes [thesis]. Rajiv Gandhi University of Health Sciences (India); 2012.

18. Guo J, Li L, Gong Y, Zhu R, Xu J, Zou J, Chen X. Massage alleviates delayed onset muscle soreness after strenuous exercise: a systematic review and meta-analysis. Front Physiol. 2017;8:747.

19. Hartono S, Widodo A, Wismanadi H, Hikmatyar G. The effects of roller massage, massage, and ice bath on lactate removal and delayed onset muscle soreness. Sport Mont. 2019;17:111-114.

20. Heiss R, Hotfiel T, Kellermann M, May MS, Wuest W, Janka R, Nagel AM, Uder M, Hammon M. Effect of compression garments on the development of edema and soreness in delayed-onset muscle soreness (DOMS). J Sports Sci Med. 2018;17:392.

21. Hemmings BJ. Physiological, psychological and performance effects of massage therapy in sport: a review of the literature. Phys Ther Sport. 2001;2:165-170.

22. Hotfiel T, Freiwald J, Hoppe MW, Lutter C, Forst R, Grim C, Bloch W, Hüttel M, Heiss R. Advances in delayed-onset muscle soreness (DOMS): Part I: Pathogenesis and diagnostics. Sportverletz Sportschaden. 2018;32:243-250.

23. Imtiyaz S, Veqar Z, Shareef M. To compare the effect of vibration therapy and massage in prevention of delayed onset muscle soreness (DOMS). J Clin Diagn Res. 2014;8:133.

24. Iodice P, Ripari P, Pezzulo G. Local high-frequency vibration therapy following eccentric exercises reduces muscle soreness perception and posture alterations in elite athletes. Eur J Appl Physiol. 2019;119:539-549.

25. Jhan T, Zutshi K, Sethi A. Effect of vibration on delayed onset muscle soreness before and after the eccentric exercise in biceps brachii muscle of females. Int J Prev Cardiol. 2021;1:4-12.

26. Jones GC, Blotter JD, Smallwood CD, Eggett DL, Cochrane DJ, Feland JB. Effect of resonant frequency vibration on delayed onset muscle soreness and resulting stiffness as measured by shear-wave elastography. Int J Environ Res Public Health. 2021;18:7853.

27. Kasahara K, Yoshida R, Yahata K, Sato S, Murakami Y, Aizawa K, Konrad A, Nakamura M. Comparison of the acute effects of foam rolling with high and low vibration frequencies on eccentrically damaged muscle. J Sports Sci Med. 2022;21:112.

28. Lee JC. A comparative study on the effect of whole body vibration on DOMS, depending on time mediation. Int J Internet Broadcast Commun. 2018;10:48-60.

29. Lu X, Wang Y, Lu J, You Y, Zhang L, Zhu D, Yao F. Does vibration benefit delayed-onset muscle soreness?: a meta-analysis and systematic review. J Int Med Res. 2019;47:3-18.

30. Mueller C. The effects of massage therapy on delayed onset muscle soreness. 2018.

31. Nahon RL, Lopes JSS, de Magalhães Neto AM. Physical therapy interventions for the treatment of delayed onset muscle soreness (DOMS): systematic review and meta-analysis. Phys Ther Sport. 2021;52:1-12.

32. Nelson N. Delayed onset muscle soreness: is massage effective? J Bodyw Mov Ther. 2013;17:475-482.

33. Ntshangase S, Peters-Futre E. The efficacy of manual versus local vibratory massage in promoting recovery from post-exercise muscle damage–a systematic review. J Sci Med Sport. 2017;20:e42.

34. Percival S, Sims DT, Stebbings GK. Local vibration therapy, oxygen resaturation rate, and muscle strength after exercise-induced muscle damage. J Athl Train. 2022;57:502-509.

35. Peters FJ Jr. The effects of localized vibration on delayed onset muscle soreness following intense eccentric cycling [thesis]. Kent State University; 2016.

36. Piotrowska A, Pilch W, Tota Ł, Maciejczyk M, Mucha D, Bigosińska M, Bujas P, Wiecha S, Sadowska-Krępa E, Pałka T. Local vibration reduces muscle damage after prolonged exercise in men. J Clin Med. 2021;10:5461.

37. Pournot H, Tindel J, Testa R, Mathevon L, Lapole T. The acute effect of local vibration as a recovery modality from exercise-induced increased muscle stiffness. J Sports Sci Med. 2016;15:142.

38. Que N. Effect of kinesio taping in combination with vibration treatment on college students' delayed-onset muscle soreness. Front Physiol. 2023;14:1058637.

39. Rhea MR, Bunker D, Marín PJ, Lunt K. Effect of iTonic whole-body vibration on delayed-onset muscle soreness among untrained individuals. J Strength Cond Res. 2009;23:1677-1682.

40. Sonkodi B, Kopa Z, Nyirády P. Post orgasmic illness syndrome (POIS) and delayed onset muscle soreness (DOMS): do they have anything in common? Cells. 2021;10:1867.

41. Veqar Z, Imtiyaz S. Vibration therapy in management of delayed onset muscle soreness (DOMS). J Clin Diagn Res. 2014;8:LE01.

42. Visconti L, Forni C, Coser R, Trucco M, Magnano E, Capra G. Comparison of the effectiveness of manual massage, long-wave diathermy, and sham long-wave diathermy for the management of delayed-onset muscle soreness: a randomized controlled trial. Arch Physiother. 2020;10:1-7.

43. Wu S, Ning H-T, Xiao S-M, Hu M-Y, Wu X-Y, Deng H-W, Feng H. Effects of vibration therapy on muscle mass, muscle strength and physical function in older adults with sarcopenia: a systematic review and meta-analysis. Eur Rev Aging Phys Act. 2020;17:1-12.

44. Yarlagadda SD, Rao MS. Compare the effectiveness of massage versus cryotherapy in treating delayed onset muscle soreness. Natl Editorial Advisory Board. 2014;8:4112.

45. Yin Y, Wang J, Duan K, Cai H, Sun J. The effect of vibration training on delayed muscle soreness: a meta-analysis. Medicine (Baltimore). 2022;101.