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Title: The Impact of a 6-Week Massage Therapy Program on Pain, Flexibility and Quality of Life of Athletes with Lower Limb Amputation and Chronic Nonspecific Low Back Pain

Authors: Mojtaba Babaie Khorzoghi[1], Abouzar Saadatian[2,*], Azam Saber Tahan[3]

1. *Center of Physical Education, Isfahan University of Technology, Isfahan, Iran.*
2. *Department of Physical Education, Faculty of Literature and Human Sciences, University of Yasouj, Yasouj, Iran.*
3. *Department of Sport Injuries and Corrective Exercises, Faculty of Sport Sciences, Islamic Azad University, Isfahan (Khorasgan Branch), Isfahan, Iran.*

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Abstract

Purpose: Among athletic populations with lower extremity amputations, chronic non-specific low back pain (LBP) represents a prevalent complication that significantly impairs physical comfort, vertebral mobility, and overall well-being. To address this, manual therapy is often introduced as a conservative, non-drug restorative strategy. The primary objective of the current investigation was to evaluate how a structured 6-week massage intervention influences pain intensity, thoracolumbar flexibility, and health-related quality of life in amputee athletes suffering from persistent non-specific LBP.

Methods: Utilizing a quasi-experimental design, volunteers were enrolled and allocated into either an un-treated control cohort (mean age: 35.53±9.28 years; BMI: 24.56±1.88kg/m^2) or a treatment collective (mean age: 40.53±7.66 years; BMI: 23.19±2.30 kg/m^2). Pre-intervention data collection encompassed clinical discomfort severity, lumbar spine flexibility, sleep metrics, and subjective well-being via the WHOQOL tool. Individuals in the intervention arm participated in three weekly massage sessions spanning six weeks, whereas the control cohort sustained their baseline habits. Final post-intervention profiles were recorded immediately after the final week. Statistical evaluations comprised paired-sample t-tests, ANCOVA, and non-parametric Wilcoxon/Mann-Whitney criteria, establishing significance at $P<0.05$.

Results: Post-test indicators revealed substantial enhancements within the massaged cohort regarding lower back discomfort reduction ($p=0.001$), expanded trunk flexibility ($p=0.001$), and boosted quality of life scores ($p\leq0.01$) relative to the control group. The data confirmed distinct inter-group variances favoring the active treatment arm upon trial completion.

Conclusion: Implementing a 6-week manual soft-tissue manipulation program serves as a viable, productive approach to mitigate lumbosacral pain while simultaneously advancing daily physical capacity and health satisfaction in disabled athletes dealing with post-amputation spinal discomfort

Keywords: Chronic Low back pain, Massage therapy, Lower Limb Amputation, athletes, quality of life

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Highlights

- A six-week soft-tissue manipulation regimen successfully mitigated persistent lower back irritation in amputee sports participants.

- Spinal mobility and trunk bending capacity expanded following the intervention period.

- Multidimensional health domains, focusing on psychological and physical well-being, exhibited marked post-treatment upgrades.

- Manual friction and stroking function as a reliable drug-free rehabilitative tool for athletes presenting lower limb loss.

Plain Language Summary

Individuals engaged in adaptive sports after losing a lower limb frequently encounter lingering back issues that limit their biomechanical freedom and everyday comfort. This research indicated that six weeks of regular body massage diminished backache intensity, made the spine more flexible, and elevated life satisfaction. Consequently, massage techniques offer a secure, realistic therapeutic modality for addressing muscular spine distress in adaptive athletes.

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1. Introduction

The lack of limbs is a phenomenon causing disability in individuals facing these limitations; approximately 1.2 million Americans have this disability[1] . The amputation process is complex and challenging to investigate because of its wide range of causes and associated complications. Individuals with traumatic amputations are generally younger and physically fitter compared with those who undergo amputation due to vascular disorders or diabetes[2]. Moreover, traumatic amputees often regain independent walking ability and return to a high level of daily functioning. Nevertheless, secondary musculoskeletal problems, particularly low back pain (LBP), remain a major contributor to additional disability. Previous studies have reported that approximately 52–71% of amputees suffer from LBP, a prevalence considerably higher than that observed in non-amputee populations (12–34%)[3]. Lower-limb amputation often leads to substantial biomechanical and neurophysiological changes that increase the risk of low back pain (LBP). In fact, back pain affects a majority of amputees. For example, Sivapuratharasu et al. (2019) found LBP prevalence of 52–64% in traumatic amputees.[4] Moreover, individuals with diverse disabilities may experience physical challenges in their bodies, along with issues arising from the environment and society, contributing to reduced mobility or immobility[5, 6]. Amputees with lower extremity loss demonstrate an elevated susceptibility to back complaints owing to kinetic modifications, adaptive gait mechanisms, and changes in alignment following surgery. Missing a limb disrupts the standard equilibrium of weight distribution across the pelvic girdle and vertebral axis, thereby intensifying the physical workload on the lumbar sector. Prior literature has consistently highlighted a clear link between restricted movement in the lower back and hamstrings and the onset of lumbar distress[7, 8]. This reduction, along with the subsequent decline in motor functions in individuals with disabilities can also affect their quality of life and social relationships [7]. Existing evidence suggests that the prevalence of LBP among amputees is influenced by several factors, including prosthetic use, associated comorbidities, levels of physical activity, and the availability of psychological and social support [3, 4].

Amputation and back pain also lead to significant financial losses due to the high cost of treatment [9]. Considering the physical-psychological and socio-economic complications caused by the low back pain, timely treatment and prevention of associated complications and disabilities caused by it can be of special importance. Therefore, Limb loss, low back pain, and reduced flexibility are among the factors that decrease quality of life in individuals with amputation who suffer from low back pain[9, 10]. To manage chronic low back pain, some

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guidelines recommend that exercise , massage and controlled physical activity be the initial steps in reducing pain and treating limited mobility[11]. Research has demonstrated that exercise not only alleviates pain but also enhances the performance of individuals with low back pain, those with various disabilities. Therefore, exercise is considered an integral part of the multi-stage approach to treating chronic low back pain [8]. Massage therapy has a well-established role in chronic LBP. Recent systematic reviews report that massage can produce short-term pain relief in chronic nonspecific LBP[12, 13]. For instance, Skelly et al. (2020) found that massage provided a small but significant reduction in chronic LBP pain in the short term. Massage also tends to improve muscle relaxation and blood flow, which can increase spinal flexibility. Therefore, it is plausible that a structured massage program could reduce LBP and improve lumbar flexibility and function in amputees. This rationale – grounded in high LBP prevalence in amputees, known trunk compensations, and evidence of massage efficacy in LBP[14]. The benefits of massage include reducing stress and pressure on muscles, increasing red blood cells, decreasing pain and accelerating recovery from acute and chronic disorders. Previous studies attribute the mechanism of pain relief after massage to the endogenous system, blocking impulses entering the brain and endorphin secretion[15]. On the other hand, contemporary research has demonstrated that the use of massage can improve physical functions and reduce pain in the patients with chronic low back pain, thereby improving their daily activities and reducing pain or discomfort[16].

Based on this, the lack of previous research was for assessing the effectiveness of simultaneous therapeutic massage on variables such as flexibility, pain, quality of life in individual with lower limb amputation, particularly those experiencing chronic nonspecific low back pain. Consequently, the aim of study was the impact of a 6-week massage therapy program on pain, flexibility, quality of life in athletes with lower limb amputation and chronic nonspecific low back pain.

2. methods

A quasi-experimental approach incorporating pre- and post-intervention assessments was utilized, comparing an experimental cohort against a control group. Before the study began of the research, individuals were invited to participate by completing the consent form; those who agreed provided their informed consent. Inclusion criteria included being in the age range of 20 to 50 years, lower extremity amputation (unilateral below-knee amputation), chronic non-specific low back pain

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Exclusion criteria for this study also encompassed the presence of injury, the use of specific drugs that could negatively impact their performance during the massage therapy, and any postural abnormalities that might affect the research process.

Subsequently, 30 women athletes with unilateral below-knee amputation and non-specific chronic low back pain in (sports club) Kashan city were recruited for the study. All participants had a unilateral transtibial amputation and were screened based on the inclusion criteria. After enrollment, participants were randomly divided into either the training or the control group for further analysis. Following these assessments, the participants in the experimental group underwent a 6-week massage therapy. Participants in the control group were instructed to refrain from receiving any additional rehabilitation or therapeutic interventions during the study period and to maintain their usual daily activities. Adherence to the study protocol was monitored through weekly follow-up contacts

2.1 Pain assessment

To evaluate subjective pain levels, the Visual Analogue Scale (VAS) was deployed. This assessment tool consists of a 100-mm horizontal continuum, where the polar extremes of 0 and 10 cm define the minimum and maximum thresholds of pain, respectively. Owing to its strong psychometric properties, this scale remains a widely accepted standard in research, exhibiting excellent validity and a reliable Cronbach's alpha range of 0.67–0.80 [17].

2.2 Quality of life assessment

Participants' well-being was evaluated via the Persian adaptation of the World Health Organization Quality of Life-Brief (WHOQOL-BREF) instrument. This widely accepted self-administered tool captures subjective quality of life across multiple dimensions. The instrument encompasses 26 items: two baseline questions address global health and overall life satisfaction, while the remaining 24 items are divided into four specific domains: physical health (7 items), psychological well-being (6 items), social interactions (3 items), and environmental health (8 items). Responses are recorded on a 5-point Likert scale (1 to 5), with elevated scores reflecting superior quality of life. The cumulative raw scores for individual domains are subsequently converted to a linearized 0–100 range. The psychometric properties of the Persian version are well-established, with prior literature reporting satisfactory internal consistency (Cronbach's alpha ranging from 0.69 to 0.86)[18].

2.3 Lumbar-Hamstring and Trunk Extensor Flexibility Evaluation

To evaluate the flexibility of the lower back and hamstring musculature, the Sit-and-Reach test was employed as a practical, widely validated metric for lumbo-pelvic mobility. This

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assessment was highly suitable for the target cohort, given that all participants with unilateral transtibial amputations could execute the protocol safely and independently to track changes tied to chronic low back pain. During the extensor flexibility protocol, subjects assumed a seated position on the floor with their lower limbs fully extended. A testing box/bench was placed directly ahead so that the plantar surface of the foot made contact with it. A standardized scale was affixed to the apparatus, setting the 15-cm mark at the front edge with the zero-point oriented toward the subject. Participants were instructed to reach forward as far as possible, extending their trunk. The maximum displacement achieved by the tips of their middle fingers was measured in centimeters using the ruler as the primary indicator of flexibility[19].

2.4 Massage therapy program

During the massage program (Table 1), the patient first lies on their back to achieve a completely comfortable position (Figure 1). The application of the manual protocol incorporated structured phases of light effleurage, localized deep petrissage, and targeted circular friction, aggregating to a uniform 40-minute application per designated clinical appointment[14].

Table 1. Massage therapy program

Movement	Week 1-2	Week 3-4	Week 5-6
Superficial stroking	10 min	12 min	**15 min**
Deep stroking	10 min	12 min	**15 min**
Kneading friction	10 min	12 min	**15 min**

In this study, the distributional normality of the data was assessed via the Shapiro-Wilk protocol. To analyze the differences and control for potential confounders, paired t-tests and an analysis of covariance (ANCOVA) were implemented. All the aforementioned analyses were conducted using SPSS24 software.

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Figure 1. Types of massage therapy movements (Yellow arrows indicate the directions of force application).

3. Results

Table 2 outlines the baseline characteristics of each cohort, detailing descriptive metrics for age, height, weight, and body mass index (BMI).

Table 2. Descriptive statistics related research variables

	Group	Number	SD ± mean	p
age (y)	Control	15	35/53 ± 9/28	0.11
	Intervention	15	40/53± 7/66	
Height (m)	Control	15	1/68 ± 0/04	0.22
	Intervention	15	1/70 ± 0/03	
weight (kg)	Control	15	69/53 ± 7/03	0.46
	Intervention	15	67/33 ± 906	
Body mass index (kg/m^2)	Control	15	24/56 ± 1/88	0.08
	Intervention	15	23/19 ± 2/30	

Note: y= year, m= meter, kg=kilogram, p= p value independent t test

The results of independent t-test, in comparison with descriptive variables, indicated no significant difference between the two groups, signifying their homogeneity in terms of descriptive variables. Due to the normality of the data for variables such as flexibility and quality of life, as determined by Shapiro Wilk test, and the verification of the homogeneity of

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variance, as examined by Leven test, pair t-test and analysis of covariance were applied to evaluate the impact of massage. Group comparisons were also conducted. Regarding the abnormal pain variable, Mann-Whitney and Wilcoxon tests were used to determine the inter-group and intra-group differences, and the results are presented in Table 3.

Table 3. Intra-group and inter-group differences in subjects before and after intervention

		Intra-group difference				**Inter-group difference**			
variable	group	Pre-test	Post-test	T	P	Mean squares	F	P	Partial eta square
Flexibility(cm)	Control	9.53±1.99	9.73±1.86	-0.71	0.48	183.78	63.53	0.001*	0.70
	Intervention	10.93±2.52	16.20±3.25	-9.62	0.001				
Physical health	Control	37.38±6.16	38.95±6.65	-1.66	0.11	6070.49	191.23	0.001*	0.87
	Intervention	38.33±8.15	69.76±7.12	13.41	0.001				
Mental health	Control	36.6±10.476	38.3±11.086	-1.29	0.21	6069.28	99.80	0.001*	0.78
	Intervention	39.5±10.835	69.00±9.66	-10.51	0.001				
Social relations	Control	42.7±11.727	44.5±12.851	-1.94	0.07	3072.89	30.20	0.001*	0.52
	Intervention	44.9±16.915	66.3±15.825	-5.58	0.007				
Environmental health	Control	46.87±8.09	44.37±7.30	1.99	0.25	83.61	2.25	0.14	0.07
	Intervention	48.95±6.21	48.54±5.77	0.23	0.81				
Quality of life total score	Control	27.1±15.206	33.4±18.373	-1.87	0.08	20959.13	103.38	0.001*	0.79
	Intervention	30.8±12.383	88.33±11.04	-11.85	0.01				
variable	**group**	**Pre-test**	**Post-test**	**Z**	**P**	**time**	**U**	**Z**	**P**
Pain(cm)	Control	4.73±0.70	4.46±0.74	-1.41	0.15	Pre-test	101.50	-0.50	0.61
	Intervention	4.60±0.63	2.33±0.61	-3.50	0.001*	Post-test	3.00	123	0.001*

Not: cm: centimeter,

The results of the paired t-test and showed that the use of massage had a significant effect on improving the flexibility (P = 0.001), quality of life and its dimensions (P = 0.001), except for environmental health (P> 0.05), and pain (P = 0.001). Additionally, the results of covariance analysis test showed a significant difference in the variables of the flexibility (P = 0.001), quality of life total score (P = 0.001) and its dimensions (P = 0.001), except for environmental health. (P> 0.05) but result pair t-test and covariance analysis showed no significant in

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environmental health variable. Furthermore, the results of Wilcoxon test showed a significant difference in the variable of pain (P = 0.001) between the two groups.

4. Discussion

This investigation explored the outcomes of a 6-week massage therapy intervention on pain severity, lumbo-hamstring flexibility, and quality of life (QoL) among athletes presenting with unilateral lower limb amputations and chronic nonspecific low back pain. Our results revealed that the massage protocol yielded a significant mitigation in pain intensity alongside substantial enhancements in both flexibility and overall QoL relative to the control cohort. When examining specific QoL dimensions, marked post-intervention improvements were captured in the physical health, psychological well-being, and social relationship domains; conversely, the environmental health dimension exhibited no statistically significant modifications

A primary outcome of this investigation was the marked alleviation of pain severity following the implementation of the massage therapy protocol. This outcome aligns with prior research that highlights the therapeutic advantages of massage interventions for managing chronic low back pain and various musculoskeletal conditions. Furthermore, existing systematic reviews and meta-analyses corroborate that massage therapy offers effective short-term analgesia and functional recovery for populations suffering from chronic nonspecific low back pain[13, 14]. Similarly, Field et al. reported that massage therapy improves pain perception and reduces muscle tension by enhancing parasympathetic activity and decreasing stress-related physiological responses[20]. In individuals with lower limb amputation, chronic low back pain is often associated with altered gait mechanics, asymmetrical loading patterns, compensatory trunk movements, and muscular imbalance[21]. Therefore, reducing muscular tension and improving soft tissue mobility through massage may contribute to pain alleviation in this population.

The attenuation of pain observed in this study can be attributed to diverse physiological and neurophysiological pathways. Specifically, massage therapy enhances localized microcirculation and tissue perfusion, which in turn accelerates the clearance of noxious inflammatory byproducts and alleviates ischemic discomfort within the myofascial structures[22]. In addition, massage stimulates mechanoreceptors and activates the gate control mechanism of pain modulation, thereby inhibiting nociceptive transmission at the spinal cord level[23]. Previous evidence also suggests that massage therapy can stimulate the release of endorphins and serotonin while decreasing cortisol levels, which may further contribute to analgesic and psychological benefits[24]. Considering that athletes with amputation frequently experience increased mechanical stress on the lumbar spine because of altered biomechanics and compensatory movement strategies, these physiological effects may play a substantial role in reducing chronic pain symptoms[3].

Another important finding of this study was the significant improvement in lumbar and hamstring flexibility following the intervention. This result is in agreement with previous studies indicating that massage therapy can enhance range of motion and flexibility by decreasing muscle stiffness and increasing tissue extensibility[25, 26]. Reduced hamstring and lumbar flexibility are common in individuals with chronic low back pain and may contribute to abnormal pelvic mechanics and increased lumbar stress[27]. In athletes with lower limb amputation, asymmetrical posture and altered gait patterns may further exacerbate muscle tightness and movement limitations.

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Several mechanisms may explain the improvement in flexibility observed in the present study. Massage therapy may reduce passive muscle stiffness and increase viscoelastic properties of connective tissue, thereby improving joint mobility and soft tissue extensibility[28]. Deep stroking and kneading techniques used in the present intervention may also have contributed to the breakdown of adhesions and reduction of myofascial restrictions. Furthermore, increased blood flow and muscle temperature during massage may improve tissue elasticity and decrease neuromuscular tension[29]. These adaptations could facilitate greater trunk flexion and hamstring extensibility during the sit-and-reach assessment.

Our data further indicated meaningful advancements in global quality of life, alongside specific improvements within the physical, psychological, and social interaction spheres following the massage intervention. These outcomes resonate with historical literature establishing that the mitigation of pain and the restoration of physical capacities are fundamentally linked to enhanced psychosocial well-being and heightened quality of life among populations navigating chronic pain[10, 30]. Athletes with lower limb amputation often experience not only physical limitations but also emotional stress, reduced self-confidence, and social participation restrictions due to chronic pain and disability. Therefore, interventions capable of reducing pain and improving mobility may positively influence mental and social functioning[31].

The improvement in psychological health observed in this study may be attributed to the relaxation effects of massage therapy and its influence on the autonomic nervous system. Previous studies have demonstrated that massage therapy reduces anxiety, stress, and depressive symptoms by increasing parasympathetic activity and promoting relaxation responses[32]. Moreover, reduced pain intensity and enhanced mobility may improve independence and self-efficacy, which are strongly associated with quality of life in individuals with disabilities and chronic musculoskeletal disorders.

Despite the positive findings, no significant improvement was observed in the environmental health domain of the WHOQOL-BREF questionnaire. This result may be explained by the fact that environmental health is influenced by broader socioeconomic and environmental factors such as financial resources, accessibility, transportation, and social services, which are unlikely to change during a short-term intervention period[33]. Therefore, while massage therapy may improve physical and psychological dimensions of health, environmental aspects of quality of life may require long-term social and rehabilitation support.

Several limitations must be acknowledged when interpreting the outcomes of this investigation. First, the sample size was relatively modest, which potentially restricts the broader generalizability of our findings. Second, the cohort exclusively comprised female athletes with unilateral transtibial amputations; consequently, these results may not readily apply to male populations, non-athletic individuals, or those with alternative levels of amputation. Lastly, the absence of a long-term follow-up assessment precludes the determination of whether the documented therapeutic benefits are sustained over an extended period.

Conclusion

In conclusion, this investigation confirms that a 6-week massage therapy regimen successfully mitigates pain severity while enhancing lumbo-hamstring extensibility and quality of life in athletic individuals with unilateral lower extremity amputations suffering from chronic nonspecific low back pain. These outcomes highlight manual massage as a safe, viable, and non-pharmacological rehabilitative modality for managing chronic lumbar discomfort in this

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specific cohort. The documented therapeutic benefits are likely driven by optimized regional circulation, attenuated muscular tension, modulated nociceptive pathways, and boosted psychological well-being. Consequently, integrating massage interventions into rehabilitation protocols for amputee athletes could play a pivotal role in optimizing physical performance, functional mobility, and global life satisfaction.

Research Ethics Statement

The protocol of this investigation strictly adhered to the ethical tenets mandated by the Declaration of Helsinki. Formal ethical clearance was granted by the Institutional Ethics Committee of Islamic Azad University, Khorasgan Branch, Iran (Approval Code: IR.IAU.KHUISF.REC.1399.103). Before enrollment, all candidates received a comprehensive briefing regarding the study's primary objectives, experimental procedures, anticipated advantages, and prospective risks. Prior to initiating data collection, written informed consent was acquired from each volunteer. Furthermore, participants were explicitly guaranteed absolute data confidentiality and informed of their right to withdraw from the research at any juncture without incurring any adverse repercussions**.**

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Authors' contributions
M. B. Kh; contributed to the study design, statistical analysis, supervision of the study protocol, and drafting of the manuscript. A. S, as the corresponding author, contributed to study conception, statistical analysis, interpretation of the results, and critical revision of the manuscript. A.S.T; implementation of the massage therapy intervention, data collection, contributed to the methodology design, interpretation of findings, and manuscript editing. All authors read and approved the final version of the manuscript.

Conflict of interest Statement
There was no conflict of interest in this study.

AI Use Statement
Artificial intelligence (AI) tools were used only for language editing, grammar correction, and improvement of academic writing during the preparation of this manuscript. Specifically, AI-assisted language tools were utilized to enhance clarity, readability, and English expression. All study design, data collection, statistical analyses, interpretation of results, and scientific conclusions were performed solely by the authors, who take full responsibility for the content of the manuscript.

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References

1. Keeves J, Hutchison A, D'Cruz K, Anderson S. Social and community participation following traumatic lower limb amputation: an exploratory qualitative study. Disabil Rehabil. 2023;45(26):4404-12.
2. Wnuk-Scardaccione A, Zawojska K, Barłowska-Trybulec M, Mazur-Biały AI. Exercise Therapy in Nonspecific Low Back Pain among Individuals with Lower-Limb Amputation: A Systematic Review. Life. 2023;13(3):772.
3. Sadowski PK, Battista S, Leuzzi G, Sansone LG, Testa M. Low Back Pain in People With Lower Limb Amputation: A Cross-Sectional Study. Spine (Phila Pa 1976). 2022;47(22):1599-606.
4. Sivapuratharasu B, Bull AMJ, McGregor AH. Understanding Low Back Pain in Traumatic Lower Limb Amputees: A Systematic Review. Arch Rehabil Res Clin Transl. 2019;1(1-2):100007.
5. Ebrahimi E, Rashidy P, Mohammadalinezhad SE, Hajizadeh R. The effect of a 6-week AI-generated core stability training program on balance and flatfoot in blind female students. Journal of Advances in Para Sport Science. 2024;4(2):83-91.
6. Ebrahimi E, Sheikhhoseini R, Mohammadi F, Piri H. Better gait kinematics and balance, worsen body posture: Comparing goalball athletes with non-athletes with visual impairments. British Journal of Visual Impairment. 2025;0(0):02646196251322125.
7. Schömig F, Pumberger M, Becker L, Reitmaier S, Bashkuev M, Duda GN, Schmidt H. Chronic low back pain is associated with a reduction in lumbar movement – a prospective cohort study. Scientific Reports. 2025;15(1):19800.
8. Gordon R, Bloxham S. A Systematic Review of the Effects of Exercise and Physical Activity on Non-Specific Chronic Low Back Pain. Healthcare (Basel). 2016;4(2).
9. Standaert CJ, Li JW, Glassman SJ, Manolov NE, Thomas SA, Lee AA, et al. Costs Associated with the Treatment of Low Back Disorders: A Comparison of Surgeons and Physiatrists. Pm r. 2020;12(6):551-62.
10. Chang S, Yan JX, Mu L. Effects of exercise on physical performance and quality of life in individuals with limb amputation: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2025;26(1):965.
11. George SZ, Fritz JM, Silfies SP, Schneider MJ, Beneciuk JM, Lentz TA, et al. Interventions for the Management of Acute and Chronic Low Back Pain: Revision 2021. J Orthop Sports Phys Ther. 2021;51(11):Cpg1-cpg60.
12. Farber K, Wieland LS. Massage for Low-back Pain. Explore (NY). 2016;12(3):215-7.
13. Furlan AD, Giraldo M, Baskwill A, Irvin E, Imamura M. Massage for low-back pain. Cochrane Database Syst Rev. 2015;2015(9):Cd001929.
14. Skelly AC, Chou R, Dettori JR, Turner JA, Friedly JL, Rundell SD, et al. AHRQ Comparative Effectiveness Reviews. Noninvasive Nonpharmacological Treatment for Chronic Pain: A Systematic Review Update. Rockville (MD): Agency for Healthcare Research and Quality (US); 2020.
15. Chen P-C, Wei L, Huang C-Y, Chang F-H, Lin Y-N. The Effect of Massage Force on Relieving Nonspecific Low Back Pain: A Randomized Controlled Trial. International Journal of Environmental Research and Public Health. 2022;19(20):13191.

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16. Er G, Yüksel İ. A comparison of the effects of connective tissue massage and classical massage on chronic mechanical low back pain. Medicine. 2023;102(15):e33516.
17. Akbari H, Ghasemi M, Yegani T, Fesharaki MG, Saraei M, Barsam Y, Akbari H. Million Visual Analogue Scale Questionnaire: Validation of the Persian Version. Asian Spine J. 2019;13(2):242-7.
18. Abbasi-Ghahramanloo A, Soltani-Kermanshahi M, Mansori K, Khazaei-Pool M, Sohrabi M, Baradaran HR, et al. Comparison of SF-36 and WHOQoL-BREF in Measuring Quality of Life in Patients with Type 2 Diabetes. Int J Gen Med. 2020;13:497-506.
19. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. J Sports Sci Med. 2014;13(1):1-14.
20. Field T. Massage therapy research review. Complement Ther Clin Pract. 2016;24:19-31.
21. Hendershot BD, Bazrgari B, Nussbaum MA. Persons with unilateral lower-limb amputation have altered and asymmetric trunk mechanical and neuromuscular behaviors estimated using multidirectional trunk perturbations. J Biomech. 2013;46(11):1907-12.
22. Karcz M, Abd-Elsayed A, Chakravarthy K, Aman MM, Strand N, Malinowski MN, et al. Pathophysiology of pain and mechanisms of neuromodulation: a narrative review (a neuron project). Journal of pain research. 2024:3757-90.
23. Arsovski D. Deep Tissue Massage Therapy: Effects on Muscle Recovery and Performance in Athletes. Int J Ther Massage Bodywork. 2025;18(2):40-51.
24. Rapaport MH, Schettler P, Bresee C. A preliminary study of the effects of repeated massage on hypothalamic-pituitary-adrenal and immune function in healthy individuals: a study of mechanisms of action and dosage. J Altern Complement Med. 2012;18(8):789-97.
25. Dakić M, Toskić L, Ilić V, Đurić S, Dopsaj M, Šimenko J. The Effects of Massage Therapy on Sport and Exercise Performance: A Systematic Review. Sports (Basel). 2023;11(6).
26. Yildiz S, Gelen E, Çilli M, Karaca H, Kayihan G, Ozkan A, Sayaca C. Acute effects of static stretching and massage on flexibility and jumping performance. J Musculoskelet Neuronal Interact. 2020;20(4):498-504.
27. Sadler SG, Spink MJ, Ho A, De Jonge XJ, Chuter VH. Restriction in lateral bending range of motion, lumbar lordosis, and hamstring flexibility predicts the development of low back pain: a systematic review of prospective cohort studies. BMC Musculoskelet Disord. 2017;18(1):179.
28. Best TM, Hunter R, Wilcox A, Haq F. Effectiveness of sports massage for recovery of skeletal muscle from strenuous exercise. Clin J Sport Med. 2008;18(5):446-60.
29. Tiidus PM. Mechanisms and Efficacy of Massage Therapy for Post-Exercise Muscle Repair: A Narrative Review. Muscles. 2026;5(2):29.
30. Zhu F, Zhang M, Wang D, Hong Q, Zeng C, Chen W. Yoga compared to non-exercise or physical therapy exercise on pain, disability, and quality of life for patients with chronic low back pain: A systematic review and meta-analysis of randomized controlled trials. PLoS One. 2020;15(9):e0238544.

Accepted Manuscript (Uncorrected Proof)

31. Hando DJ, Byomuganyizi MJ, Ngendahayo JB, Khamisi RH, Kivuyo NE, Kunambi PP, et al. Factors Influencing the Health-Related Quality of Life Among Lower Limb Amputees: A Two-Center Cross-Sectional Study. East Afr Health Res J. 2023;7(1):121-6.
32. Ntoumas I, Karatzaferi C, Boubougiatzi F, Manakou N, Aslanidi A, Giannaki CD, et al. Massage positively influences daytime brain activity and reduces arousal state in poor sleepers: a randomized controlled trial. BMC Complement Med Ther. 2025;25(1):290.
33. Barros R, Ohnuma AA, Jr., Manso MC. Self-Perceived Quality of Life (WHOQOL-Bref), and Self-Reported Health, Social and Environmental Factors Related to Its Improvement among Residents of Anil, Rio de Janeiro-Cross-Sectional Study. Healthcare (Basel). 2024;12(15).

Accepted Manuscript (Uncorrected Proof)