Effectiveness of massage on muscle recovery: a randomized controlled trial

Efectividad del masaje en la recuperación muscular: ensayo clínico aleatorizado

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Abstract

Introduction: High-performance athletic training induces substantial muscle fatigue, which underscores the need for effective recovery strategies. Massage therapy has been proposed as a potential intervention to promote post-exercise recovery in athletes.
Objective: To evaluate the effectiveness of massage therapy on muscle recovery following exercise.
Methods: A randomized controlled trial was conducted with 37 football and futsal players, who were allocated to either an experimental group (EG) that received massage therapy or a control group (CG) that attended an educational session. Measurements were taken at three time points: before the intervention, immediately after, and 24 hours later. Muscle soreness was assessed using the Visual Analogue Scale (VAS), and physical performance was evaluated using lower-limb mechanical power output, the Reactive Strength Index (RSI) during a Drop Jump, and mean propulsive velocity (MPV) during a back squat.
Results: No statistically significant between-group differences were observed in pain perception, jump power, RSI, or MPV either immediately after the intervention or 24 hours later (all $p > .05$).
Conclusion: Applying massage therapy after a fatigue protocol did not produce significant changes in the analyzed physical performance variables. However, a tendency toward reduced perceived soreness was observed after 24 hours, suggesting that potential benefits of massage may emerge after longer recovery windows (>48 h).

Keywords

Pain perception; mechanical power; mean propulsive velocity; reactive strength index.

Resumen

Introducción: El entrenamiento deportivo de alto rendimiento genera elevados niveles de fatiga muscular, lo que resalta la importancia de estrategias de recuperación eficaces. En este contexto, el masaje se plantea como una herramienta potencial para favorecer la recuperación del deportista.
Objetivo: Evaluar la efectividad del masaje en la recuperación muscular posterior al ejercicio.
Metodología: Se realizó un ensayo controlado aleatorizado con una muestra de 37 deportistas de fútbol y fútbol sala, divididos en un grupo experimental (GE) que recibió masaje y un grupo control (GC) que recibió una charla formativa. Las mediciones se realizaron antes de la intervención, inmediatamente después y a las 24 horas de su finalización. Se evaluó la percepción del dolor mediante la escala visual análoga y el rendimiento físico a través de la potencia mecánica, el índice de fuerza reactiva en salto Drop Jump y la velocidad media propulsiva en sentadilla trasera.
Resultados: Se encontró que no hubo diferencias estadísticamente significativas entre los grupos en la percepción del dolor, la potencia de salto, el índice de fuerza reactiva y la velocidad media propulsiva, post intervención ni a al final 24 horas posteriores ($p > .05$ en todos los casos).
Conclusión: El masaje aplicado tras un protocolo de fatiga no generó cambios significativos en las variables físicas analizadas. No obstante, se observó una tendencia a la reducción del dolor percibido a las 24 horas, lo que sugiere que los beneficios del masaje podrían manifestarse en plazos mayores a 48 horas.

Palabras clave

Percepción de dolor; potencia mecánica; velocidad media propulsiva; índice de fuerza reactiva.

Introduction

High performance training generates substantial physiological stress that induces skeletal muscle fatigue through mechanisms such as metabolic acidosis, glycogen depletion, altered blood flow (Triscott et al., 2008; Weineck, 2005), and eccentric contraction–related muscle damage, which triggers inflammation and delayed-onset muscle soreness (DOMS) (Cheung et al., 2003; Dugué, 2015; Hody et al., 2019; White et al., 2020). These responses can compromise subsequent athletic performance.

Massage, a long-standing therapeutic intervention (Curran, 2008), is widely used in sport as a recovery method after training or competition. Evidence suggests that massage can reduce DOMS (Andersen et al., 2013; Dupuy et al., 2018; Han et al., 2014; Nahon et al., 2021), perceived pain (Dakić et al., 2023; Kargarfard et al., 2015; Nunes et al., 2016; Visconti et al., 2020), inflammatory responses (White et al., 2020), perceived fatigue (Nunes et al., 2016; Wiewelhove et al., 2018), and biochemical markers of muscle damage (Davis et al., 2020; Guo et al., 2017).

Football and futsal impose high neuromuscular demands (Bauer et al., 2023) and often provide limited recovery windows between matches, increasing injury risk (Bengtsson et al., 2013; Brink et al., 2010; Dupont et al., 2010). Thus, identifying effective recovery strategies is essential, yet findings remain inconsistent and research in these sports is still limited (Altarri-ba-Bartes et al., 2020).

Physiologically, massage has been linked to enhanced blood and lymphatic circulation, improved joint flexibility (Han et al., 2014), facilitation of muscle recovery (Dupuy et al., 2018), reduced muscle tension and soreness (Kuruma et al., 2013; Zhong et al., 2019), and decreased perceived fatigue (Ogai et al., 2008; Nahon et al., 2021). It is also simple, safe, and low-cost (Dakić et al., 2023; Visconti et al., 2020), although optimal application parameters remain unclear (Andersen et al., 2013; Hilbert et al., 2003; Visconti et al., 2015). Moreover, its effects on strength related outcomes particularly jump power, reactive strength, and movement velocity are still poorly defined.

Therefore, this study aimed to examine the effect of massage therapy on: (a) pain perception; (b) jump power and reactive strength; and (c) mean propulsive velocity during the back squat in trained athletes.

Method

Study Design and Methodological Approach

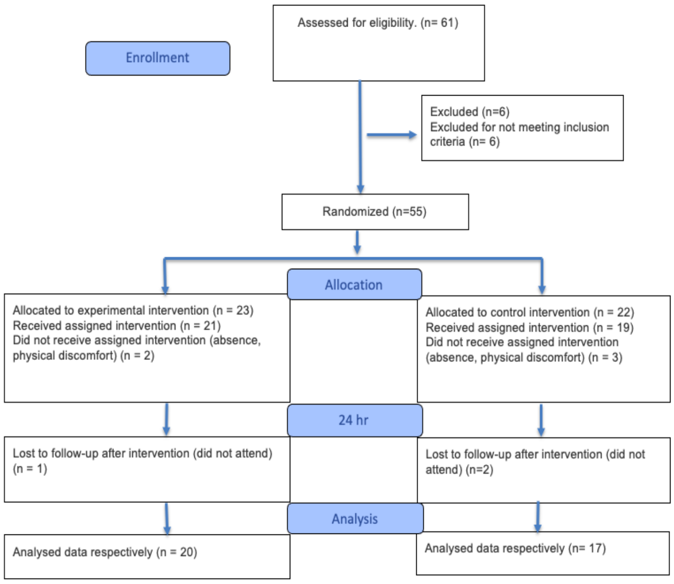
A randomized experimental design with a control group was employed. Randomization was conducted using a computer-generated sequence (Randomizer.org) with permuted blocks of four to ensure balanced allocation. The sequence was prepared by an external researcher, and allocation concealment was maintained using opaque, sealed, and sequentially numbered envelopes opened only at the time of assignment. *Statistical power was calculated independently for each dependent variable using G*Power 3.1. The a priori analysis, based on a mixed ANOVA design (2 groups × 2 time points), an expected medium effect size (f = 0.25), α = 0.05, and power (1–β) = 0.80, determined the required sample sizes as follows: pain perception (n = 34), mechanical power (n = 32), RSI (n = 36), and mean propulsive velocity (n = 30). The final sample (n = 37) exceeded the minimum required for all four variables, ensuring adequate statistical power across all Models.

Participants

A total of 61 participants were initially recruited; however, a 39% attrition rate was recorded, primarily due to unavailability across the different phases of the study (Figure 1). The final sample comprised 37 athletes (20 in the experimental group and 17 in the control group), slightly exceeding the minimum number estimated by the power analysis and thereby ensuring sufficient sensitivity to detect changes in the four independent variables. This sample size is consistent with previous experimental studies (Kargarfard et al., 2016; Shin & Sung, 2015; Wiewelhove et al., 2018).

Participants (mean age = 21.89 years; range = 18–29 years) were randomly assigned in accordance with the ethical standards for human experimentation established in Article 7 of Resolution 8430 (1993). Two groups were formed: the control group (CG; n = 17; mean age = 21.94, SD = 2.97) and the experimental group (EG; n = 20; mean age = 21.85, SD = 2.58) (Figure 1).

Figure 1. Flow diagram showing participant recruitment, random allocation "CONSORT", and analysis.



Procedure

The study was conducted in three phases: participant recruitment, baseline assessment, and experimental intervention.

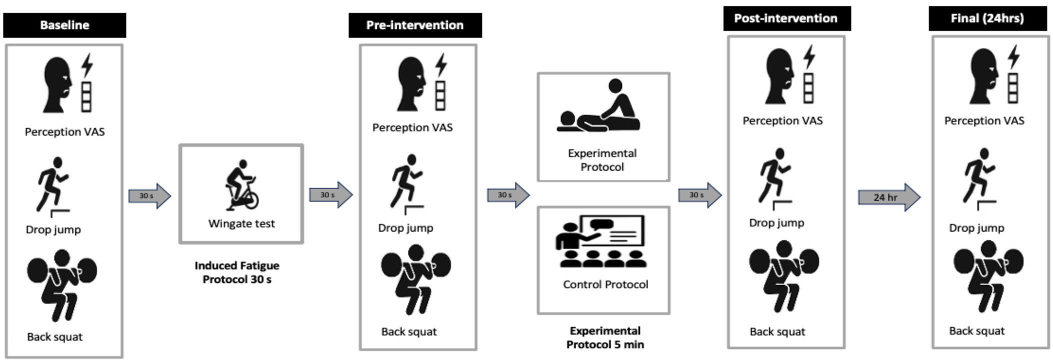
Participant recruitment

Two weeks before the intervention, participants were informed of the study objectives, provided written informed consent, and underwent physical screening along with a sociodemographic and sport-related questionnaire. Inclusion criteria required participants to be healthy, to comply with the study recommendations (no exercise or caffeine 24 hours before or after testing), and to complete all phases of the protocol.

Baseline Assessment

Participants attended the laboratory after 24 hours of rest. They completed a standardized 10-minute dynamic warm-up consisting of mobility exercises, skipping, heel kicks, and triple-step drills. Subsequently, the following variables were assessed: (a) perceived pain; (b) mechanical power during a Drop Jump; (c) Reactive Strength Index (RSI); and (d) mean propulsive velocity (MPV) during the back squat (Figure 2).

Figure 2. Flow of events for the participants in this study.



Instruments

PAR-Q & You

The Physical Activity Readiness Questionnaire (PAR-Q & You) consists of seven items designed to screen for potential health risks prior to beginning an exercise program, targeting individuals aged 15 to 69 years (Warburton et al., 2011). In this study, it was administered before physical testing. Participants who responded "yes" to one or more questions were excluded.

Visual Analogue Scale (VAS)

Perceived pain was assessed using the Visual Analogue Scale (VAS, 0–10), which measures pain intensity on a 100-mm line. The left anchor represents "no pain" (0), and the right anchor represents "worst possible pain" (10) (Huskisson, 1974). This tool has been widely used in studies examining the effects of massage on muscle recovery (Courtois & Duchesne, 2024; Fuller et al., 2015; Kargarfard et al., 2015).

Drop Jump Performance

Mechanical power and the Reactive Strength Index (RSI) of the lower limbs were evaluated using the Drop Jump (DJ) test. Athletes performed three bipodal repetitions with 30 seconds of rest between attempts, and the best jump was recorded (Moya-Ortega, 2024). Data were collected using a Chronojump platform and Bosco System software (v1.6.2) (Pueo et al., 2020). The protocol consisted of stepping off a 40 cm box, keeping the hands on the hips to avoid arm swing, performing a rapid hip and knee flexion, and immediately jumping upward. RSI was calculated as flight time divided by ground contact time (Balsalobre-Fernández et al., 2015).

Back Squat Performance

Mean propulsive velocity (MPV) in the back squat was assessed using a standardized 60 kg load for three repetitions (Pérez-Castilla et al., 2019). Participants began from an upright position with the barbell on the shoulders, descended in a controlled manner to 90° of knee flexion, and then returned to the initial position as rapidly as possible. The mean value from the three repetitions was recorded using a linear encoder (Vitruve, Madrid, Spain), which has been validated for measuring velocity under moderate to high load conditions (García-Ramos et al., 2018).

Induced Fatigue Protocol

The Wingate test was performed on a Monark 828E cycle ergometer for 30 seconds, with a resistance load of 0.075 Kp/kg (Bar-Or, 1987). Cyclist position and saddle height were adjusted to trochanteric height (Welbergen & Clijsen, 1990). Following the test, participants completed one minute of light pedaling, after which baseline, measurements were repeated.

Experimental Protocol

The experimental group received a 5-minute massage applied to the thighs (2.5 minutes per thigh) using Swedish massage techniques (effleurage, friction, and petrissage) (Andersen et al., 2013; Kargarfard et al., 2016; Wiewelhove et al., 2018), combined with venous drainage techniques (Ferrándiz, 1995, 2008). The intervention was administered by three trained massage therapists using Biocorp oil. Duration was standardized using a timed projection. The same variables—pain, mechanical power, reactive strength, and movement velocity—were reassessed immediately after the intervention and again 24 hours later.

Control Protocol

The control group did not receive any form of manual intervention. Participants remained seated for 7 minutes, a duration equivalent to the total time of the experimental massage. During this period, a therapist explained basic concepts about the physiological effects of massage, without any physical contact and without stimuli that could induce tactile placebo effects. This design allowed us to control for the influence of passive time and informational content without generating biomechanical or neuromuscular changes. This duration was equivalent to that of the experimental intervention (Weerapong et al., 2005).

Ethical Principles

Data collection was carried out in 2024 as part of a longitudinal project. Participants were informed of the minimal risk associated with the study, classified as "Category B—minimal risk" under Article 11 of Resolution 8430 (1993), and were briefed on risk mitigation strategies. The project was approved by the Ethics Committee of the Politecnico Colombiano Jaime Isaza Cadavid (Minutes No. 14, October 19, 2023; Code: 202301006894).

Data Analyses

The experiment underwent the following statistical procedures. First, an exploratory data analysis was performed in accordance with technical recommendations (Hair et al., 2014) to identify missing or extreme values using visual inspection (box plots) and/or interquartile range (Q3–Q1). In certain cases, the Winsorizing method was applied to adjust extreme physical measurement values.

Descriptive statistics (M = mean; SD = standard deviation) and 95% confidence intervals for the mean (CI = 95%) were estimated for both the control and experimental groups.

Each outcome was analyzed separately to estimate and control the effect of each physical condition. The assumptions of normality (Shapiro–Wilk, for $n < 50$) and sphericity (Mauchly) were tested across the four models. The effects of the post-competition massage intervention were compared using a mixed factorial ANOVA. The dependent variables were analyzed separately due to their distinct analytical characteristics: perceived pain, mechanical power, reactive strength, and mean propulsive velocity. Four factorial models were specified:

- Model 1: 1 × 2 × 2 = perceived pain × two time points (pre-test, post-test) × two groups (experimental, control).
- Model 2: 1 × 2 × 2 = mechanical power × two time points (pre-test, post-test) × two groups (experimental, control).
- Model 3: 2 × 2 × 2 = Reactive Strength Index × two components (flight time and contact time) × two time points (pre-test, post-test) × two groups (experimental, control).
- Model 4: 1 × 2 × 2 = mean propulsive velocity × two time points (pre-test, post-test) × two groups (experimental, control).

Sphericity in each model was corrected using the Greenhouse–Geisser adjustment. The significance of main effects and interactions was examined using Bonferroni-adjusted post hoc tests. Effect size was estimated using partial eta squared (η^2p). Repeated-measures analyses were conducted in R (R Core Team, 2020).

Results

Both groups exhibited the expected decline in pain over time, with slightly lower mean values in the experimental group (Table 1). In the experimental group, significant within-group changes were observed from baseline to pre-intervention (Mdiff = −3.63, 95% CI [−5.07, −1.13], p = .001, d = −2.14) and from pre-intervention to 24 hours (Mdiff = 2.70, 95% CI [1.26, 4.14], p = .001, d = 1.59), whereas the remaining comparisons were non-significant (p > .05).

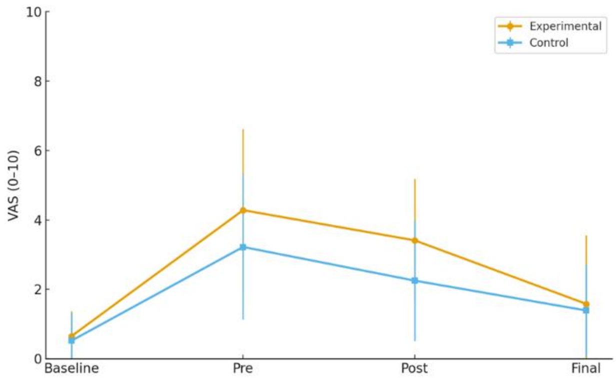
Table 1. Descriptive statistics of the experimental and control groups over time for pain perception.

Time	Group	M	SD	SE
Baseline	Experimental	0.65	0.72	0.16
	Control	0.52	0.79	0.19
Pre-intervention	Experimental	4.28	2.34	0.52
	Control	3.22	2.09	0.51
Post-intervention	Experimental	3.41	1.77	0.39
	Control	2.25	1.74	0.42
Final (24hrs)	Experimental	1.58	1.97	0.44
	Control	1.39	1.32	0.32

Note. M = Mean; SD = Standard Deviation; SE = Standard Error

In the control group, significant differences were detected from baseline to pre-intervention (Mdiff = −2.69, 95% CI [−4.26, −2.19], p = .001, d = −1.59) and from pre-intervention to 24 hours (Mdiff = −0.87, 95% CI [−2.44, 0.70], p = .001, d = 1.07), with no other meaningful changes (p > .05). Between-group post hoc comparisons revealed no significant differences at post-intervention (Mdiff = 1.16, 95% CI [−0.63, 2.95], p > .05) or at 24 hours (Mdiff = 0.19, 95% CI [−1.61, 1.98], p > .05).

Figure 3. Intergroup and intragroup comparison of the massage stimulus over time for pain perception.



Note. PRE = Pre-Intervention; POST = Post-Intervention; FINAL = 24 hr post

Mechanical power:

Table 2. Descriptive statistics of the experimental and control groups over time for jump power in the Drop Jump test.

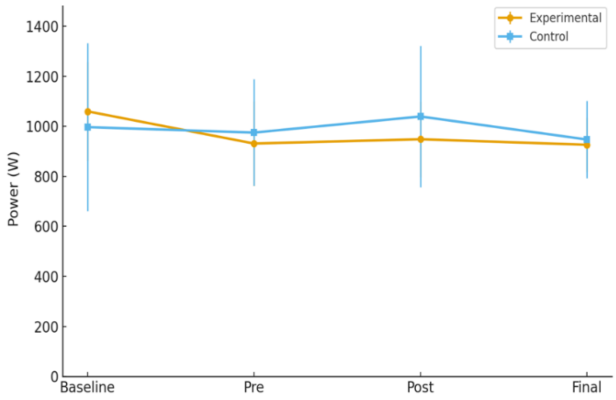
Time	Group	M	SD	SE
Baseline	Experimental	1059.71	197.18	47.82
	Control	996.75	335.28	74.97
Pre-intervention	Experimental	931.06	168.83	40.95
	Control	974.80	213.05	47.64
Post-intervention	Experimental	948.24	150.19	36.43
	Control	1039.20	281.94	63.04
Final (24hrs)	Experimental	926.06	107.78	26.14
	Control	947.10	155.08	34.68

Note. M = Mean, SD = Standard Deviation, SE = Standard Erro

Both groups demonstrated an overall reduction in mechanical power over time, with mean differences slightly favoring the experimental group. For the experimental group, within-group Bonferroni contrasts revealed no significant differences between any time points (all p > .05). Similarly, no significant differences were found in the control group across time points.

Between-group post hoc comparisons indicated no significant differences between the experimental and control groups either immediately after the intervention (Mdiff = 90.96, 95% CI [−166.97, 348.90], p > .05) or at 24 hours (Mdiff = 21.04, 95% CI [−130.13, 172.22], p > .05) (Figure 4).

Figure 4. Intergroup and intragroup comparison of the massage stimulus over time for jump power in the Drop Jump test.



Note. PRE = Pre-Intervention; POST = Post-Intervention; FINAL = 24 hr post

Reactive strength index (RSI):

Table 3. Descriptive statistics of the experimental and control groups over time for the reactive strength index (RSI) in the Drop Jump test.

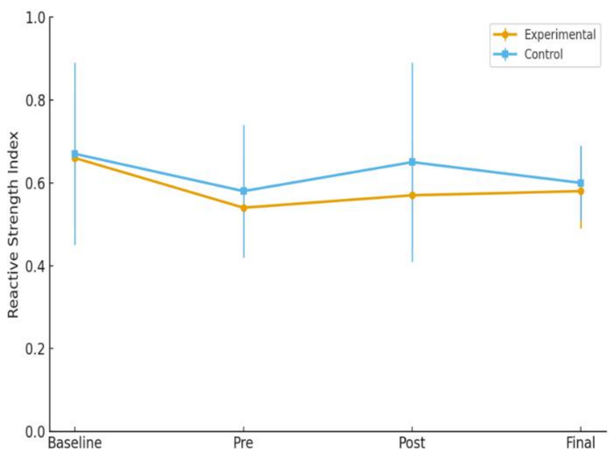
Time	Group	M	SD	SE
Baseline	Experimental	0.66	0.16	0.04
	Control	0.67	0.22	0.05
Pre-intervention	Experimental	0.54	0.12	0.03
	Control	0.58	0.16	0.04
Post-intervention	Experimental	0.57	0.13	0.03
	Control	0.65	0.24	0.05
Final (24hrs)	Experimental	0.58	0.09	0.02
	Control	0.60	0.09	0.02

Note. M = Mean, SD = Standard Deviation, SE = Standard Error

Both groups showed the expected RSI pattern, with an initial decline followed by partial recovery, and mean values slightly favoring the control group (Table 3). In the experimental group, all within-group comparisons were non-significant (all $p > .05$), with wide confidence intervals indicating substantial variability.

Similarly, the control group showed no significant changes across any time points (all $p > .05$). Between-group comparisons revealed no significant differences at post-intervention (Mdiff = 90.96, 95% CI [−166.97, 348.90], $p > .05$) or at 24 hours (Mdiff = 21.04, 95% CI [−130.13, 172.22], $p > .05$) (Figure 5).

Figure 5. Interaction between group and time on the Reactive Strength Index (RSI).



Note. PRE = Pre-Intervention; POST = Post-Intervention; FINAL = 24 hr post

Mean propulsive velocity:

Table 4. Descriptive statistics by time and group for mean propulsive velocity.

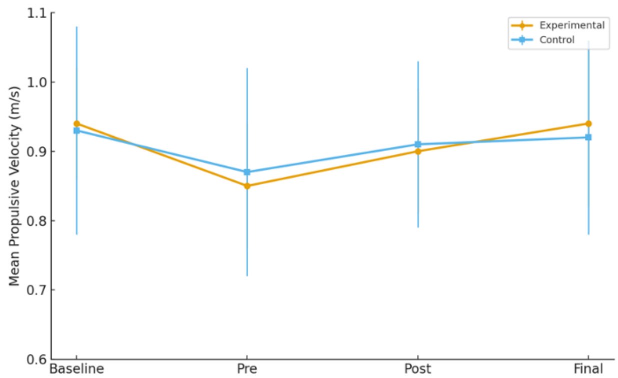
Time	Group	M	SD	SE
Baseline	Experimental	0.94	0.08	0.02
	Control	0.93	0.15	0.03
Pre-intervention	Experimental	0.85	0.09	0.02
	Control	0.87	0.15	0.03
Post-intervention	Experimental	0.90	0.09	0.02
	Control	0.91	0.12	0.03
Final (24hrs)	Experimental	0.94	0.12	0.03
	Control	0.92	0.14	0.03

Note. M = Mean, SD = Standard Deviation, SE = Standard Error

With respect to mean propulsive velocity, the comparison in the experimental group between baseline and pre-intervention (Mdiff = 0.06, 95% CI [−0.09, 0.11], $p > .01$) was not significant. In contrast, in the control group the comparison between baseline and pre-intervention (Mdiff = 0.09, 95% CI [0.04, 0.14], $p < .001$) was significant.

For the experimental group, the comparison between pre-intervention and 24-hour measurements (Mdiff = −0.05, 95% CI [−0.10, −0.14], $p > .05$) was not significant. Similarly, in the control group the comparison between pre-intervention and post-intervention (Mdiff = −0.06, 95% CI [−0.11, −0.44], $p > .05$) was not significant; however, the contrast between pre-intervention and 24 hours (Mdiff = −0.06, 95% CI [−0.14, −0.04], $p < .001$) was significant (Figure 6).

Figure 6. Interaction between group and time on mean propulsive velocity.



Note. PRE = Pre-Intervention; POST = Post-Intervention; FINAL = 24 hr post

Overall, these results indicate that although both groups exhibited natural recovery tendencies in pain and performance measures, the massage intervention did not elicit statistically significant differences compared with the control condition. Nonetheless, a slight trend toward reduced pain and improved recovery was noted in the experimental group after 24 hours.

Discussion

The purpose of this study was to evaluate the effect of massage therapy on (a) pain perception; (b) mechanical power and the Reactive Strength Index (RSI) in jumping performance; and (c) mean propulsive velocity (MPV) during the back squat in trained athletes, both immediately and 24 hours after the intervention. The findings showed that both the control group (educational session) and the experimental group (massage intervention) experienced significant increases in pain perception following the fatigue protocol ($p < .05$). This confirms that the fatigue procedure effectively induced an inflammatory response associated with pain and muscle fatigue, which are known to impair performance and which are common targets of recovery strategies such as massage.

Effects of Massage on Subjective Pain Perception

The analysis of acute pain perception revealed no significant between-group differences between massage (EG) and rest/education (CG). These findings are consistent with White et al. (2020), who observed significant increases in perceived pain after intense physical exertion in both conditions. Although no statistically significant differences were detected between groups, previous studies have reported that massage may exert an acute analgesic effect (Andersen et al., 2013; Bender et al., 2019; Han et al., 2014; Hoffman et al., 2016; Weerapong et al., 2005).

The immediate pain-relieving effect of massage has been attributed to several neuroendocrine mechanisms: (i) gate control theory, in which tactile stimulation activates fast-conducting A-beta fibers that inhibit nociceptive transmission carried by slower C fibers (Melzack & Wall, 1965); (ii) increased release of β-endorphins, which act as endogenous analgesics (Kaada & Torsteinbø, 1989); (iii) modulation of parasympathetic activity through mechanoreceptor stimulation that enhances vagal tone (Diego et al., 2007; Field, 2014; Weerapong et al., 2016); and (iv) reductions in cortisol, which may improve subjective well-being and perceived pain control (Field, 2014).

At 24 hours post-intervention, neither massage nor rest produced a statistically significant analgesic effect, aligning with reports that massage does not always yield measurable pain reductions within 24 hours (Hart et al., 2005; White et al., 2020). Meta-analytic evidence suggests that the analgesic effects of massage tend to be greater after 48–72 hours (Guo et al., 2017). Other authors have also reported delayed pain reductions approximately 48 hours after massage (Bender et al., 2019; Holub & Smith, 2017; Kargarfard et al., 2016; Wiewelhove et al., 2018).

The small but favorable trend for the experimental group after 24 hours in this study may be related to the mechanical action of massage, which can enhance blood and lymphatic circulation (Zainuddin et al., 2005) and facilitate the clearance of inflammatory mediators such as creatine kinase (Dupuy et al., 2018; Kargarfard et al., 2016). This mechanism may support muscle recovery and reduce muscle soreness, as well as inflammatory cytokines such as TNF-α and IL-8 (White et al., 2020). Additionally, massage may influence psychological factors (Dakić et al., 2023; Zainuddin et al., 2005), which could further modulate pain perception.

Effects of Massage on Mechanical Power During Jumping

The present study observed a non-significant trend toward improved mechanical power following the massage intervention, with the experimental group showing a partial recovery from the initial decline detected between baseline and pre-intervention assessments. This response is consistent with earlier findings reporting small yet favorable short-term effects of massage on neuromuscular performance (Espí-López et al., 2020; Kargarfard et al., 2016). Such improvements are often attributed to enhanced muscle compliance, increased local circulation, and reductions in perceived discomfort, all of which may transiently optimize force production.

Despite these tendencies, no significant between-group differences were identified, supporting the conclusions of recent meta-analyses that report trivial pooled effects of massage on jump-related outcomes (Davis et al., 2020). This apparent discrepancy between individual trends and aggregated evidence suggests that the influence of massage on explosive performance is highly variable and may depend on individual responsiveness, the pre-existing level of fatigue, and the specific timing of the intervention relative to testing.

Effects of Massage on Reactive Strength Index (RSI)

Reactive strength reflects the ability to utilise the stretch–shortening cycle (Komi, 2000). In this study, the experimental group showed the expected decline–increase pattern in RSI; however, these variations were not statistically significant (all $p > .05$). This limited response aligns with Koźlenia and Domaradzki (2022), who also reported non-significant RSI changes ($p = .27$, $ES = 0.02$), suggesting that massage may have minimal acute influence on stretch–shortening cycle function. Although Klich et al. (2024) observed significant CMJ improvements, their protocol differed substantially, indicating that massage-related effects may be highly protocol-dependent.

Dakić et al. (2023) reported that massage rarely induces immediate neuromuscular benefits—except for flexibility—and that improvements typically appear 48 hours after intense exercise. In contrast, no significant group differences were observed in the present study at post-intervention or 24 hours, suggesting that massage may not meaningfully affect reactive strength under the conditions tested.

Effects of Massage on Mean Propulsive Velocity in the Back Squat

A reduction in movement velocity during resistance exercise is considered one of the most reliable indicators of acute neuromuscular fatigue (Li et al., 2024; Moya-Ortega et al., 2025; Pareja-Blanco et al., 2020; Rodríguez-Rosell et al., 2021). In the current study, the experimental group demonstrated a reduction in MPV from baseline to pre-intervention, followed by a subsequent increase after massage. Although no significant between-group differences were detected, this trend supports the hypothesis that massage may promote acute neuromuscular recovery.

These findings are consistent with Davis et al. (2020), who reported no conclusive evidence that manual massage enhances strength outcomes, but align with García-Sillero et al. (2021), who found that percussion-based massage devices delayed fatigue and improved movement velocity in upper-body resistance training.

From an applied perspective, manual massage may help athletes sustain training volume and intensity by maintaining MPV, which could favor hypertrophic adaptations (Schoenfeld et al., 2019). Considering the increasing integration of resistance training in soccer, defining optimal application protocols and clarifying the underlying physiological mechanisms of massage remain priorities for sports science.

Study Limitations

This study presents several limitations. The small sample size especially when divided by time and group likely reduced statistical power and may explain the marginal effects observed. Additionally, the study was not blinded for the investigators, introducing potential observational bias. The exclusive use of self-reported pain measures and the absence of physiological biomarkers (e.g., creatine kinase, IL-6) limited the ability to confirm the proposed mechanisms. The massage intervention also targeted only the quadriceps, which may have been insufficient to produce broader performance or recovery effects. Future research should incorporate larger samples, greater experimental control, and more comprehensive outcome measures.

Finally, although the fatigue-induction protocol was standardized, it may not have been sensitive enough to detect subtle variations in neuromuscular fatigue among trained athletes. Future studies should incorporate more demanding or sport-specific fatigue protocols, including repeated eccentric actions, to better differentiate recovery responses in soccer players.

Based on these considerations, future work should combine subjective and objective indicators of muscle recovery, optimize massage duration and intensity, and extend treatment to multiple lower-limb muscle groups involved in soccer performance.

Conclusions

This study indicates that immediate post-fatigue massage does not produce meaningful short-term improvements in neuromuscular performance, as no significant changes were found in jump power or movement velocity within a 24-hour window. However, the trend toward reduced perceived pain in the massage group suggests a potential benefit for subjective recovery, even in the absence of objective performance enhancements.

Overall, the findings highlight the need to extend recovery monitoring beyond 24 hours, as previous research suggests that massage-related benefits may emerge after 48–72 hours. Future research should employ larger samples, standardized massage protocols, and biochemical or physiological markers to clarify the mechanisms through which massage might influence recovery and performance in athletes.

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