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THE EFFECT OF PHYSICAL EXERCISE ON RECOVERY TIME FROM DELAYED ONSET MUSCLE SORENESS: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT. ***Background****:* Delayed onset muscle soreness (DOMS) is a common response to unaccustomed or strenuous activity, characterized by pain, stiffness, and reduced mobility for several days. Light exercise is often recommended as an active recovery strategy; however, evidence for its efficacy remains inconclusive. This study examined whether a structured program of light exercise accelerates recovery from DOMS compared with inactivity. ***Methods****:* In a parallel-group randomized controlled experiment, 28 healthy adults (18–30 years) underwent DOMS induction via a standardized squat protocol (four sets to local fatigue, then 30 additional repetitions; 90-s rests). Participants were randomized to an Exercise group (daily light exercises targeting major lower-limb muscle groups) or Control (no exercise). Functional recovery was assessed with seated hip flexion (knees extended). All sessions were video-recorded and analyzed in Kinovea with calibration to foot length (neutral position). Raw fingertip-to-toe distances were converted to coded mobility units (1 unit = 10° hip flexion; negative = regression, positive = improvement). Assessments were conducted each morning for five consecutive days; post-recovery missing values were coded as 0 (baseline). The primary outcome was days to recovery (absence of soreness with baseline mobility). The secondary outcome was the daily coded mobility trajectory. Analyses used independent-samples t-tests (primary) and mixed ANOVA (Day × Group) for secondary outcomes ($\alpha = .05$; Greenhouse–Geisser corrections where appropriate). ***Results****:* Daily mobility improved over time in both groups. The mixed ANOVA showed a non-significant trend for Day ($F[5,130] = 2.06$, $p = .074$; Greenhouse–Geisser $p = .124$) and no Day × Group interaction ($F[5,130] = 0.48$, $p = .789$); the between-subjects Group effect was non-significant ($p = .710$). Independent t-tests at each day found no between-group differences (all $p > .05$). The between-group comparison of days to recovery showed no significant difference.

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***Conclusion**:* A structured program of light exercise did not significantly accelerate recovery from DOMS compared with rest. Although mobility improved steadily across days, exercise conferred no measurable advantage. Larger trials with standardized interventions and multimodal outcomes are warranted.

Keywords: delayed onset muscle soreness (DOMS), active recovery, light exercise, randomized controlled trial, muscle recovery

INTRODUCTION

Delayed onset muscle soreness (DOMS) is a well-established phenomenon that typically develops 24 to 72 hours following unaccustomed or strenuous physical activity (Cheung et al., 2003). It is characterized by muscle stiffness, tenderness, reduced range of motion, and performance decrements, often interfering with both athletic performance and activities of daily living (Clarkson & Hubal, 2002; Byrne et al., 2004). The pathophysiology of DOMS is not fully understood, but it is widely associated with eccentric muscle contractions that induce microtrauma and subsequent inflammatory responses (Proske & Morgan, 2001; Armstrong, 1990).

Numerous interventions have been explored to alleviate DOMS and accelerate recovery, ranging from stretching, massage, cryotherapy, and nutritional supplementation to more active strategies such as light exercise or "active recovery" (Herbert & de Noronha, 2007; Torres et al., 2012; Dupuy et al., 2018). Light exercise is thought to increase blood flow, promote metabolite clearance, and maintain neuromuscular activation, potentially reducing discomfort and restoring mobility more quickly (Connolly et al., 2003; Howatson & van Someren, 2008). However, evidence for the efficacy of active recovery remains mixed. While some studies report attenuated soreness and improved performance following light activity (Zainuddin et al., 2006; Vaile et al., 2008), others have failed to detect meaningful benefits compared to passive rest (Jakeman et al., 2009; Isabell et al., 1992).

Given these inconsistencies, further controlled investigations are warranted to clarify whether exercise performed during DOMS genuinely accelerates recovery or simply modifies symptom perception. In particular, functional measures such as mobility may provide a practical and clinically relevant assessment of recovery, complementing subjective pain ratings.

The present randomized controlled trial aimed to test the hypothesis that engaging in physical exercise during DOMS would reduce recovery time compared with inactivity. Specifically, we examined whether participants performing light daily exercise recovered mobility faster than those assigned to a control group, using standardized hip flexion as a functional proxy for symptom resolution.

MATERIALS AND METHODS

Study Design

This investigation employed a parallel-group, randomized controlled experimental design, aimed at evaluating the effect of physical exercise on recovery from delayed onset muscle soreness (DOMS). Randomized controlled trials (RCTs) are widely regarded as the gold standard for testing causal hypotheses in clinical and sports science research, as they minimize selection bias and allow for balanced comparison between intervention and control conditions (Schulz et al., 2010; Higgins et al., 2019).

The study followed participants over a period of five consecutive days after the experimental induction of DOMS, comparing an exercise group with a no-exercise control group. The design was chosen to allow repeated assessment of mobility within subjects while maintaining between-group comparisons, thus integrating both longitudinal and interventional components. This approach has been recommended in previous exercise science studies investigating recovery dynamics, as it enables a more nuanced understanding of changes across time (Twist & Eston, 2009; Vaile et al., 2008).

All procedures conformed to the Declaration of Helsinki. Written informed consent was provided by all participants prior to enrollment.

Participants

A total of 28 healthy volunteers (age range 18–30 years; mixed gender) were recruited through university announcements and word of mouth. Participants were recreationally active but not engaged in structured resistance training in the month preceding the study, to ensure susceptibility to delayed onset muscle soreness (DOMS). Similar recruitment strategies have been employed in previous experimental studies of DOMS induction and recovery (Byrne, Eston, & Edwards, 2001; Zainuddin et al., 2005).

Inclusion criteria

- Self-reported good health with no contraindications to exercise,
- Absence of musculoskeletal injuries in the past 6 months,
- No current use of medications affecting muscle function or recovery (e.g., anti-inflammatories, corticosteroids),
- Successful induction of DOMS in the quadriceps following the standardized exercise protocol, confirmed by reduced hip flexion mobility and localized soreness on palpation.

Exclusion criteria

- History of chronic pain conditions or neuromuscular disorders,
- Previous participation in similar DOMS protocols in the last 3 months,
- Failure to develop DOMS symptoms after the induction session.

All participants provided written informed consent prior to enrollment, in accordance with ethical standards for human research (World Medical Association, 2013). The study was approved by the institutional ethics review board.

Randomization and Groups

Participants were randomly allocated to one of two groups using a computer-generated random sequence:

- **Exercise group (n = 14):** participants performed daily light physical activity during the recovery period.
- **Control group (n = 14):** participants refrained from exercise and underwent only daily mobility assessments.

Randomization procedures are recommended in experimental designs to minimize allocation bias and ensure baseline comparability between groups (Schulz et al., 2010; Higgins et al., 2019). Due to the nature of the intervention, blinding of participants was not feasible; however, assessments were standardized, and instructions were identical across groups to minimize measurement bias.

The chosen sample size (N = 28) was based on feasibility and comparability with prior experimental studies on DOMS recovery interventions, which typically include small-to-moderate cohorts ranging from 20 to 40 participants (Vaile et al., 2008; Jakeman et al 2009). While no a priori power calculation was conducted, the sample size was deemed adequate for exploratory analysis, with results interpreted cautiously considering this limitation.

Procedures

Induction of Delayed Onset Muscle Soreness (DOMS)

DOMS was experimentally induced through a standardized squat protocol designed to overload the quadriceps musculature eccentrically, consistent with methods used in previous studies (Proske & Morgan, 2001; Chen et al., 2007). Each participant completed four sets of bodyweight squats to the point of local muscular failure, defined as the onset of a strong burning sensation in the thighs. From this threshold, participants were instructed to perform an additional 30 repetitions, ensuring sufficient muscular stress to elicit soreness. Between sets,

participants rested for 90 seconds. This protocol reliably induced DOMS in the quadriceps and occasionally the hamstrings, resulting in reduced functional capacity of both the hip and knee.

Recovery Exercise Protocol (Exercise Group)

Participants randomized to the exercise group performed a structured daily program of light physical exercises during the recovery period, targeting major lower-limb muscle groups commonly affected by DOMS. The protocol consisted of:

1. Half-range squats (30 repetitions), primarily activating the quadriceps musculature.
2. Mini-bridges from supine position with knees flexed and feet grounded (30 repetitions), emphasizing hamstrings and gluteal activation.
3. Standing calf raises (50 repetitions), engaging the gastrocnemius–soleus complex.

This exercise protocol was selected because it provided low-intensity, closed-chain movements shown to promote circulation and neuromuscular activation without imposing excessive mechanical strain (Tufano et al 2017; Vaile et al 2008). The control group refrained from physical exercise during recovery but completed the same daily functional assessments as the exercise group.

Functional Mobility Assessment

To evaluate the functional impact of DOMS and track recovery, seated hip flexion with extended knees was selected as the reference movement. In this standardized test, participants sat on the floor with knees fully extended and attempted to bend forward to reach or surpass their toes. Hip flexion was chosen because hamstrings, glutes and also quadriceps soreness directly limits this action, making it a sensitive and practical functional indicator (Byrne et al., 2004).

Video Recording and Kinovea Calibration

All mobility tests were video-recorded and analyzed using Kinovea software (version 0.9.5), an open-source motion analysis program validated in sports biomechanics (Puig-Diví et al., 2019). To ensure consistent and accurate measurements, a calibration procedure was performed for each recording:

- A reference scale of 100 calibration points was placed along the longitudinal axis of the foot, with the foot kept in a neutral position (toes pointing vertically).
- Using this calibrated scale, the distance between the participant's fingertips and the tip of the foot was extracted as the mobility outcome.

- This calibration method eliminated potential errors due to perspective or anthropometric variability, ensuring comparability across participants.

Coding of Mobility Values

To facilitate standardized analysis across participants, raw values were converted into coded scores in 10° increments. A score of 0 represented baseline mobility, positive values reflected improvements beyond baseline, and negative values indicated regression. For example:

- 12.43 cm = 0 (baseline),
- 17.71 cm = –1 (regression),
- 29.95 cm = –3 (greater regression),
- 3.30 cm = +1 (improvement).

This approach provided an ordinal scale suitable for tracking mobility changes over time, while simplifying inter-individual comparisons (similar scoring approaches have been used in other DOMS and recovery studies; Connolly et al., 2003).

Daily Follow-Up

A baseline test was conducted prior to the induction protocol. Following the squat protocol, participants repeated the mobility test every morning for five consecutive days, with each session recorded and analyzed as described above. DOMS typically appeared within 24–48 hours and resolved fully by Day 5 in all participants, consistent with established timelines reported in the literature (Cheung et al., 2003; Howatson & van Someren, 2008).

Handling of Missing Data

As DOMS duration varied (2–5 days across individuals), participants who recovered earlier did not exhibit mobility restrictions on subsequent days. To allow repeated-measures analysis, all missing post-recovery values were coded as 0 (baseline mobility), representing full functional restoration. This approach ensured equal observation points per participant while conservatively estimating recovery trajectories.

Measures

Primary Outcome

The primary outcome of the study was the number of days until DOMS resolution, operationally defined as the disappearance of muscle soreness and the restoration of baseline hip flexion mobility. This functional endpoint was chosen because it reflects both the subjective recovery from discomfort and the objective return of mobility, which are critical for athletes and physically active individuals (Cheung et al., 2003; Byrne, Twist, & Eston, 2004).

Secondary Outcomes

Secondary outcomes included **daily hip flexion mobility scores**, coded according to the procedure described above. These values allowed the trajectory of recovery to be analyzed day by day, rather than relying solely on the endpoint of full symptom resolution. Such longitudinal tracking provides greater sensitivity to subtle changes in mobility and is consistent with best practices in monitoring exercise-induced muscle damage (Howatson & van Someren, 2008; Twist & Eston, 2009).

The dual approach—endpoint analysis (time to recovery) and repeated-measures analysis (daily coded mobility)—enabled the study to address both clinical relevance and detailed recovery dynamics.

Statistical Analysis

Data were analyzed in SPSS 27. Descriptive statistics were computed for each group. Between-group differences in recovery time were tested with an independent-samples t-test. To assess changes in mobility across days and groups, a mixed ANOVA was conducted with Day (five levels) as a within-subject factor and Group (exercise vs. control) as a between-subject factor. Mauchly's test of sphericity was used to verify the assumption of sphericity, and when violated, Greenhouse–Geisser corrections were applied (Girden, 1992). Statistical significance was set at $p < .05$, as recommended in exercise physiology research (Atkinson & Nevill, 1998).

RESULTS

Primary Outcome: Days to Recovery

The mean number of days until DOMS resolution was 31.89 (SD = 15.12) in the exercise group and 30.66 (SD = 19.69) in the control group. An independent-samples t-test revealed no significant difference between groups, $t(26) = 0.19$, $p = .855$, 95% CI [−12.41, 14.87]. These results suggest that engaging in light physical exercise did not significantly accelerate recovery compared with inactivity.

Secondary Outcomes: Daily Mobility Trajectories

A mixed-design ANOVA with Day (1–5) as the within-subjects factor and Group (exercise vs. control) as the between-subjects factor indicated:

- A main effect of Day, $F(5,130) = 2.06$, $p = .074$, $\eta^2p = .073$, which did not reach statistical significance after Greenhouse-Geisser correction ($p = .124$).
- No significant Day × Group interaction, $F(5,130) = 0.48$, $p = .789$, $\eta^2p = .018$.
- No significant main effect of Group, $F(1,26) = 0.14$, $p = .710$, $\eta^2p = .005$.

These results indicate that mobility improved progressively across days in both groups, but the pattern of recovery did not differ significantly between exercise and control participants.

Exploratory Independent-Samples t-Tests by Day

Independent-samples t-tests were conducted for each day of follow-up (Days 1–5). Results showed no significant differences between groups at any time point:

- **Day 1:** *t(26) = 0.75, p = .463, 95% CI [−2.01, 4.30]*
- ***Day 2:*** *t(19.72) = 0.63, p = .536, 95% CI [−1.49, 2.77]*
- ***Day 3:*** *t(26) = −0.26, p = .795, 95% CI [−2.52, 1.95]*
- ***Day 4:*** *t(26) = −0.54, p = .596, 95% CI [−1.72, 1.01]*
- ***Day 5:*** *t(*26) = 0.22, *p* = .824, 95% CI [−1.23, 1.52]

All confidence intervals included zero, and effect sizes were negligible (Cohen's $d < 0.30$).

Summary

Taken together, both the primary endpoint and secondary analyses indicated that light exercise performed during the recovery period from DOMS did not significantly influence the time course of recovery or daily mobility outcomes compared with inactivity.

DISCUSSION

The present randomized controlled trial investigated whether engaging in light physical exercise during delayed onset muscle soreness (DOMS) would accelerate recovery compared with inactivity. Contrary to the initial hypothesis, both the primary endpoint (days to recovery) and secondary analyses (daily mobility trajectories) revealed no significant group differences. Participants in both exercise and control groups experienced progressive improvement in mobility, with soreness subsiding by Day 5, consistent with the well-established natural time course of DOMS (Cheung et al., 2003; Howatson & van Someren, 2008).

Interpretation of Findings

Our findings align with studies that have reported no significant advantage of active recovery over passive rest in alleviating DOMS (Isabell et al., 1992; Jakeman et al 2009). Although light exercise has been hypothesized to increase blood flow and facilitate metabolite clearance, the lack of observed differences suggests that these mechanisms may not be sufficient to alter the underlying inflammatory and structural processes driving DOMS (Proske & Morgan, 2001; Armstrong, 1990). It is possible that while exercise may temporarily modulate soreness perception, it does not meaningfully influence the overall duration of recovery, as indicated by our results.

Conversely, other investigations have reported benefits of active recovery strategies, including reduced soreness and improved performance (Zainuddin et al., 2006; Vaile et al., 2008). Differences between those studies and the present trial may be attributable to variations in exercise modality, intensity, and timing of interventions, as well as the use of different outcome measures (e.g., pain ratings vs. functional mobility). Our use of a functional mobility test rather than subjective pain scales may have provided a more objective assessment but may also capture different aspects of recovery.

Strengths and Limitations

A key strength of this study is the use of video analysis with Kinovea software, calibrated to foot length, which allowed precise and reproducible measurement of hip flexion mobility. In addition, the coding system reduced anthropometric variability and enabled standardized comparisons across participants.

However, several limitations should be acknowledged. First, the sample size was modest (N = 28), which may have limited statistical power to detect small effects. Second, the intervention consisted of unspecific light exercise rather than a carefully standardized recovery protocol, potentially reducing sensitivity. Third, the study focused exclusively on functional mobility, without incorporating subjective pain ratings or biochemical markers of muscle damage, which may have provided a more comprehensive picture of recovery. Finally, the relatively young and healthy participant group limits the generalizability of findings to other populations such as elite athletes or older adults.

Practical Implications

From a practical perspective, the findings suggest that light physical exercise during DOMS neither accelerates nor delays recovery when compared with rest. This indicates that athletes and recreational exercisers may safely choose either strategy depending on personal preference, comfort, and training schedules, without concern for significantly prolonging recovery.

Future Directions

Future studies should aim to replicate these findings with larger sample sizes, more standardized active recovery protocols (e.g., low-intensity cycling or resistance exercise), and multimodal outcome measures, including both subjective soreness ratings and objective performance indicators. Additionally, integrating biomarkers of inflammation and muscle damage could help clarify the physiological mechanisms underpinning recovery dynamics.

CONCLUSIONS

This randomized controlled trial investigated whether light physical exercise could accelerate recovery from delayed onset muscle soreness (DOMS) compared with inactivity. The results demonstrated no significant differences between groups in either recovery time or daily mobility trajectories. Both exercise and control participants experienced progressive improvement, with full resolution of DOMS by Day 5.

These findings suggest that light exercise during DOMS neither accelerates nor impairs recovery relative to rest. While the study employed objective functional measures and standardized assessments, limitations related to sample size and intervention specificity warrant cautious interpretation. Future research with larger cohorts, multimodal outcome measures, and carefully standardized exercise interventions is recommended to further clarify the role of active recovery in managing DOMS.

AUTHOR CONTRIBUTIONS

The author solely conceived and designed the study, developed the methodology, conducted data collection, performed the statistical analyses, interpreted the results, and wrote and revised the manuscript. The author has read and approved the final version of the manuscript and agrees to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this paper. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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