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# IMMEDIATE EFFECTS OF CALF MUSCLE FATIGUE AND RECOVERY ON BALANCE AND JUMP PERFORMANCE IN CONSTRUCTION WORKERS-AN EXPERIMENTAL STUDY

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## ABSTRACT

**Introduction:** Calf muscle fatigue is a common issue in physically demanding professions like construction work, where repetitive activities can lead to muscle exhaustion. This fatigue is thought to negatively affect balance and lower limb performance, increasing the risk of accidents and injuries. As these muscles become fatigued, their ability to maintain balance and generate power for tasks such as jumping or lifting can be significantly compromised. However, there is limited research focusing specifically on construction workers, a population that faces unique physical demands.

**Material and Methodology:** A total of 150 construction workers (ages 25–45). Fatigue was induced through repeated heel raises until voluntary exhaustion. Participants performed the single-leg stance test for balance assessment and the vertical jump test to measure jump height before and

after fatigue following treatment was given. Pre and post fatigue results were statistically analyzed to determine significant changes.

**Result:** Data were analyzed using Microsoft excel for statistical analysis. A paired t-test was conducted to compare pre- and post-fatigue results. Statistically significant decline in both balance (mean score reduced from 82.5 to 67.8) and jump height (39.2 cm to 35.1 cm), with $p < 0.001$. Following recovery intervention, both balance (77.2 sec) and jump height (37.6 cm) showed significant improvement ($p < 0.001$).

**Conclusion**: Immediate calf muscle fatigue negatively affects postural stability and jump performance, which improves with short recovery strategies.

**Keywords: Calf fatigue, balance, jump performance, construction workers, recovery intervention**

## INTRODUCTION

Construction work involves a range of strenuous physical tasks that demand constant balance, coordination, muscular strength, and power output. Routine activities such as climbing ladders, carrying heavy loads, manoeuvring across uneven surfaces, and jumping place substantial stress on the lower extremities especially the calf muscles. These muscles, mainly the gastrocnemius and soleus, are key contributors to plantarflexion and are critical for ensuring both stability and dynamic movement. They also facilitate explosive actions like jumping and contribute to maintaining balance during both stationary and mobile tasks **[1]**.

Muscle fatigue refers to a temporary reduction in the capacity of a muscle to produce force or power, typically resulting from intense or prolonged activity **[2]**. It involves a multifactorial physiological process, influenced by both peripheral factors such as metabolic by-product accumulation and central mechanisms like decreased motor drive or impaired neural signalling **[3]**. In occupational environments like construction, fatigue can develop rapidly due to repetitive motion, extended working hours, and inadequate recovery between tasks **[4]**. Fatigue in the calf muscles specifically can hinder neuromuscular performance, thereby diminish balance and lower the effectiveness of movements such as jumping skills that are essential for safety and performance in physically demanding work roles.

Maintaining postural stability is vital, particularly in jobs with elevated risks, such as those faced by construction workers. These workers often function at heights or navigate

unstable and unpredictable surfaces. Balance control depends on the integration of sensory input from visual, vestibular, and proprioceptive systems, along with timely and coordinated motor responses **[5]**. When muscles are fatigued, the ability to process proprioceptive input is impaired, joint control becomes less efficient, and motor coordination declines all of which negatively affect balance **[6]**. As the calf muscles play a central role in ankle stabilization, their fatigue may reduce joint proprioception, increase sway and elevate the likelihood of slips, trips, or falls **[7]**.

Jumping ability particularly vertical jump performance is another critical indicator of neuromuscular function and lower limb strength. While not a primary task in construction, a worker's ability to rapidly generate force and react to sudden loss of balance may be indirectly reflected in their jump performance. Fatigue hampers muscular force production, disrupts motor unit activation, and slows neural response times, collectively degrading jump efficiency **[8]**.

Numerous studies have explored how localized muscle fatigue impacts postural control. For instance, Paillard and colleagues demonstrated that fatigue of the plantar flexors significantly increased body sway, especially in situations where visual input was removed, highlighting the importance of ankle proprioception for balance **[9]**. Similarly, research by Yaggie and Campbell showed that fatigue in the ankle musculature impaired both static and dynamic balance tasks **[10]**. These findings carry important implications for construction workers, who frequently operate in environments where sensory input is limited and postural challenges are heightened.

The extent to which fatigue affects performance may also depend on how much recovery time is allowed. Recovery from muscle fatigue involves both biological and neuromuscular repair processes. While some recovery may be observed shortly after exercise ceases, full restoration of proprioceptive and neuromuscular functioning can take longer **[11]**. Strategies such as passive rest, light activity (active recovery), and neuromuscular exercises have been studied in athletes, but their effectiveness in work-based settings is still under-researched **[12]**.

Construction workers, due to their long hours and physically intense labour, often lack sufficient time for muscle recovery. Continuous exposure to fatigue without adequate rest can result in chronic musculoskeletal strain and elevate the risk of occupational injuries **[13]**. Notably, lower

limb musculoskeletal problems are prevalent in this population and are a significant contributor to time lost from work due to pain or disability **[14]**. Therefore, examining how acute calf muscle fatigue and short-term recovery affect balance and jump performance is not only relevant but necessary for occupational health and injury prevention.

Advances in biomechanical assessment tools and rehabilitation sciences have underscored the importance of evaluating function through task-specific tests. Devices like force plates, balance platforms, and jump mats are increasingly used to measure postural control and muscular performance before and after fatigue-inducing activities **[15]**. Such evaluations provide insight into how fatigue alters movement and can help inform the design of customized training or recovery interventions for high-risk workers.

Additionally, individual characteristics such as age, body composition, and previous injury history can influence how fatigue affects performance. Older workers, those with higher body mass indices, and individuals with past musculoskeletal injuries tend to show greater performance declines following fatigue **[16]**. Age-related physiological changes such as a shift in muscle Fiber composition, slower neural conduction, and diminished proprioceptive acuity can worsen fatigue effects and prolong recovery periods **[17]**.

Understanding the immediate impact of muscle fatigue, followed by short-term recovery assessment, is essential for identifying vulnerable periods during which workers may be more prone to accidents or suboptimal performance. Findings from such studies can inform ergonomic interventions, including job rotation schedules, optimized work-rest ratios, and pre-shift warm-up routines like calf stretches and balance exercises **[18]**. Neuromuscular and proprioceptive training programs, commonly used in sports to improve postural control, may also be effective in reducing injury risk among construction workers **[19]**.

Despite increasing awareness of these occupational risks, there is still a lack of focused research on how calf muscle fatigue and recovery impact essential functional outcomes such as balance and jumping in construction labourers. Most existing studies are concentrated on healthy young individuals or athletes, which limits the applicability of their results to older, physically stressed worker populations **[20]**.

**OBJECTIVES**

1. To evaluate the immediate effect of calf muscle fatigue on balance among construction workers.

2. To assess the impact of calf fatigue on vertical jump performance.
3. To evaluate the effectiveness of a short post-fatigue recovery protocol.
4. To highlight the need for fatigue monitoring strategies in high-risk occupational groups.

**METHODS**

**Study Design:** Experimental study

**Population:** 150 male and female construction workers aged 25–45

**Inclusion Criteria:**

- Construction workers aged between 25 and 45 years.
- Minimum of 1 year of continuous work experience in construction
- No reported history of lower limb musculoskeletal injuries in the past 6 months.
- Willingness to participate
- Actively employed construction workers
- Able to follow instructions
- No lower limb injury in the past 3 months

**Exclusion Criteria:**

- History of recent lower limb fractures, sprains, or surgeries (within the last 6 months)
- Diagnosed with neurological, vestibular, or balance disorders
- Current use of medications that may affect muscle performance or balance.
- Cardiorespiratory limitations

**Outcome Measures:**

- Single Leg Stance Test
- Vertical Jump Test

**Protocol:**

1. **Pre-Test Assessment:** Balance and jump baseline
2. **Fatigue Protocol:** Repeated double-leg heel raises at 30 reps/min until exhaustion
3. **Post-Fatigue Assessment:** Immediately after fatigue
4. **Recovery Intervention:**
   - Static calf stretches (3 × 30 sec)
   - Breathing control (3 minutes)
   - Hydration
5. **Post-Recovery Assessment**

**Data Analysis:** Paired t-tests for pre-post and post-recovery comparisons ($p < 0.05$)

**RESULTS**

**Balance Performance:**

**- Pre-Fatigue: 82.5 ± 5.3 sec**

**- Post-Fatigue:** 67.8 ± 6.1 sec

**- Post-Recovery:** 77.2 ± 5.6 sec

**T-Tests:**

**- Pre vs Post-Fatigue: t** = 15.63, $p < 0.001$ (significant decline)

**- Post-Fatigue vs Post-Recovery: t** = 12.41, $p < 0.001$ (significant improvement)

**Jump Height:**

**- Pre-Fatigue:** 39.2 ± 3.8 cm

**- Post-Fatigue:** 35.1 ± 3.5 cm

**- Post-Recovery:** 37.6 ± 3.6 cm

**T-Tests:**

**- Pre vs Post-Fatigue: t =** 11.27, $p < 0.001$ (significant decline)

**- Post-Fatigue vs Post-Recovery: t =** 9.86, $p < 0.001$ (significant improvement)

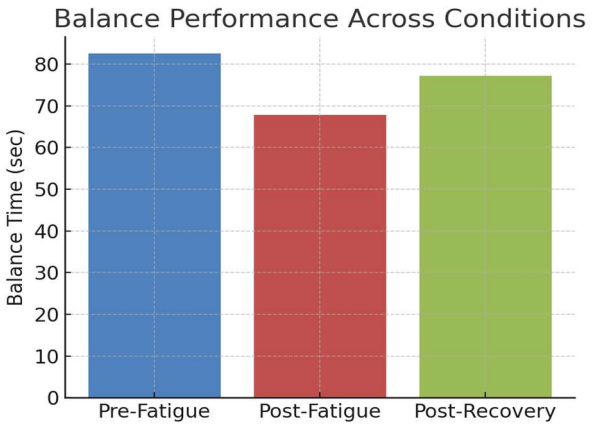


**Figure 1**

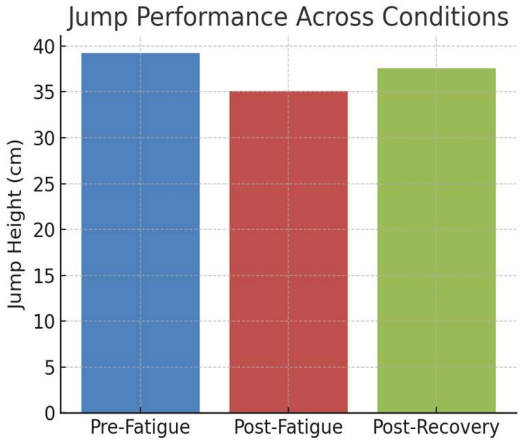


**Figure 2**

## DISCUSSION

The present study investigated the immediate effects of calf muscle fatigue and the efficacy of a short recovery protocol on balance and vertical jump performance among construction workers. The findings provide valuable insights into how lower limb fatigue can compromise functional performance and how brief, targeted interventions can aid recovery in occupational settings.

The results revealed a significant decline in balance performance following the fatigue protocol. The single-leg stance duration reduced from 82.5 ± 5.3 seconds pre-fatigue to 67.8 ± 6.1 seconds post-fatigue ($t = 15.63$, $p < 0.001$), indicating that fatigue of the calf muscles impairs postural control. This is consistent with existing literature, where plantar flexor fatigue has been shown to reduce proprioceptive sensitivity and impair neuromuscular coordination, especially at the ankle joint **[1]**. Since the calf muscles are crucial for stabilizing the body in upright positions, their fatigue may disrupt the sensorimotor feedback loop required to maintain balance, thereby increasing the risk of slips or falls in real-life tasks.

Importantly, balance performance improved to 77.2 ± 5.6 seconds following a short recovery protocol involving static stretching,

controlled breathing, and hydration ($t = 12.41$, $p < 0.001$). While the recovery did not completely restore balance to pre-fatigue levels, the improvement demonstrates that even brief interventions can enhance postural stability. These results are in line with studies showing that muscle recovery can be accelerated through passive modalities such as stretching and breathing exercises, which reduce muscle tightness and improve central nervous system relaxation **[2]**. In physically demanding professions like construction, incorporating short, structured breaks for recovery could mitigate the risk of fatigue-related incidents.

Vertical jump performance followed a similar trend. A significant reduction was noted from 39.2 ± 3.8 cm pre-fatigue to 35.1 ± 3.5 cm post-fatigue ($t = 11.27$, $p < 0.001$), suggesting impaired lower limb power output after repetitive heel raises. Fatigue likely contributed to reduced motor unit recruitment and decreased efficiency in force transmission, leading to diminished jump height. This is particularly relevant in occupational settings, where workers may need to respond quickly to environmental hazards or perform physically intense manoeuvre. Any decrement in power output could compromise their performance and safety.

Post-recovery, jump height improved significantly to 37.6 ± 3.6 cm ($t = 9.86$, $p < 0.001$), reflecting partial restoration of neuromuscular function. Although full recovery to baseline was not achieved, the increase reinforces the role of brief recovery strategies in functional restoration. Static stretching may have aided in resetting muscle length-tension relationships, while hydration and breathing helped in reducing physiological stress and improving circulation **[3]**.

Overall, the study highlights the functional vulnerabilities caused by calf muscle fatigue in construction workers and supports the implementation of simple, evidence-based recovery strategies. These findings underscore the need for workplace protocols that prioritize short rest intervals, warm-up routines, and fatigue monitoring systems to promote safety and productivity.

## CONCLUSION

Calf muscle fatigue significantly impairs balance and jumps performance in construction workers. A brief recovery intervention involving stretching, breathing, and hydration resulted in significant improvement. Such interventions are simple, time-efficient, and should be included in occupational safety protocols.

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