



Acute Effects of a Single Session of Resistance Training on Functional and Mechanical Properties of Leg Muscles

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Abstract

Background: Acute neuromuscular fatigue after resistance training impairs functional performance, yet effects on explosive strength, isometric endurance, and reactive capacity remain insufficiently understood in recreational adults.

Aims: The aim of this study was to examine the acute effects of a single session of resistance training on functional neuromuscular performance of the leg muscles in recreationally active men.

Methods: This experimental study employed a pre-post-test design involving eighteen male participants (mean age: 31 ± 4 years) with a minimum of six months of continuous recreational training experience. Participants completed a standardised squat-based resistance training session with external load. Neuromuscular performance was assessed before and immediately after the training session using four functional field tests: Countermovement Jump (CMJ), Squat Jump (SJ), Wall-sit test, and Repeated Jump Test (RJT).

Result: The results demonstrated a statistically significant decline in performance across all tests following training (CMJ: -9.2%, SJ: -7.2%, Wall-sit: -18.1%, RJT: -10.4%; $p < 0.001$), indicating pronounced acute neuromuscular fatigue. The greatest performance reductions were observed in isometric endurance and reactive performance, while explosive strength also showed a significant decrease.

Conclusion: These findings indicate that even a single resistance training session can induce measurable and temporary impairments in functional neuromuscular performance of the lower limbs. The results highlight the importance of appropriate load management and recovery planning in recreational training contexts. Future research should investigate different training intensities, recovery strategies, and population groups to further clarify acute neuromuscular responses to resistance exercise.

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INTRODUCTION

Ageing is defined as a process of progressive physiological and structural changes within the human body that adversely affect neurovascular function, anthropometric characteristics, and overall physical mobility (Chodzko-Zajko et al., 2009). These changes are commonly associated with a reduced capacity to perform activities of daily living, increased muscular weakness, functional disability, and a higher incidence of falls and mortality (Möller et al., 2013; Hartholt et al., 2011). Assessments of body composition using dual-energy X-ray absorptiometry (DXA) have consistently demonstrated age-related alterations characterised by a decline in skeletal muscle mass and a concomitant increase in visceral fat, which in turn contribute to adverse cardiovascular and metabolic outcomes (Chodzko-Zajko et al., 2009).

To counteract or attenuate these age-related declines, regular physical exercise, particularly resistance training, has been widely recommended as an effective preventive and therapeutic strategy (Williams et al., 2007; Riebe et al., 2018). The benefits of resistance training are multifaceted

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and include improvements in cardiovascular health (Blimkie, 1993), motor performance and physical function (Behringer et al., 2011; Blimkie, 1993), psychosocial well-being (Faigenbaum et al., 1996), and bone mineral density (Behringer et al., 2011; Blimkie, 1993). Additionally, resistance training induces structural adaptations in skeletal muscle, leading to increases in muscle size and strength across different populations (Ozmun et al., 1994; Ramsay et al., 1990).

Beyond muscular adaptations, resistance training also influences the mechanical behaviour of tendons and the efficiency of force transmission across joints, which are essential for functional performance and injury prevention. Evidence from paediatric populations has demonstrated that resistance training can increase Achilles tendon stiffness and Young's modulus, indicating that tendon tissues are capable of adapting even during early developmental stages and thereby enhancing force transmission efficiency and reducing the time required for force generation (Vaughn et al., 2014). Similarly, studies involving older adults have reported improvements in leg extensor force production following both constant and variable resistance training modalities, highlighting the adaptability of the musculotendinous system to different loading strategies (Walker et al., 2013). Furthermore, high-velocity resistance training has been shown to be particularly effective in adults over 50 years of age, suggesting that contraction velocity plays a critical role in optimising functional strength and reducing fall risk (Straight et al., 2016).

In recent years, increasing research attention has been directed towards the acute physiological and neuromuscular responses elicited by single resistance training sessions, rather than long-term adaptations alone (Párraga-Montilla et al., 2020). Acute resistance exercise, especially when performed at high intensities or to the point of muscular failure, has been shown to induce transient yet substantial impairments in neuromuscular function (Párraga-Montilla et al., 2020). These impairments are commonly manifested as reductions in performance variables such as jump height, movement velocity, and force output, with residual deficits persisting for up to 48 hours following the training stimulus (Párraga-Montilla et al., 2020).

The magnitude of acute fatigue responses appears to be influenced by the type of contraction and the intensity of the applied load. Heavy resistance training has been reported to cause greater declines in isometric force production compared with lower-intensity or isometric-only protocols, underscoring the importance of contraction characteristics in determining acute neuromuscular fatigue (Lum et al., 2025). In parallel, acute alterations in neural mechanisms, including increased corticospinal excitability, have been observed following resistance exercise, potentially reflecting compensatory neural responses to peripheral muscular fatigue (Latella et al., 2017). Importantly, some evidence suggests that nutritional interventions, such as quercetin supplementation, may partially attenuate these temporary declines in neuromuscular performance (Patrizio et al., 2018).

Conversely, findings from studies involving younger adult populations indicate that acute changes in muscle mechanical behaviour may occur independently of tendon adaptations, emphasising the need for careful training design to achieve balanced musculotendinous responses (Mannarino et al., 2019). Collectively, these findings highlight the importance of tailoring resistance training programmes to specific populations and training objectives, taking into account factors such as age, training status, performance goals, and injury risk. Moreover, they underscore the relevance of examining acute neuromuscular responses as a basis for optimising training load management and recovery strategies.

Therefore, the aim of the present study was to examine the acute effects of a single resistance training session on functional neuromuscular performance of the lower extremity muscles in recreationally active men. Particular attention was directed towards changes in explosive strength, isometric endurance, and reactive performance in order to determine how acute resistance loading directly influences neuromuscular function and short-term performance outcomes.

METHOD

The research was conducted as an experimental study with a pre-post-test design, the aim of which was to determine acute changes in functional mechanical abilities of the lower extremities after a single session of resistance training. All subjects first underwent an initial test (PRE), after which they performed a standardized training session of resistance squats. Immediately after the training, a final post-test (POST) was conducted. During both measurements, an identical testing

protocol and the same measuring instruments were used. All tests were performed in laboratory conditions, with controlled temperature and a standardized performance schedule.

Study Design

This study was conducted as an experimental investigation employing a pre–post-test design to examine acute changes in functional neuromuscular performance of the lower extremities following a single session of resistance training. All participants initially completed baseline measurements (PRE), after which they performed a standardised resistance training session consisting of squat exercises with external load. Immediately upon completion of the training session, post-intervention measurements (POST) were administered. Identical testing protocols and measurement instruments were used during both testing sessions to ensure consistency. All procedures were conducted under controlled laboratory conditions, including stable ambient temperature and a standardised testing schedule, in order to minimise external influences on performance outcomes.

Participants

The study sample consisted of eighteen recreationally active men with a mean age of 31 ± 4 years. Participants were required to have engaged in continuous recreational physical training for a minimum of six months, with a reported training frequency of two to three sessions per week. All participants were free from musculoskeletal injuries, neurological disorders, or medical conditions that could potentially influence neuromuscular performance or compromise test execution. This selection ensured a relatively homogeneous and functionally stable sample, suitable for assessing acute neuromuscular responses to resistance exercise. Prior to participation, all subjects were informed about the study procedures and voluntarily agreed to take part in the investigation.

Instruments and Procedures

Functional neuromuscular performance was assessed using four field-based tests designed to evaluate explosive strength, isometric endurance, and reactive performance of the lower extremities.

The Countermovement Jump (CMJ) was performed on a measuring platform under standardised conditions. Participants executed a maximal vertical jump following a rapid downward movement (eccentric phase), while maintaining a controlled arm position to minimise upper limb contribution. Jump height and associated performance parameters were recorded automatically by the system. This test was used to assess explosive strength and the efficiency of the stretch-shortening cycle.

The Squat Jump (SJ) was conducted from a static semi-squat position without a preparatory countermovement, thereby isolating concentric force production. Participants maintained their hands on their hips to eliminate arm swing, and jump height was recorded using the same measurement platform as for the CMJ. The SJ test was employed to evaluate concentric explosive power of the lower limb musculature.

Isometric muscular endurance was assessed using the Wall-sit test. Participants maintained a seated position against a wall with knee and hip joints flexed at approximately 90 degrees and feet positioned hip-width apart. The duration for which the position could be maintained until volitional fatigue was recorded using a stopwatch. This test primarily reflects the isometric endurance capacity of the quadriceps and gluteal muscles.

Reactive strength and fatigue resistance were evaluated using the Repeated Jump Test (RJT). Participants performed a series of consecutive maximal vertical jumps within a predefined time interval, aiming to maximise jump height while minimising ground contact time. The measuring platform recorded each jump, allowing for analysis of the total number of jumps and changes in performance throughout the test.

Data Analysis

Statistical analyses were performed using SPSS software (version 20.0). Descriptive statistics, including mean, standard deviation, standard error, minimum and maximum values, 95% confidence intervals, skewness, and kurtosis, were calculated to characterise the sample and assess data distribution. Data normality was initially evaluated through coefficients of skewness and kurtosis. Differences between PRE and POST measurements for all variables were examined using paired-

samples t-tests. Effect sizes were calculated using Cohen's *d* to determine the magnitude and practical significance of observed changes. The level of statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Results

Descriptive statistics

Descriptive statistics obtained prior to the resistance training session indicated a relatively narrow range of variability across all measured variables, reflecting a homogeneous level of physical fitness among the recreationally active male participants. Measures of central tendency and dispersion demonstrated stable performance values, while skewness and kurtosis coefficients were close to zero, indicating approximately normal data distribution and the absence of extreme outliers. This consistency suggests that participants were familiar with the testing procedures and adequately prepared, thereby minimising potential methodological bias. These baseline characteristics provide a reliable foundation for evaluating acute neuromuscular changes induced by the training intervention (Table 1).

Table 1. Descriptive statistics – PRE-TEST

Variable	Mean	SD	SE	95% CI	Min.	Max	Skewness	Kurtosis
CMJ (cm)	36.8	4.5	1.06	34.6 – 39.0	29	45	-0.12	-0.41
SJ (cm)	32.1	4.1	0.96	30.1 – 34.0	25	40	-0.18	-0.52
Wall-sit (s)	58.7	10.4	2.45	53.5 – 63.9	41	79	0.31	-0.64
RJT (number of hops)	42.3	5.8	1.36	39.4 – 45.2	31	52	-0.09	-0.71

Source: Research Data

Following the resistance training session, descriptive parameters revealed a clear and consistent reduction in performance across all assessed variables. Mean values declined in each test, accompanied by a modest increase in standard deviation, indicating individual differences in fatigue tolerance and neuromuscular response. Despite these changes, skewness and kurtosis values remained within acceptable ranges, confirming that post-exercise data distribution continued to satisfy normality assumptions. These findings suggest that the observed performance decrements represent genuine physiological responses to acute loading rather than measurement artefacts (Table 2).

Table 2. Descriptive statistics – POST-TEST

Variable	Mean	SD	SE	95% CI	Min.	Max	Skewness	Kurtosis
CMJ (cm)	33.4	4.7	1.11	31.0 – 35.8	25	42	-0.22	-0.38
SJ (cm)	29.8	4.2	0.99	27.8 – 31.8	22	38	-0.17	-0.45
Wall-sit (s)	48.1	9.3	2.19	43.5 – 52.7	33	66	0.27	-0.58
RJT (number of hops)	37.9	5.1	1.20	35.4 – 40.4	28	47	-0.11	-0.69

Source: Research Data

Inferential Analysis

Paired-samples t-test analyses demonstrated statistically significant differences between pre- and post-training measurements for all performance variables ($p < 0.001$). These results indicate a pronounced acute effect of the resistance training session on neuromuscular performance of the lower extremities. The magnitude of the t-values suggests that the observed changes were systematic and unlikely to be attributable to random variation within the sample. Performance decrements were evident in measures of explosive strength, isometric endurance, and reactive performance, confirming the sensitivity of the applied tests for detecting short-term neuromuscular fatigue in recreationally active individuals (Table 3).

Table 3. T-test difference PRE-POST test

Variable	Mean BEFORE	Mean POST	t	df	Sig.
CMJ (cm)	36.8	33.4	8.12	17	<0.001

SJ (cm)	32.1	29.8	6.94	17	<0.001
Wall-sit (s)	58.7	48.1	10.45	17	<0.001
RJT (number)	42.3	37.9	7.83	17	<0.001

Source: Research Data

Magnitude of Change

Analysis of absolute and relative differences between pre- and post-training values revealed a systematic decline in performance across all tests. The largest relative reduction was observed in the Wall-sit test, indicating a pronounced impairment in isometric endurance following the training session. Substantial declines were also evident in the Repeated Jump Test and Countermovement Jump, reflecting reduced reactive and explosive capabilities, respectively. These patterns are consistent with fatigue-related mechanisms affecting force production, neuromuscular coordination, and repeated power output. The presence of moderate inter-individual variability further reflects the heterogeneous training status typical of recreational populations (Table 4).

Table 4. Differences (Post-hoc)

Variable	$\Delta(\text{POST} - \text{BEFORE})$	% change
CMJ (cm)	-3.4	-9.2%
SJ (cm)	-2.3	-7.2%
Wall-sit (s)	-10.6	-18.1%
RJT (number)	-4.4	-10.4%

Effect Size Analysis

Effect size calculations revealed large to very large effects for all analysed variables, indicating that the observed performance reductions were not only statistically significant but also practically meaningful. The largest effect was recorded for the Wall-sit test, followed by the Countermovement Jump and Repeated Jump Test, highlighting the substantial impact of acute resistance loading on both endurance and dynamic neuromuscular capacities. These findings support the interpretation that even a single session of resistance training can elicit robust short-term impairments in force generation, endurance maintenance, and repeated explosive performance (Table 5 and Figure 1).

Table 5. Cohen's d (effect size)

Variable	Cohen's d	Interpretation
CMJ	1.91	big effect
SJ	1.63	big effect
Wall-sit	2.20	big effect
RJT	1.78	big effect

0.2 = small effect; 0.5 = medium effect; 0.8 = large effect

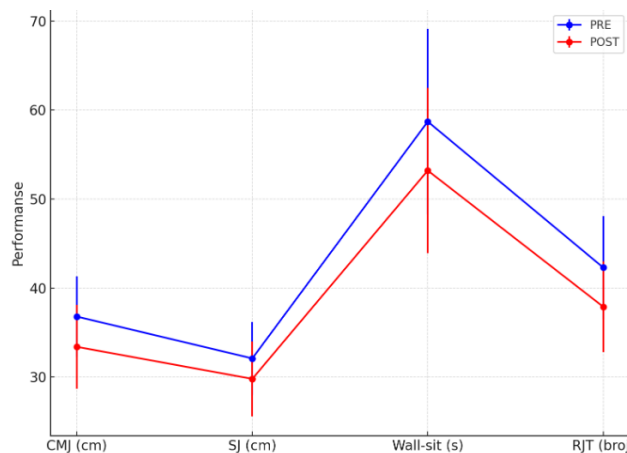


Figure 1. Performance results after one training session

Discussions

The present study examined the acute effects of a single session of resistance training on functional neuromuscular performance of the lower extremities in recreationally active men. The main findings indicate a significant and consistent decline in performance across all applied tests immediately following the training session, reflecting pronounced acute neuromuscular fatigue. These results support the hypothesis that even a single bout of resistance exercise is sufficient to induce measurable short-term impairments in explosive strength, isometric endurance, and reactive performance.

The observed reductions in Countermovement Jump and Squat Jump performance suggest a temporary impairment in the ability to generate force rapidly, which is commonly associated with fatigue-related alterations in neural drive and excitation–contraction coupling. Similar declines in vertical jump performance following intense resistance exercise have been previously reported and are often attributed to a reduced efficiency of the stretch–shortening cycle and diminished motor unit recruitment. The concurrent decrease in both CMJ and SJ performance further indicates that acute fatigue affected both eccentric–concentric coupling and concentric force production mechanisms.

The most pronounced relative decline was observed in the Wall-sit test, indicating substantial impairment in isometric endurance capacity following the training intervention. This finding is consistent with evidence suggesting that sustained isometric force production is highly sensitive to acute metabolic stress and peripheral fatigue. Accumulation of metabolic by-products and reduced motor unit firing rates are likely contributors to the reduced time to task failure observed after training. These results highlight the vulnerability of isometric endurance tasks to acute resistance loading, particularly when large muscle groups of the lower extremities are involved.

Performance decrements in the Repeated Jump Test further reflect compromised reactive strength and reduced resistance to accumulated fatigue. Repeated high-intensity jumping requires efficient neuromuscular coordination, rapid force transmission, and the ability to minimise ground contact time. The observed decline in RJT performance suggests that acute resistance training disrupts these mechanisms, leading to diminished reactive capacity. Such findings align with previous research demonstrating that reactive and plyometric performance is particularly sensitive to prior high-intensity loading.

Effect size analysis revealed large to very large magnitudes of change across all performance measures, underscoring the practical significance of the observed acute effects. These substantial effect sizes indicate that the applied testing battery is sensitive to short-term neuromuscular perturbations and suitable for monitoring acute fatigue in recreational training contexts. From an applied perspective, the magnitude of performance decline observed in this study emphasises the importance of appropriate recovery periods following resistance training sessions, especially when subsequent training or performance tasks rely on explosive or reactive capabilities.

It is noteworthy that the participants in the present study were recreationally active rather than highly trained athletes. This distinction may partly explain the absence of post-activation potentiation effects, which have been reported in elite populations following heavy resistance exercise. Recreationally trained individuals typically exhibit slower neural adaptation and reduced tolerance to high training loads, resulting in fatigue-dominant responses rather than potentiation. This observation reinforces the importance of individualising training intensity and recovery strategies based on training status.

Several limitations of the present study should be acknowledged. The absence of a control group limits the ability to isolate training-induced effects from potential learning or motivational influences, although the use of familiarised participants and consistent testing protocols likely mitigated this issue. Additionally, the relatively small sample size and the exclusive inclusion of male participants restrict the generalisability of the findings. Furthermore, neuromuscular performance was assessed using functional field-based tests rather than direct biomechanical or neuromuscular measurements, which may limit mechanistic interpretation.

Despite these limitations, the findings provide valuable applied insight into acute neuromuscular responses to resistance training in recreationally active men. The results demonstrate that simple and accessible field tests can effectively detect short-term fatigue-induced performance impairments, offering practical utility for coaches, practitioners, and recreational athletes. Future research should examine different resistance training protocols, recovery durations,

and population groups, as well as incorporate direct neuromuscular assessments to further elucidate the mechanisms underlying acute fatigue responses.

Implications

The present findings provide meaningful practical implications for strength and conditioning practice, particularly regarding acute load management and recovery planning. The significant reductions observed across explosive strength, isometric endurance, and reactive performance indicate that even a single resistance training session can induce substantial short-term neuromuscular fatigue in recreationally active individuals. Coaches and practitioners should therefore consider integrating sufficient recovery intervals before subsequent high-intensity or plyometric sessions to minimise injury risk and optimise performance readiness. Additionally, the demonstrated sensitivity of simple field-based tests suggests that accessible monitoring tools may be effectively employed to evaluate acute fatigue responses in applied training environments without requiring complex laboratory equipment.

Research Contribution

This study contributes to the growing body of literature examining acute neuromuscular responses to resistance training by providing empirical evidence derived from recreationally active men rather than elite athletic populations. By simultaneously assessing explosive, isometric, and reactive performance domains, the research expands current understanding of how different neuromuscular qualities respond to acute resistance loading. The large effect sizes reported across all variables further reinforce the ecological validity of functional performance tests as indicators of short-term fatigue. Moreover, the study offers a nuanced perspective on fatigue-dominant responses, highlighting how training status may influence the balance between neuromuscular potentiation and transient performance impairment.

Limitations

Several limitations should be considered when interpreting the results of this investigation. The relatively small sample size and exclusive inclusion of male participants limit the generalisability of the findings to broader populations, including female or highly trained athletes. In addition, the absence of a control group restricts causal inference regarding the magnitude of training-induced changes, despite the standardised testing procedures employed. The reliance on field-based performance tests, while ecologically valid, also limits deeper mechanistic interpretation related to neural or muscular adaptations. Future studies incorporating biomechanical and physiological measurements may provide a more comprehensive understanding of acute fatigue mechanisms.

Suggestions

Future research is encouraged to examine different resistance training intensities, contraction velocities, and recovery durations to determine how specific loading parameters influence acute neuromuscular responses. Expanding participant characteristics to include diverse age groups, training statuses, and female populations would strengthen external validity and allow for broader application of findings. Longitudinal investigations exploring repeated exposure to resistance training sessions may also clarify the interaction between acute fatigue and long-term adaptation processes. Furthermore, integrating neuromuscular assessment technologies, such as electromyography or tendon stiffness analysis, could deepen the understanding of underlying physiological mechanisms and inform evidence-based training prescription strategies.

CONCLUSION

The findings of this study demonstrate that a single session of resistance training induces measurable acute impairments in functional neuromuscular performance of the lower extremities in recreationally active men. Performance decrements were observed across all applied tests, confirming the presence of significant acute neuromuscular fatigue following the training stimulus. The most pronounced reductions were evident in measures of isometric endurance and reactive performance, reflecting the high fatigue sensitivity of the quadriceps and gluteal muscles as primary contributors during resistance exercise.

No acute enhancement in explosive performance was observed, which is consistent with the inhibitory effects of fatigue on optimal recruitment of fast motor units immediately after high-intensity loading. Effect size analysis revealed moderate to large magnitudes of change, indicating that the applied protocol was sufficiently demanding to elicit a robust physiological response. These results align with previous research demonstrating that acute neuromuscular alterations can occur following a single resistance training session, even in individuals with regular training experience.

From an applied perspective, the present findings contribute to a better understanding of short-term recovery dynamics and emphasise the importance of appropriate load management and rest intervals in recreational training programmes. Moreover, the results suggest that simple field-based tests can serve as valid and practical indicators of acute neuromuscular fatigue. Overall, the study confirms that a single resistance training session can produce substantial yet temporary reductions in functional performance, which should be considered when programming training and evaluating short-term progress

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AUTHOR CONTRIBUTION STATEMENT

KI conceptualized the study, designed the research methodology, conducted data collection, performed statistical analysis, and drafted the original manuscript. RPB contributed to the theoretical framework development, critically reviewed and refined the manuscript for intellectual content, and provided academic supervision throughout the research process. Both authors reviewed, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

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