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

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ABSTRACT

The aim of this study was to determine the acute effects of a single session of resistance training on the functional and mechanical properties of leg muscles in recreationally active men. Eighteen subjects, with a mean age of 31 ± 4 years, with at least six months of continuous recreational activity and a frequency of 2–3 physical activities per week, participated in the study. All subjects performed a standardized squat session with external load, while four tests were used to assess neuromuscular performance: Countermovement Jump (CMJ), Squat Jump (SJ), Wall-sit test and Repeated Jump Test (RJT). The results showed a statistically significant decrease in performance in all tests after training (CMJ: -9.2%, SJ: -7.2%, Wall-sit: -18.1%, RJT: -10.4%; $p < 0.001$), indicating pronounced acute neuromuscular fatigue. The largest decreases were registered in isometric and reactive strength tests, while the decrease in explosive strength was also significant. The data obtained confirm that even a single session of resistance training can induce measurable, temporary changes in functional capacity of leg muscles, emphasizing the importance of adequate rest and training intensity planning. Future research could examine different training protocols, populations of different age groups, and recovery strategies to further investigate acute neuromuscular responses and optimize training planning in recreational and competitive athletes.

Keywords: Motor Skills, Fatigue, Explosive Power, Endurance, Training Effects.

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1. Introduction

The process of physiological and structural changes occurring in the human body system, which impair neurovascular and anthropometric parameters as well as physical mobility itself, is defined as aging (Chodzko-Zajko et al., 2009).

Reduced ability to perform daily life activities, weakness, disability, as well as an increase in the percentage of falls and mortality are just some of the accompanying factors (Möller et al., 2013; Hartholt et al., 2011).

With the body composition assessment device "dual-energy X-ray", changes in body composition can be observed in the form of loss of muscle mass, an increase in visceral fat in particular, and therefore, through a cause-and-effect reaction, changes in cardiovascular and metabolic processes (Chodzko-Zajko et al., 2009).

For the prevention and treatment of age-related effects and slowing down the process, the method of exercise and resistance training is recommended (Williams et al., 2007; Riebe et al., 2018).

The positive effects are reflected in the improvement of cardiovascular parameters (Blimkie, 1993), motor performance (Behringer et al., 2011; Blimkie, 1993), psychosocial health (Faigenbaum et al., 1996), bone density (Behringer et al., 2011; Blimkie, 1993) as well as changes in muscle structure and size (Ozmun et al., 1994; Ramsay et al., 1990).

Strength training not only improves muscle strength and volume, but also directly affects the mechanical properties of tendons and the ability to transmit force through joints, which is crucial for functional performance and injury prevention. The increase in Achilles tendon stiffness and Young's modulus in prepubertal children (Waugh et al., 2014) indicates that tendons can adapt even in the early stages of development, allowing for more efficient force transmission and a reduction in the time required for force generation. In older adults, improvements in leg extensor force production through constant and variable training (Walker et al., 2014) highlight the ability of the musculotendinous system to respond to different loading modalities, while the superiority of high-velocity training in adults over 50 years of age (Straight et al., 2016) suggests that a specific focus on contraction velocity may further optimize functional strength and reduce the risk of falls. A growing body of research is also focusing on the acute responses of the body to individual strength training sessions, particularly the neuromuscular changes that occur immediately after loading (Párraga-Montilla et al., 2020).

Studies indicate that intense training, especially those performed to the point of muscle failure, can lead to temporary but significant disruptions in neuromuscular function (Párraga-Montilla et al., 2020).

It has been found that after just one session of this type of training, there is a pronounced decline in performance such as jump height and movement speed, with part of the deficit remaining for up to 48 hours after the activity (Párraga-Montilla et al., 2020).

Heavy strength training also causes a stronger decline in isometric force compared to milder isometric protocols, indicating that the type of contraction and intensity have a significant impact on the level of acute fatigue (Lum & Howatson, 2025). In addition, changes in neural mechanisms — such as increased corticospinal excitability — are also registered, which probably represent compensation for the decline in function at the muscle level (Latella et al., 2017).

However, research shows that certain nutritional interventions, such as quercetin supplementation, can alleviate these temporary declines in performance (Patrizio et al., 2018).

On the other hand, results in younger men (Mannarino et al., 2019) show that changes in muscle properties can occur independently of tendon adaptations, which emphasizes the need for careful training planning to achieve balanced adaptations of the musculotendinous system. Together, these findings suggest the importance of tailoring resistance training to specific populations and age groups, taking into account goals such as strength gains, functional performance, and injury risk reduction, as well as the potential role of specific training modalities in optimizing neuromuscular and tendon function. The aim of this study was to examine the acute effects of a single resistance training session on functional and mechanical properties of lower extremity muscles in recreationally active men. Particular attention was paid to changes in explosive strength, isometric endurance, and muscle reactivity; in order to determine how intense resistance training directly affects neuromuscular function and performance.to determine how intense the load directly affects neuromuscular function and performance.to determine how intense the load directly affects neuromuscular function and performance.

2. 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.

- ***Participants***

The study involved 18 recreationally active men, with an average age of 31 ± 4 years. The subjects had a continuous recreational training of at least 6 months, with a frequency of 2–3 physical activities per week. All were free of current injuries or medical conditions that could affect the performance of the tests, which ensures a homogeneous and functionally stable population suitable for monitoring acute changes after exercise.

- ***Instruments***

CMJ – Countermovement Jump- (The test was performed on a measuring platform with standardized arm position and execution technique. The subject performed a vertical jump after a rapid forward bend (eccentric phase), and the device recorded the jump height and other mechanical parameters. This test is used to assess explosive strength and the efficiency of the stretch-shortening cycle).

SJ – Squat Jump- (It was performed from a semi-squat starting position without a prior swing, thus isolating the ability to generate force exclusively from the concentric phase. The arms were controlled to exclude their influence, and the jump height was recorded using the same measurement system as in the CMJ. The test allows for the assessment of pure explosive power of the lower extremities).

Wall-sit test– (Isometric endurance test where the subject held a sitting position against a wall at a 90° angle, with feet hip-width apart. Time to failure was recorded with a stopwatch. This test assesses the capacity of the quadriceps and gluteal muscles to maintain isometric contraction under fatigue).

RJT – Repeated Jump Test– (The subject performed a series of continuous vertical jumps of maximum intensity in a predefined time interval. The measuring platform registered each jump, allowing analysis of the total number of jumps and changes in performance during the test. RJT is used to assess reactive power and resistance to accumulated fatigue).

- ***Data Analysis***

1. SPSS 20 software was used for statistical data processing.
2. Descriptive statistics (Mean, SD, SE, Min, Max, 95% CI, skewness, kurtosis) to determine the basic characteristics of the sample.

3. Test of normality of data distribution using coefficients of asymmetry and flattening.
4. Paired t-test to determine differences between PRE and POST measurements in all variables.
5. Cohen's d to calculate effect size and assess the practical significance of differences.
6. The level of statistical significance was set at Sig. 0.05.

3. Results

Descriptive results obtained before the training show the expected range of variability within the recreationally active male population, with a relatively narrow dispersion of values and stable coefficients of deviation. The data distribution shows a slightly negative or almost symmetrical asymmetry, which indicates a homogeneous physical fitness of the subjects and the absence of extreme values that would violate the normality of the sample. High consistency in measurements suggests that the subjects were adequately prepared and familiar with the testing protocol, which reduces the likelihood of methodological deviations. This profile of descriptive parameters provides a stable basis for assessing the acute effects of resistance training on neuromuscular characteristics.

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

Descriptive parameters after training show a clear and consistent decline in performance in all tested variables, which is consistent with the expected physiological response to acute lower limb loading. The range and direction of changes indicate the presence of neuromuscular fatigue, with a noticeable increase in standard deviation compared to initial measurements, suggesting individual differences in tolerance and speed of fatigue. The asymmetry and flattening of the distribution remain within acceptable normality, confirming that the changes are the result of a real physiological response, and not measurement

artifacts. These findings confirm the validity of the tests used in detecting acute changes in functional mechanical properties of muscles.

Table 2. Descriptive statistics – pos-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

The results of the t-test show statistically significant differences between pre- and post-testing in all analyzed variables, which points to a pronounced acute effect of one training session with load. High t-values and low p-values confirm that the changes are systematic and consistent and are not likely to arise from random deviations within the sample. Such results clearly indicate that the training protocol causes immediate neuromuscular perturbations, especially in capacities related to explosive strength and isometric endurance. This confirms the sensitivity of the tests used to detect short-term performance changes in recreationally active men.

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

The post-hoc differences presented indicate a systematic decline in performance after the training, with percentage changes consistent with physiological mechanisms of fatigue. The most pronounced declines were recorded in tests requiring a high level of neuromuscular coordination and rapid force generation, reflecting the sensitivity of these parameters to short-term disturbances in muscle function. At the same time, the results also indicate a certain degree of individual variability, which is characteristic of a recreational population of heterogeneous training status. Overall, such differences confirm the effectiveness of the protocol in inducing acute fatigue and provide clear insight into the direction and magnitude of the changes.

Table 4. Differences (post-hoc)

Variable	Δ(POST – 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%

The effect sizes indicate pronounced and high values in all tests, suggesting that resistance training caused a strong acute effect on the analyzed motor abilities. Cohen's d values in the range of large to very large effect confirm not only the statistical, but also the practical significance of the observed differences, which further supports the interpretation of a robust effect of the protocol on neuromuscular function. Such findings are particularly important in the context of research on acute adaptations, as they indicate that the tests used are sensitive and adequate for detecting short-term changes in performance. In practical terms, such effects confirm that even a single session of intensive training can significantly impair the ability to generate force, maintain endurance and repeat explosive movements.

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

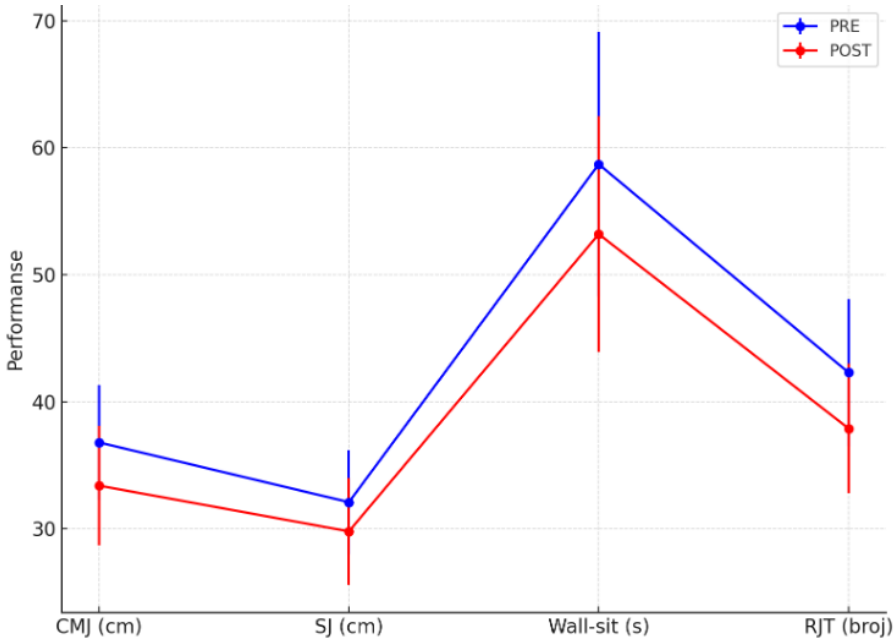

Chart .1 performance results after one training session

4. DISCUSSIONS

The results of this study show a consistent and statistically significant decrease in performance in all tests after a single session of resistance training, which clearly indicates a pronounced acute neuromuscular fatigue. The decrease in jump height in CMJ and SJ is consistent with previous findings confirming that high-intensity lower limb training reduces the ability to generate force rapidly immediately after loading (Cormie et al., 2011). Accordingly, it is likely that the efficiency of the muscle-tendon cycle is also compromised, which affects both the explosive and reactive abilities of athletes.

Reduced endurance in the wall-sit test further confirms the presence of peripheral fatigue, probably associated with reduced motor unit activation and accumulation of metabolic products, a phenomenon previously described in the literature (Enoka & Duchateau, 2016). The decline in performance in the repeated jump test also indicates impaired neuromuscular coordination and a reduced ability to maintain the efficiency of the stretch-shortening cycle, which is consistent with the findings of Nicol et al. (2006), who showed that reactive power is significantly reduced after eccentric and high-intensity loading.

It is important to note that in some studies, high-intensity exercise can induce short-term post-activation potentiation (PAP), but such an effect usually

requires a longer rest period and is more common in highly trained athletes (Seitz & Haff, 2016). Since the subjects in this study were recreationally active, it is more likely that acute fatigue rather than potentiation dominates, which is consistent with the observations of Tillin and Bishop (2009). Compared to the athlete population, recreational athletes show slower neural adaptation and a lower ability to recover quickly, which may explain the more pronounced performance declines immediately after exercise.

The results of this study confirm that a single session of resistance training can induce significant short-term changes in the functional mechanical properties of leg muscles. These findings are consistent with current scientific literature and emphasize the importance of proper planning of load and rest intervals, especially in recreational athletes and individuals with a lower level of fitness. The data obtained can serve as a basis for future research with different load protocols, as well as for practical recommendations in the training process.

The discussion section provides an opportunity to critically assess the findings of other studies.

5. Conclusion

The results of this study showed that a single session of resistance training leads to measurable acute changes in the functional mechanical properties of lower extremity muscles. A decrease in performance was observed in all applied tests, confirming the existence of significant neuromuscular fatigue after performing the load. The most pronounced decline was registered in static and dynamic endurance tests, which is in line with expectations for the quadriceps and gluteal muscles as the primary load bearers during training. No improvements in explosiveness were registered, which is expected because acute fatigue inhibits optimal recruitment of fast motor units. Cohen's d analysis showed moderate to large effects, indicating that the protocol was intense enough to induce a robust physiological response. The obtained results confirm the findings of previous studies indicating that acute changes occur after just one session even in experienced recreational athletes. These findings contribute to a better understanding of the dynamics of recovery and planning the training process in individuals who train regularly. The results also highlight the importance of adequate rest between sessions and careful intensity planning to minimize the risk of overtraining. The research suggests that even simple field tests can be valid indicators of acute fatigue. Ultimately, the study confirms that even a single training session can have a significant, but temporary, impact on

functional performance, which should be taken into account when programming training and evaluating progress.

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- ***Conflict of Interest***

The author declares no conflict of interest.

- ***Funding***

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- ***Ethic Approval***

This study was approved by the Ethics Committee of the Faculty of Physical Education and Sport, University of East Sarajevo (Approval No. 01-EK/2025, issued in 2025).

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