

Influence of Resistance Training Volume on Muscular Fitness and Strength Development in University Students

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Article history: Received 2026 February 11; Revised 2026 March 03; Accepted 2026 March 05; Available online 2026 March 30; Available print 2026 April 30
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ABSTRACT. Introduction. Muscular fitness is essential for health and performance in young adults. Training volume plays a key role in resistance training adaptations, yet limited research compares different volumes in university students. **Objective.** This study examined the influence of resistance training volume on muscular fitness and strength development in students aged 20 to 26 years. **Methods.** Thirty two university students were assigned to a moderate volume group or a high volume group. Both groups trained three times per week for eight weeks at 65 to 80 percent of one repetition maximum. The moderate group performed three sets per exercise, while the high volume group performed five sets. Maximal strength was assessed using bench press and squat one repetition maximum tests. Muscular endurance was evaluated through push up and sit up tests. Paired and independent samples t tests were applied. **Results.** Both groups showed significant improvements in all variables after training, with p values lower than .001. The high volume group demonstrated greater mean increases across all measures. A significant between group difference was observed in the sit up test, favoring the high volume protocol. **Conclusions.** Resistance training significantly improves muscular fitness in university students. Both volumes are effective, while higher volume produces greater improvements, especially in muscular endurance.

Keywords: *resistance training, training volume, muscular fitness, maximal strength, muscular endurance, university students*

INTRODUCTION

Muscular fitness represents a central component of physical performance and long term health in young adults. It includes maximal strength and muscular endurance, both of which influence posture, movement efficiency, injury prevention, and metabolic regulation (American College of Sports Medicine, 2009). During university years, academic demands often increase sedentary behavior, which may negatively affect physical condition. Structured resistance training offers an effective strategy to counteract this decline and improve functional capacity (Keating et al., 2015).

Resistance training produces adaptations at neural and muscular levels. Early strength gains occur primarily through improved motor unit recruitment, synchronization, and firing frequency (Moritani & deVries, 1979). With continued exposure to progressive overload, structural adaptations such as muscle fiber hypertrophy and increases in cross sectional area contribute to further improvements (Schoenfeld, 2010). These mechanisms explain the consistent increases in maximal strength observed in young adults following structured programs.

Maximal strength, commonly assessed through the one repetition maximum test, represents a reliable indicator of neuromuscular performance (Kraemer & Ratamess, 2004). Muscular endurance reflects the capacity to sustain repeated contractions against submaximal resistance and is strongly linked to daily functional tasks and sport specific performance (Campos et al., 2002). Enhancing both components improves overall muscular fitness and supports long term physical development.

Among resistance training variables, volume plays a decisive role in adaptation. Training volume is usually quantified through total sets and repetitions performed at a given intensity. Research indicates that weekly set volume significantly influences hypertrophy and strength outcomes (Schoenfeld, Ogborn, & Krieger, 2017). Meta analytic evidence supports a dose response relationship between higher training volumes and greater muscle mass increases, especially in young adults (Schoenfeld et al., 2019). However, the extent to which volume influences maximal strength in short term interventions remains debated (Grgic et al., 2018). In university populations, optimizing training volume has practical implications. Students often manage academic workload, limited recovery time, and varying levels of training experience. Identifying whether moderate volumes produce similar adaptations compared to higher volumes allows practitioners to design efficient programs. If higher volumes lead to superior endurance or hypertrophy gains, program prescription can prioritize increased set numbers when recovery capacity permits.

Previous investigations conducted in youth and student populations highlight the importance of structured training models in improving physical performance. For example, Teris, Lakotos, and Koronas (2024) demonstrated that well designed training interventions significantly enhance technical and physical capacities in junior athletes. Although focused on skill development, the findings emphasize that systematic program design leads to measurable improvements. Similarly, Onea and Balint (2017) reported associations between physical fitness levels and injury incidence, reinforcing the importance of muscular conditioning in youth populations. Neuromuscular efficiency and biomechanical adaptations also play a critical role in performance development. Onea, Balint, and Pascu (2017) described how targeted training influences lower limb neuromuscular patterns and biomechanical efficiency in hurdling events. These findings support the concept that structured resistance training can modify neuromuscular characteristics that underlie strength expression.

Beyond performance enhancement, resistance training contributes to physiological regulation. Badau et al. (2019) demonstrated that physiological parameters in athlete students are influenced by body composition and hydration status. Improved muscular fitness may positively affect cardiovascular and metabolic markers, strengthening the argument for systematic resistance training in university settings. Ethical and professional standards must also guide training implementation in academic institutions. Teris and Enoiu (2023) highlighted the importance of ethical norms within military academic physical education environments. Teris and Alecu (2025) further emphasized adherence to ethical and deontological principles in university physical education activities. These studies underline that resistance training interventions in academic settings must combine scientific rigor with professional responsibility.

While previous research has explored training effects in athletes and youth, fewer controlled studies have directly compared moderate and high resistance training volumes in general university students aged 20 to 26 years. Young adults possess high adaptive potential due to favorable hormonal profiles and neuromuscular plasticity (Peterson et al., 2004). Even moderate programs can induce substantial improvements in strength and endurance (ACSM, 2009). However, clarifying whether higher volumes produce superior outcomes remains relevant for evidence based prescription.

Therefore, the aim of this study was to examine the influence of resistance training volume on muscular fitness and strength development in university students aged 20 to 26 years. The intervention compared moderate and high volume protocols over eight weeks. Maximal strength was assessed through one repetition maximum tests, and muscular endurance was evaluated through

standardized field tests. It was hypothesized that both protocols would significantly improve muscular fitness, with higher training volume producing greater improvements, particularly in endurance related outcomes.

MATERIAL AND METHODS

The purpose of this study was to examine the influence of resistance training volume on muscular fitness and strength development in university students aged 20 to 26. The intervention lasted eight weeks and followed a pre test and post test experimental design, with assessments conducted before and after the training period.

Participants

Thirty two university students participated in the study. Their age ranged between 20 and 26 years, with a mean age of 22.8 years. All participants were enrolled in undergraduate programs and volunteered to take part in a structured resistance training program. Inclusion criteria were age between 20 and 26 years, apparently healthy status, absence of musculoskeletal injuries in the previous six months, and no participation in systematic resistance training during the last three months. Exclusion criteria included absence from more than three training sessions, incomplete testing data, or withdrawal from the study.

All participants provided written informed consent prior to enrollment. The study was conducted in accordance with institutional ethical standards for research involving human subjects.

Study Design

The study followed a pre test and post test design over eight weeks. All participants completed muscular fitness assessments before the intervention and immediately after the training period. The research design compared two resistance training volumes within a structured program. Participants were assigned to one of two training groups based on total sets performed per exercise. One group followed a moderate volume protocol, while the other followed a high volume protocol.

Training Protocol

Training sessions, presented in table 1, were performed three times per week on non consecutive days. Each session lasted approximately 60 minutes and was supervised by certified strength and conditioning specialists to ensure

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correct execution and compliance. The training program included multi joint and single joint exercises targeting major muscle groups. The exercises were barbell squat, bench press, lat pulldown, Romanian deadlift, shoulder press, leg press, biceps curl, and triceps extension. Training intensity ranged between 65 and 80 percent of one repetition maximum. Load progression was applied every two weeks according to individual performance improvements. The moderate volume group performed three sets per exercise. The high volume group performed five sets per exercise. Rest intervals were standardized between 90 and 120 seconds between sets.

Table 1. Resistance Training Protocol Over 8 Weeks

Exercise	Intensity (%1RM)	Moderate Volume Group	High Volume Group	Rest Interval
Barbell Squat	65 to 80	3 sets × 8 to 12 reps	5 sets × 8 to 12 reps	90 to 120 s
Bench Press	65 to 80	3 sets × 8 to 12 reps	5 sets × 8 to 12 reps	90 to 120 s
Lat Pulldown	65 to 80	3 sets × 8 to 12 reps	5 sets × 8 to 12 reps	90 to 120 s
Romanian Deadlift	65 to 80	3 sets × 8 to 12 reps	5 sets × 8 to 12 reps	90 to 120 s
Shoulder Press	65 to 80	3 sets × 8 to 12 reps	5 sets × 8 to 12 reps	90 to 120 s
Leg Press	65 to 80	3 sets × 8 to 12 reps	5 sets × 8 to 12 reps	90 to 120 s
Biceps Curl	65 to 75	3 sets × 10 to 12 reps	5 sets × 10 to 12 reps	60 to 90 s
Triceps Extension	65 to 75	3 sets × 10 to 12 reps	5 sets × 10 to 12 reps	60 to 90 s

* %1RM - percentage of your one repetition maximum.

** Training frequency was three sessions per week on non consecutive days. Load progression was applied every two weeks based on individual performance capacity. All sessions were supervised to ensure correct technique and adherence to the prescribed intensity and volume.

Fitness Assessments and Measurements

Muscular strength and muscular endurance were evaluated using standardized field tests.

Maximal strength was assessed and presented in Table 2, through the one repetition maximum test for bench press and squat. A standardized warm up protocol was applied before testing. The highest successfully lifted load with correct technique was recorded. Upper body muscular endurance was evaluated using the push up test. Participants performed the maximum number of repetitions until failure. Abdominal muscular endurance was measured using the sit up test. The maximum number of repetitions completed in 60 seconds was recorded. All assessments were conducted indoors under controlled conditions. The same evaluators supervised both pre test and post test sessions to ensure consistency.

Table 2. Muscular Fitness Assessment Protocol

Test	Variable Measured	Protocol Description	Outcome Recorded
Bench Press 1RM	Maximal upper body strength	Progressive loading until one repetition maximum with correct technique	Maximum load in kg
Squat 1RM	Maximal lower body strength	Progressive loading until one repetition maximum with correct technique	Maximum load in kg
Push Up Test	Upper body muscular endurance	Maximum repetitions performed continuously until failure	Number of repetitions
Sit Up Test	Abdominal muscular endurance	Maximum repetitions completed in 60 seconds	Number of repetitions

* 1RM – one repetition maximum

** All tests were performed indoors under standardized conditions. A general warm up of 10 minutes was completed before strength testing. The same evaluators supervised both pre test and post test sessions to ensure consistency and reliability of measurements.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the institutional ethics committee. Written informed consent was obtained from all participants and their legal guardians. Participants were informed of their right to withdraw at any time without penalty.

Statistical Analysis

Descriptive statistics included mean, standard deviation, minimum, and maximum values for each variable. Paired samples t tests were used to examine within group differences between pre test and post test results. Independent samples t tests were applied to compare post intervention results between the moderate and high volume groups. Effect sizes were calculated using Cohen's d to determine the magnitude of differences. Statistical significance was set at p lower than .05. Data were analyzed using IBM SPSS version 26.

RESULTS

The results of the eight week resistance training intervention are presented below. Analyses include descriptive statistics for the total sample, within group comparisons for moderate and high volume groups, and post test comparisons between groups.

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Table 3 presents the descriptive statistics for all muscular fitness variables at initial test and final test for the total sample of 32 subjects. All variables increased from pre to post intervention.

Table 3. Descriptive statistics for all tests

Test	Phase	Min	Max	X	SD
Bench Press 1RM (kg)	IT	35.0	86.5	61.64	11.03
	FT	45.0	91.5	69.27	11.20
Squat 1RM (kg)	IT	53.0	120.0	86.38	14.39
	FT	67.5	137.0	99.13	15.75
Push Up Test (reps)	IT	10	35	22.47	6.49
	FT	12	44	28.81	7.21
Sit Up Test (reps, 60 s)	IT	15	49	28.72	6.83
	FT	19	53	36.28	7.78

Note. IT = initial test, FT = final test, Min = minimum value, Max = maximum value, X = arithmetic mean, SD = standard deviation, 1RM = one repetition maximum, kg = kilograms, reps = repetitions, s = seconds.

Bench press 1RM increased by approximately 7.6 kg on average. Squat 1RM increased by nearly 13 kg. Push up performance improved by more than 6 repetitions, while sit up performance increased by over 7 repetitions. These results indicate a clear positive adaptation to resistance training in the total sample.

Within Group Comparisons

Table 4 presents inferential statistics for the moderate volume group of 16 subjects. All variables improved significantly from pre to post intervention.

Table 4. Inferential statistics for the Moderate volume group

Test	DX (FT - IT)	DSD	95% CI low	95% CI high	p	d
Bench Press 1RM (kg)	5.44	1.85	4.45	6.42	< 0.001	2.94
Squat 1RM (kg)	8.66	2.25	7.46	9.86	< 0.001	3.85
Push Up Test (reps)	4.19	2.12	3.06	5.31	< 0.001	1.98
Sit Up Test (reps, 60 s)	5.81	2.07	4.71	6.92	< 0.001	2.81

Note. DX = mean difference between final test and initial test, DSD = standard deviation of differences, CI = confidence interval, p = paired samples t test significance level, d = Cohen's d effect size, 1RM = one repetition maximum, kg = kilograms, reps = repetitions.

The moderate volume protocol led to significant improvements in maximal strength and muscular endurance. Effect sizes were large across all variables, especially for squat 1RM.

Table 5. Inferential statistics for the High volume group

Test	DX (FT - IT)	DSD	95% CI low	95% CI high	p	d
Bench Press 1RM (kg)	9.81	2.19	8.64	10.98	< 0.001	4.48
Squat 1RM (kg)	17.91	3.00	16.31	19.51	< 0.001	5.97
Push Up Test (reps)	8.50	2.80	7.01	9.99	< 0.001	3.03
Sit Up Test (reps, 60 s)	9.31	2.22	8.13	10.50	< 0.001	4.20

Note. DX = mean difference between final test and initial test, DSD = standard deviation of differences, CI = confidence interval, p = paired samples t test significance level, d = Cohen's d effect size, 1RM = one repetition maximum, kg = kilograms, reps = repetitions.

The high volume protocol presented in Table 5 produced larger mean improvements in all variables compared to the moderate volume group. Squat 1RM increased by nearly 18 kg, and bench press by almost 10 kg. Muscular endurance improvements were also greater, with increases of over 8 repetitions in both push up and sit up tests. Effect sizes were very large, particularly for lower body strength.

Between Group Comparisons

Table 6. Post Test Independent t Tests, Moderate vs High Volume

Test	X Moderate	SD Moderate	X High	SD High	p	d
Bench Press 1RM (kg)	66.94	10.41	71.59	11.81	0.246	0.42
Squat 1RM (kg)	94.22	11.69	104.03	18.02	0.079	0.65
Push Up Test (reps)	26.50	6.59	31.13	7.25	0.069	0.67
Sit Up Test (reps, 60 s)	32.75	7.99	39.81	5.90	0.008	1.01

Note. X Moderate = post test mean value for moderate volume group, X High = post test mean value for high volume group, SD = standard deviation, p = independent samples t test significance level, d = Cohen's d effect size, 1RM = one repetition maximum, kg = kilograms, reps = repetitions.

At post test, presented in Table 6, the high volume group showed higher mean values in all variables. However, statistically significant differences were observed only for the sit up test. The effect size for this variable was large, indicating a meaningful advantage of higher training volume for abdominal muscular endurance. For squat and push up performance, p values approached

statistical significance and effect sizes were moderate to large. This suggests a tendency toward greater adaptations with higher volume, although differences did not reach the conventional threshold for significance in maximal strength measures.

Overall, both training volumes significantly improved muscular fitness. Higher training volume produced greater magnitudes of change, with clear superiority in abdominal muscular endurance and consistent trends in maximal strength and upper body endurance.

DISCUSSIONS

The purpose of this study was to examine the influence of resistance training volume on muscular fitness and strength development in university students aged 20 to 26. The results show that both moderate and high volume resistance training programs significantly improved maximal strength and muscular endurance after eight weeks. The high volume protocol produced greater mean improvements across all variables, with statistically significant superiority in abdominal muscular endurance.

The significant increases in bench press and squat 1RM in both groups confirm that structured resistance training is effective in improving maximal strength in young adults. These findings align with previous research demonstrating that progressive overload induces neural adaptations and increases in muscle cross sectional area, which directly contribute to strength gains (Kraemer & Ratamess, 2004; Schoenfeld, 2010). The magnitude of improvement observed in this study, especially in the high volume group, is consistent with reports that untrained or recreationally trained individuals experience substantial early strength gains during the first two to three months of structured training (Peterson et al., 2004).

The greater improvements observed in the high volume group support the concept that training volume is a key driver of muscular adaptation. Volume represents the total amount of work performed and directly influences mechanical tension and metabolic stress, two major stimuli for hypertrophy and strength development (Schoenfeld, Ogborn, & Krieger, 2017). In the present study, the high volume group demonstrated nearly double the improvement in squat 1RM compared to the moderate volume group. Although between group differences in maximal strength did not reach statistical significance, the effect sizes indicate a meaningful practical difference.

Previous meta analyses have shown a dose response relationship between training volume and hypertrophy, suggesting that higher weekly set numbers

produce greater muscle growth, particularly in young adults (Schoenfeld et al., 2019). The current findings partially support this perspective. While maximal strength differences between groups were not statistically significant, the consistent trend toward greater improvements with higher volume suggests that volume may influence the magnitude of adaptation, especially over longer interventions.

The most pronounced between group difference was observed in the sit up test, where the high volume group showed significantly greater improvements. This finding indicates that muscular endurance may be more sensitive to increases in training volume than maximal strength. Muscular endurance improvements depend on metabolic adaptations, capillary density, and fatigue resistance, which respond favorably to greater training workloads (Campos et al., 2002). The higher number of sets performed by the high volume group likely increased time under tension and metabolic accumulation, contributing to superior endurance gains.

The improvements in push up performance further support the role of volume in enhancing muscular endurance. Although post test differences did not reach statistical significance, the moderate to large effect size suggests a practical advantage for higher training volume. Similar findings have been reported in studies comparing different resistance training volumes, where higher set protocols resulted in greater endurance related adaptations (Rhea et al., 2003).

It is important to consider that both groups showed statistically significant improvements in all measured variables. This highlights that even moderate training volumes are sufficient to elicit meaningful gains in muscular fitness among university students. Young adults typically demonstrate high responsiveness to resistance training due to favorable hormonal profiles and adaptive capacity (ACSM, 2009). Therefore, moderate volume training remains a viable strategy when time efficiency or recovery capacity is limited.

The absence of statistically significant between group differences in maximal strength may be explained by several factors. First, the sample size was relatively small, which reduces statistical power. Second, the intervention duration was eight weeks, a period during which neural adaptations dominate strength gains (Moritani & deVries, 1979). Neural improvements may occur similarly across different volume conditions when intensity is comparable. A longer intervention may reveal clearer structural differences related to hypertrophy.

These findings are consistent with evidence suggesting that both moderate and high volume resistance training can improve strength when intensity is appropriately prescribed (Grgic et al., 2018). The key factor appears to be progressive overload rather than volume alone. However, when the objective is to maximize hypertrophy and muscular endurance, increasing weekly set volume may provide additional benefits (Schoenfeld et al., 2017).

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From a practical perspective, the results suggest that university students seeking improvements in general muscular fitness can achieve significant benefits with structured resistance training performed three times per week. If the goal is to maximize muscular endurance, especially in the abdominal region, a higher volume protocol may offer superior outcomes. Coaches and practitioners should balance volume with recovery capacity, academic workload, and individual tolerance.

Overall, this study reinforces the importance of structured resistance training in young adults and highlights the role of training volume as a relevant variable in program design. Future research should examine longer interventions, include larger samples, and directly assess muscle hypertrophy through imaging techniques to clarify the relationship between volume, strength, and structural adaptations.

CONCLUSIONS

The study examined the influence of resistance training volume on muscular fitness and strength development in university students aged 20 to 26 years. After eight weeks of structured training, both moderate and high volume protocols produced significant improvements in maximal strength and muscular endurance.

Bench press and squat one repetition maximum values increased significantly in both groups. Push up and sit up performance also improved in all participants. These findings confirm that structured resistance training performed three times per week is sufficient to enhance muscular fitness in young adults.

The high volume protocol produced greater mean improvements across all variables. A statistically significant advantage was observed in abdominal muscular endurance, where the high volume group demonstrated superior post test results. For maximal strength and upper body endurance, higher volume generated larger effect sizes and greater magnitude of change, although differences did not reach statistical significance.

These results suggest that moderate training volumes are effective for improving general muscular fitness in university students. When the objective is to maximize muscular endurance, increasing weekly training volume may provide additional benefits. Program design should balance training volume with recovery capacity, academic workload, and individual tolerance.

CONFLICT OF INTEREST

The author declare no conflict of interest.

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