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Performance Effects of Pre-Aerobic Activity on Subsequent Resistance Training in College-Aged Student-Athletes

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ABSTRACT

This study examined the effects of pre-aerobic exercise on lower-extremity muscular strength, assessed using multiple-repetition maximum tests for the squat, Romanian deadlift (RDL), and Bulgarian split squat (BSS). Fourteen college-aged student-athletes were assigned to one of three 8-week training conditions, performed three times per week in a counterbalanced design: (1) resistance training (RT) only, (2) 10 minutes aerobic exercise followed by RT, or (3) 15 minutes aerobic exercise followed by RT. All participants completed weekly RT sessions consisting of squats, RDLs, and BSSs that progressively increased in intensity. In the aerobic conditions, participants cycled for 10 or 15 minutes on a commercial stationary bike prior to RT, using the Borg Scale to regulate exercise intensity. Significant pre- to post-training increases in predicted 1RM were observed in the RT only condition for the squat ($t = 3.61$, $p = 0.04$), RDL ($t = 3.48$, $p = 0.04$), and BSS ($t = 6.41$, $p = 0.007$). The 10-minute aerobic exercise + RT condition also demonstrated significant improvements in squat ($t = 6.89$, $p = 0.002$), RDL ($t = 4.55$, $p = 0.01$), and BSS ($t = 3.26$, $p = 0.03$). In contrast, no significant strength increases were observed in the 15-minute aerobic exercise + RT condition. Collectively, these findings suggest that short-duration aerobic activity may serve as an effective warm-up prior to RT, whereas longer aerobic bouts (e.g., ≥15 minutes) may attenuate subsequent RT adaptations.

Keywords: Aerobic Exercise, Resistance Trainin, Muscle Strength, Hypertrophy, Physical Exertion, Warm-Up Exercise, Athletes.

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1. INTRODUCTION

The integration of aerobic exercise and resistance training (RT) within a single training session is common among athletes, recreational lifters, and physically active adults, yet the optimal sequencing of these modalities remains unclear. Both aerobic exercise and RT independently improve health, performance, and long-term physiological adaptations, but performing them in close succession may create competing demands that influence training quality and outcomes (American College of Sports Medicine, 2021; Haff & Triplett, 2016). This issue carries practical significance for coaches, clinicians, and individuals who routinely combine modalities due to time constraints or program design. Understanding whether aerobic exercise performed immediately before RT enhances warm-up quality or instead induces fatigue that compromises strength development is critical for optimizing training outcomes.

Research examining the interaction between aerobic exercise and RT has produced mixed findings. Several studies have demonstrated that performing aerobic exercise before RT acutely impairs strength performance. Ratamess and colleagues (2016) reported significant reductions in total repetitions, power output, and training volume following moderate- and high-intensity aerobic exercise. Similarly, Sporer and Wenger (2003) found that strength performance remained impaired for up to eight hours after aerobic exercise, particularly when recovery time was insufficient. More recent evidence reinforces these acute interference effects. A systematic review and meta-analysis by Eddens and colleagues (2021) concluded that aerobic exercise performed before RT can impair strength performance for several hours, with the magnitude of impairment influenced by aerobic duration and intensity. Fyfe and colleagues (2023) further clarified that interference is not inevitable but depends heavily on aerobic volume, intensity, and proximity to RT, with longer or more intense aerobic bouts increasing metabolic competition between AMPK- and mTOR-related pathways.

In contrast, emerging research suggests that aerobic exercise may enhance certain long-term RT adaptations when used strategically. Thomas and colleagues (2022) demonstrated that short-term aerobic conditioning performed before RT increased satellite cell activation and muscle fiber hypertrophy, indicating that aerobic exercise may act as a priming stimulus that enhances muscle perfusion and metabolic signaling. Jones and colleagues (2020) similarly reported that brief, moderate-intensity aerobic warm-ups improved neuromuscular readiness and force production, whereas longer aerobic sessions produced fatigue-related decrements. Meta-analytic evidence also supports the idea that interference is context-dependent. Murlasits and colleagues (2021) concluded that concurrent training does not inherently impair strength development; rather, interference is most likely when aerobic volume is high or when aerobic exercise is performed immediately before RT. Andrade and colleagues (2022) further demonstrated that aerobic intensity plays a critical role, with high-intensity aerobic exercise reducing subsequent RT performance, while moderate intensity has minimal negative impact.

Collectively, these findings highlight two competing perspectives: aerobic exercise performed before RT may acutely impair strength performance, yet under certain conditions, particularly when duration and intensity are moderate it may enhance long-term hypertrophic adaptations. Despite these advances, few studies have examined how aerobic duration specifically influences RT outcomes in trained college-aged athletes. This gap underscores the need for controlled investigations that determine the threshold at which pre-aerobic activity transitions from beneficial to detrimental. The present study addresses this gap by comparing the effects of 10- and 15-minute aerobic bouts performed immediately before RT on lower-body strength development. It was hypothesized that (1) the RT-only condition would produce greater strength gains than both aerobic + RT conditions, and (2) the 10-minute aerobic + RT condition would produce greater strength gains than the 15-minute aerobic + RT condition.

2. METHODS

- ***Participants***

This study used a randomized, counterbalanced, between-participants experimental design to examine the effects of pre-aerobic exercise duration on RT adaptations. Fourteen college-aged student-athletes who were in the off-season (*n* = 11 males, *n* = 3 females; age 20 ± 1.3 years; see Table 1) were assigned to one of three conditions using a counterbalanced design: (1) resistance training (RT) only, (2) 10 minutes of aerobic exercise followed by RT, or (3) 15 minutes of aerobic exercise followed by RT. A priori sample size estimation was conducted using G*Power 3.1.9.7 (Faul et al., 2007). A repeated-measures ANOVA with three groups, two time points, $\alpha = 0.05$, and an expected large effect size ($f = 0.40$) indicated that 14 participants would provide approximately 80% power to detect significant differences. Training sessions occurred three times per week, and the order of condition assignment was counterbalanced across participants. Individuals were excluded if they presented with contraindications to exercise (e.g., orthopedic injuries or musculoskeletal, cardiovascular, or pulmonary conditions). Before participation, all individuals were informed of the study's risks and benefits, instructed to abstain from strenuous exercise for at least 24 hours prior to testing, completed medical history forms, and provided written informed consent. All procedures were approved by the Hiram College Institutional Review Board.

Table 1. Average height, weight, and age of the participants in each condition.

	RT only (*n* = 4)	**10 min aerobic + RT (*n* = 5)**	**15 min aerobic + RT (*n* = 5)**
Height (cm)	179.71 ± 17.40 cm	178.31 ± 5.51 cm	173.23 ± 9.90 cm
Weight (kg)	74.20 ± 8.24 kg	84.55 ± 32.98 kg	85.45 ± 15.63 kg
Age (years)	19.75 ± 0.96 years	20.40 ± 1.34 years	20.00 ± 0.1.58 years

All data are means ± SD

No significant differences were observed between conditions

Protocol

During the initial visit, research personnel familiarized participants with the study protocol and equipment. This orientation included instruction on proper use of the recumbent bike (Matrix Fitness, WI, USA), navigation of the display console, and interpretation of the Borg 6–20 Rating of Perceived Exertion (RPE) Scale (Borg, 1982), which was used to regulate cycling intensity. The Borg 6–20 RPE scale is a validated and reliable tool for regulating aerobic intensity, with strong correlations to heart rate and VO_2 (Borg, 1982; Kang et al., 2003). Participants also received detailed coaching on the execution of each resistance training (RT) exercise (barbell squat, barbell Romanian deadlift

[RDL], and dumbbell Bulgarian split squat [BSS]) and were given the opportunity to practice each movement while receiving corrective feedback.

For pre- and post-testing, participants selected a submaximal load and performed as many repetitions as possible for each RT exercise (squat, RDL, and BSS). Predicted one-repetition maximum (1RM) values were calculated using the Brzycki equation (Brzycki, 1993), a widely adopted approach for estimating maximal strength from submaximal repetitions with strong evidence of predictive accuracy. Supporting this approach, LeSuer and colleagues (1997) reported that submaximal 1RM prediction methods demonstrate high test–retest reliability (ICC > 0.90) for lower-body, multi-joint exercises comparable to those used in the present study.

$$1RM = \frac{weight}{1.0278 - 0.0278\ x\ reps}$$

Participants were then assigned to one of three conditions using a counterbalanced design: (1) resistance training (RT) only, (2) 10 minutes of aerobic exercise followed by RT, or (3) 15 minutes of aerobic exercise followed by RT. Training was performed three times per week for a total of 8 weeks. Every two weeks, participants received an updated program that included revised %1RM targets, prescribed sets and repetitions, rest interval durations, and Borg Scale ratings for aerobic exercise intensity (see Table 2).

Table 2. Aerobic and Resistance Training Program

Weeks	%1RM	Sets x Reps	Rest Interval	Borg Scale
1-2	65% - Foundation	3x12	60 seconds	12 - Moderate
3-4	70% - Initial Overload	3x10	90 seconds	12 - Moderate
5-6	77% - Progressive Hypertrophy	4x8	90 seconds	13 - Somewhat Hard
7-8	80% - Peak Hypertrophy	4x6	120 seconds	13 - Somewhat Hard

RT Only Condition

The RT condition consisted solely of the resistance training exercises (barbell squat, barbell RDL, and dumbbell BSS), with no aerobic activity performed beforehand. Participants completed a structured RT program individualized according to their predicted 1RM values, while all other training variables were prescribed in accordance with the National Strength and Conditioning Association (NSCA) hypertrophy guidelines (Haff & Triplett, 2016).

10-Minute Aerobic Exercise + RT Conditions

The 10-minute aerobic exercise + RT condition began with participants completing 10 minutes of cycling on the recumbent bike at their prescribed weekly Borg Scale intensity. Participants adjusted resistance and cadence as needed to maintain the target RPE. Immediately after the aerobic bout, they performed the assigned RT workout. The use of RPE to regulate aerobic intensity is supported by Kang and colleagues (2003), who instructed healthy college-aged adults to cycle at a self-selected workload corresponding to an RPE of 13. Participants adjusted resistance and cadence to maintain this target, and physiological measures such as oxygen consumption (VO_2) and heart rate confirmed that RPE 13 elicited consistent moderate-to-vigorous intensity responses. These findings validate the Borg 6–20 RPE scale as an effective method for assigning aerobic exercise intensity.

15-Minute Aerobic Exercise + RT Conditions

The 15-minute aerobic exercise + RT condition began with participants completing 15 minutes of cycling on the recumbent bike at their prescribed weekly Borg Scale intensity. Participants adjusted resistance and cadence as needed to maintain the target RPE. Immediately after the aerobic bout, they performed the assigned RT workout.

3. Statistical Analysis

All data were analyzed with SPSS version 20.0 (SPSS Inc., Chicago, IL, USA), with an a-priori α level of ≤ 0.05. The physical characteristics (age, height, weight) for the three conditions were compared using independent samples t-tests. A repeated-measures ANOVA was used to evaluate the differences in estimated 1RM from pre- to post-testing for the three different conditions. Post-hoc analysis for all significant main effects were completed using paired samples t-tests with the Benjamini-Hochberg false discovery rate correction (Benjamini & Hochberg, 1995).

4. RESULTS

Participant Characteristics

Independent samples t-tests revealed no significant differences in height, weight, and age among the three conditions (see Table 1).

Estimated 1RM Values

A repeated-measures ANOVA revealed a significant main effect of condition on estimated 1RM values, $F(2,11) = 44.56$, $p < 0.001$).

RT only condition

Participants in the RT-only condition demonstrated significant increases in estimated 1RM from pre- to post-testing for all exercises. Squat 1RM increased from 91.82 ± 24.42 kg to 104.43 ± 32.98 kg, $t(3) = 3.61$, $p = 0.04$. RDL 1RM increased from 91.48 ± 32.98 kg to 102.95 ± 34.30 kg, $t(3) = 3.48$, $p = 0.04$. BSS 1RM increased from 40.40 ± 14.10 kg to 55.23 ± 13.64 kg, $t(3) = 6.41$, $p = 0.007$.

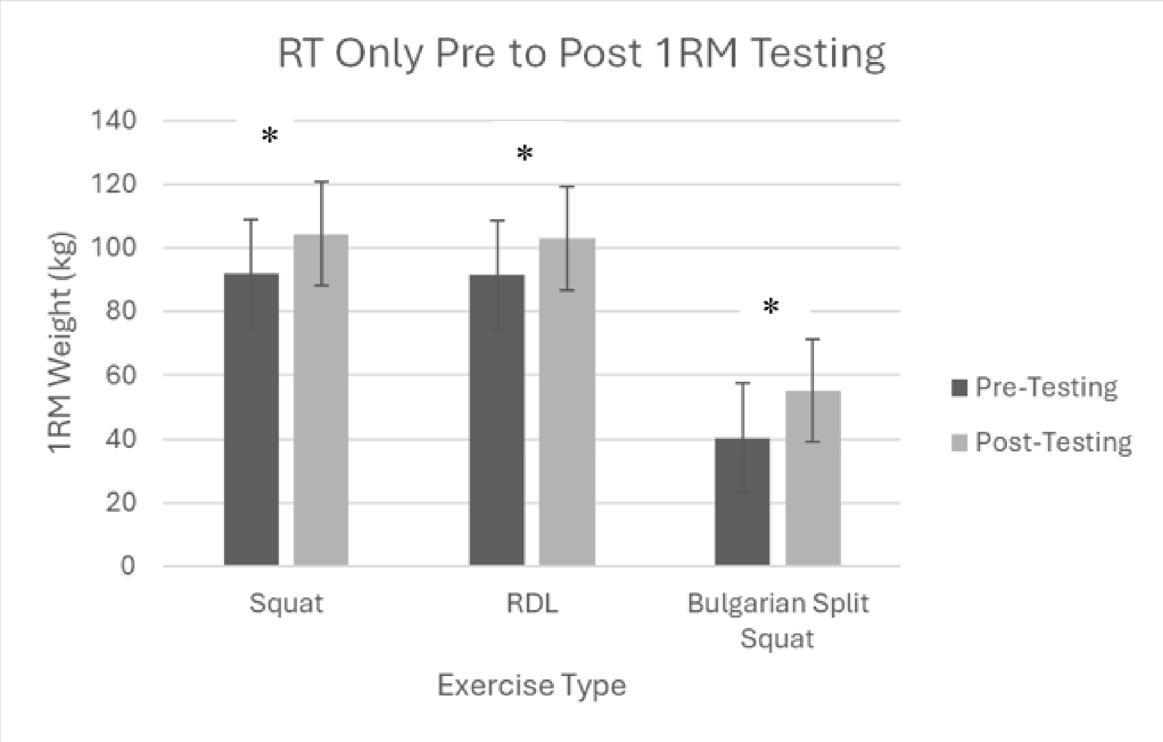

Figure 1. The above figure displays estimated 1RM results from pre- to post-testing for the RT only condition. Values mean ± SD.

10-minute aerobic exercise + RT condition

Significant improvements were also observed in the 10-minute aerobic + RT condition. Squat 1RM increased from 109.45 ± 32.95 kg to 124.64 ± 34.30 kg, $t(4) = 6.89$, $p = 0.002$. RDL 1RM increased from 67.00 ± 23.67 kg to 81.82 ± 28.89 kg, $t(4) = 4.55$, $p = 0.01$. BSS 1RM increased from 38.64 ± 18.77 kg to 47.00 ± 23.40 kg, $t(4) = 3.26$, $p = 0.03$.

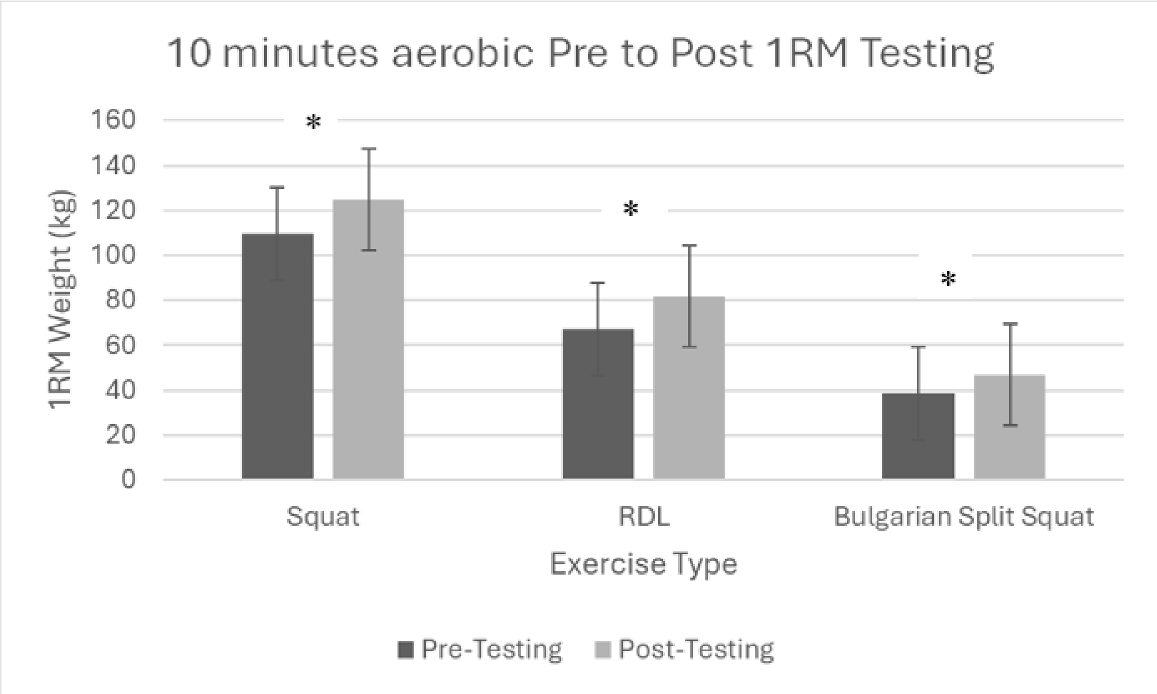

Figure 2. The above figure displays estimated 1RM results from pre- to post-testing for the 10-minute aerobic exercise + RT condition. Values mean ± SD.

15-minute aerobic exercise + RT condition

No significant changes were observed in the 15-minute aerobic + RT condition. Squat 1RM increased from 116.64 ± 23.35 kg to 126.55 ± 30.17 kg, $t(4) = 2.47$, $p = 0.07$. RDL 1RM increased from 97.73 ± 31.14 kg to 105.09 ± 29.99 kg, $t(4) = 1.45$, $p = 0.22$. BSS 1RM increased from 54.05 ± 10.38 kg to 63.55 ± 13.31 kg, $t(4) = 2.31$, $p = 0.08$.

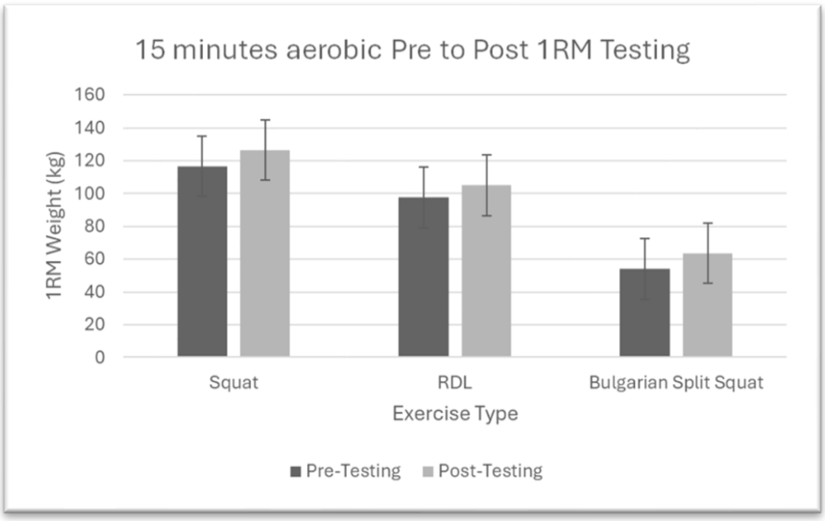

Figure 3. The above figure displays estimated 1RM results from pre- to post-testing for the 15-minute aerobic exercise + RT condition. Values mean ± SD.

5. DISCUSSION

The purpose of this study was to examine whether performing 10 or 15 minutes of aerobic exercise immediately before RT influences lower-body strength development in college-aged student-athletes. The main findings were that both the RT-only and 10-minute aerobic + RT conditions produced significant increases in estimated 1RM for the squat, RDL, and BSS, whereas the 15-minute aerobic + RT condition did not. These results indicate that short-duration aerobic activity does not impair RT adaptations and may serve as an effective warm-up, while longer aerobic bouts may attenuate strength gains.

These findings align with recent evidence suggesting that the interference effect is highly dependent on aerobic duration, intensity, and proximity to RT. Fyfe and colleagues (2023) emphasized that interference is not inevitable but emerges when aerobic volume or intensity is sufficiently high to activate competing molecular pathways (e.g., AMPK vs. mTOR). The reduced strength gains observed in the 15-minute condition are consistent with this model, as extended aerobic work may have increased metabolic fatigue and reduced the capacity to train at high intensities during RT sessions.

The present results also support earlier work demonstrating acute performance decrements when aerobic exercise precedes RT. Ratamess and colleagues (2016) reported significant reductions in total repetitions and power output following aerobic exercise, while Sporer and Wenger (2003) found that strength performance remained impaired for several hours after aerobic activity. More recently, Eddens and colleagues (2021) confirmed through meta-analysis that aerobic exercise can impair strength performance for up to six hours, particularly when performed immediately before RT. The absence of significant improvements in the 15-minute condition aligns with these findings and suggests that even moderate-intensity aerobic exercise may induce sufficient fatigue to hinder long-term strength adaptations when performed for extended durations.

In contrast, the significant strength gains observed in the 10-minute aerobic + RT condition support research indicating that brief aerobic activity may enhance neuromuscular readiness. Jones and colleagues (2020) found that short, moderate-intensity aerobic warm-ups improved neuromuscular activation and force production, whereas longer warm-ups produced fatigue-related decrements. Similarly, Thomas and colleagues (2022) demonstrated that short-term aerobic conditioning performed before RT increased satellite cell activation and muscle fiber hypertrophy, suggesting that aerobic exercise may act as a priming stimulus that enhances muscle perfusion and metabolic signaling. The comparable or greater improvements observed in the 10-minute condition in the present study support this interpretation and indicate that brief aerobic exercise may enhance warm-up quality without inducing excessive fatigue.

Meta-analytic evidence further supports the context-dependent nature of interference. Murlasits and colleagues (2021) concluded that concurrent training does not inherently impair strength development; rather, interference is most likely when aerobic volume is high or when aerobic exercise is performed immediately before RT. Andrade and colleagues (2022) also demonstrated that aerobic intensity plays a critical role, with high-intensity aerobic exercise reducing subsequent RT performance, while moderate intensity has minimal negative impact. The present study used moderate-intensity aerobic exercise (Borg RPE 12–13), which may explain why the 10-minute condition did not impair strength gains.

Taken together, these findings suggest that the threshold at which pre-aerobic activity transitions from beneficial to detrimental may lie between 10 and 15 minutes for moderate-intensity cycling in trained young adults. Shorter aerobic bouts may enhance warm-up quality by increasing muscle temperature, blood flow, and neural activation, while longer bouts may accumulate fatigue that compromises force production and reduces the quality of subsequent RT sessions.

Several limitations should be acknowledged. The sample consisted of college-aged student-athletes, limiting generalizability to untrained individuals, older adults, or clinical populations. The small sample size reduces statistical power and may have limited the ability to detect smaller but meaningful changes in the 15-minute condition. Only one aerobic modality (cycling) and one intensity range were examined; different modalities or intensities may produce different effects. Finally, estimated 1RM values were used instead of direct 1RM testing, although the Brzycki equation has demonstrated strong validity and reliability. Future research should explore how different aerobic modalities, intensities, and recovery intervals influence RT outcomes, as well as whether similar patterns emerge in other populations. Investigating physiological mechanisms such as neuromuscular fatigue, metabolic signaling, and muscle oxygenation would further clarify how aerobic exercise interacts with RT adaptations and help refine evidence-based sequencing strategies.

6. CONCLUSION & PRACTICAL APPLICATIONS

The findings of this study indicate that brief aerobic activity performed immediately before RT, specifically up to 10 minutes of moderate-intensity cycling, does not hinder strength development and may even support comparable or enhanced adaptations relative to RT alone. In contrast, extending aerobic work to 15 minutes appears to attenuate strength gains, suggesting that excessive pre-lifting aerobic volume may induce sufficient fatigue to interfere with training quality. Practically, these results support the use of short, moderate aerobic bouts as an effective warm-up strategy for college-aged student-athletes, recreational lifters, and coaches seeking to prepare athletes for lower-body training sessions without compromising strength outcomes. Strength and conditioning professionals may consider limiting pre-RT aerobic work to approximately 10 minutes when the primary goal is maximizing strength or hypertrophy, while reserving longer aerobic sessions for separate training days or post-RT placement. Future research should continue to refine optimal sequencing strategies by examining different aerobic modalities, intensities, and populations.

- ***Authors' Contributions:***

All author's contributed to the study design; Samantha Humphrey and Ryan Leto implemented the study's procedures and collected data. Mallory Kobak and Michael Rebold analyzed the study's data. All author's contributed to the preparation of the study's manuscript.

- ***Conflict of Interest:***

All authors have no conflicts of interest to declare.

- ***Ethical Approval:***

This study was approved by the Hiram College Institutional Review Board on December 3rd, 2024.

- ***Acknowledgements:***

Dear Editor,

We are pleased to send you the "Physical Effects of Pre-Aerobic Activity on Subsequent Resistance Training in College-Aged Individuals" manuscript so that you may consider having it published in your prestigious journal.

The manuscript represents results of original work that has been submitted solely to the GJSES and it will not be submitted for publication elsewhere until a decision has been made regarding its acceptability. The manuscript has not been published elsewhere and if accepted for publication, it will not be published elsewhere. All authors agree with its content and the order of authorship.

Ethical standards were followed in the conduct of the study and all authors acknowledge ethical responsibility for the content of the manuscript. This research investigation is not part of a larger study.

As the corresponding author I confirm that all authors have reviewed and approved the manuscript. All authors agree with its content and the order of authorship.

We hope that this manuscript may be of interest to you and we thank you for your valuable time.

Thank you,
Michael Rebold

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