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Original Research

The Effects of Drop Jumps on the Load-Velocity Profile of the Deadlift

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Abstract

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The primary aim of this investigation was to examine the effects of three drop jumps (DJ) on mean velocity (m/s) of subsequent deadlifts at various percentages of 1 RM. A secondary exploratory aim was to evaluate whether protocol order, sex, and relative strength moderated the effects of the DJ on deadlift velocity. Twenty-two resistance-trained participants (n = 13 males, n = 9 females; 26.1 ± 2.9 years, 168.4 ± 11.05 cm, 81.2 ± 18.1 kg), underwent a one repetition max (1RM) deadlift assessment and participated in a randomized cross-over design with two experimental sessions. The experimental sessions consisted of a deadlift load-velocity profile test, including 5 repetitions at 40%, 3 repetitions at 60%, and a single repetition each at 70%, 80%, and 90% of their tested 1RM. In the intervention protocol, participants performed 3 DJ repetitions between each deadlift set, while in the control condition, participants only rested for the designated time. A mixed factorial ANOVA was conducted with condition and load as within-subjects factors and sex, relative strength, and protocol order as between-subjects factors. No significant condition × load interaction was observed between the intervention and control protocols ($F_{2.91,113.36} = 0.48$, $p = 0.69$, $\eta^2 = 0.01$). Additionally, there were no effects for protocol order, relative strength, or sex on the intervention effect were observed ($p > 0.05$). Visual inspection of individual responses revealed substantial inter-individual variability, with participants demonstrating increases, decreases, or no change in deadlift velocity following DJ implementation. In conclusion, this study revealed that the integration of DJs between sets did not consistently affect deadlift mean velocity across different intensities. The responses of participants varied considerably, encompassing increases, interference effects, or no discernible response.

Keywords: PAP, PAPE, strength, performance, strength, kinematics.

Introduction

One of the primary objectives of a strength and conditioning program is to maximize the magnitude and rate of force production utilized under specific competition constraints. Thus, athletes typically perform resistance training to develop strength, power, and lean body mass.[1] Resistance exercises have demonstrated direct transference towards change of direction, as well as agility performance.[2,3] One resistance exercise commonly used is the deadlift.[4,5] The deadlift is programmed by strength and conditioning coaches to strengthen the hip extensors, knee

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extensors, core, back, and forearm muscles.[4,5] A variety of sports, including football, volleyball, and powerlifting, incorporate the deadlift exercise to improve explosive muscular power. This is due to the biomechanical similarities between the deadlift and athletic movements like jumping and sprinting.[2,4,6]

To optimize performance and execution of the deadlift, components such as neural drive, muscle physiology, and technical proficiency should be considered.[7,8] Coaches have used a variety of methods to leverage these mechanisms, resulting in induced performance enhancement effects that include post-activation potentiation (PAP) and post-activation performance enhancement (PAPE).[8] At the muscular level, PAP is the physiological process in which a pre-activation exercise engages phosphorylation of myosin regulatory light chains, consequently increasing muscular output.[9] Thus, PAPE refers to the enhancement of voluntary muscular performance following a high-intensity voluntary conditioning contraction, with effects persisting for approximately 3–12 minutes prior to a subsequent activity.[7,10] Previous research highlights the drop jump (DJ) as a beneficial pre-activation exercise to promote PAPE, indicating that strategic exercise sequencing and selection can exploit these physiological mechanisms to boost athlete performance.[11–13] A meta-analysis by Seitz and Haff[14] found that individual factors such as maximal strength and training experience significantly influenced the magnitude of PAP, with stronger or more experienced athletes exhibiting greater potentiation effects. While, a meta-analysis by Wilson et al.,[15] found similarly found greater experience improved PAP effects, while sex did not play a significant role. Collectively, these findings suggest that individual characteristics, particularly strength and training status, may influence responsiveness to pre-activation strategies and should be considered when evaluating PAPE responses.

To effectively quantify the acute performance benefits of potentiation strategies like PAPE or PAP, objective and reliable measures such as movement velocity are essential. Velocity, defined as the change in position over time, typically decreases with increasing load or fatigue.[16] At its most basic form, velocity has been used as a feedback tool to assess the success of acute performance-enhancement protocols. As a result, velocity-based training (VBT) is often employed to monitor performance throughout a training cycle and to adjust loads in real-time. A common application of VBT is the development of a load–velocity profile (LVP), which offers a reliable and consistent method for assessing an athlete's capabilities across the entire force–velocity spectrum.[16,17] The LVP is also a useful tool for evaluating the effects of potentiation strategies, typically by measuring mean bar velocity (m/s) at various intensities using a linear position transducer (LPT).[16] A systematic review from Weakley et al.[17] demonstrated that LPTs have greater accuracy and reliability compared to other devices (Accelerometers, optic devices, and mobile phone applications). This was particularly apparent when observing validity of the GymAware PowerTool device compared to 3D motion capture and force plate technology to assess peak velocity ($r = .96$; CV = 3.7%; ICC = 0.98) and mean velocity ($r = 0.95$; CV = 3.1%; ICC = 0.97) during back squat performed across multiple intensities.[17]

Given the physiological underpinnings of potentiation and the importance of exercise sequencing, high-intensity pre-activation movements have emerged as effective strategies for enhancing subsequent performance. The DJ, in particular, has shown promise in eliciting PAPE and improving neuromuscular output.[8,9,13,18,19] Emerging evidence[8,9,13,19] suggests the implementation of a plyometric, such as the DJ, may enhance barbell velocity across the LVP of resistance exercises such as the deadlift. Therefore, the primary aim of this study was to investigate the effects of a DJ protocol on acute changes in velocity during the LVP of the deadlift via PAPE. It was hypothesized that the implementation of a DJ would increase velocity performance during the LVP of the deadlift. Furthermore, given that there is substantial inter-individual variability in post-activation potentiation responses,[15] a secondary exploratory aim was to examine whether the effects of the drop jump intervention on velocity performance were moderated by protocol order, sex, and relative strength. As these analyses were exploratory in nature, no a priori hypotheses were formulated.

Methods

Participants

An *a priori* power analysis was conducted using G*Power (version 3.1; University of Düsseldorf, Düsseldorf, Germany) and was based on the smallest observed effect size (g = 0.30) reported by Jukic et al.[20] This analysis indicated that a minimum of 16 participants would be required to achieve 80% statistical power at an alpha level of 0.05 for the primary outcome of interest. Secondary analyses examining the influence of protocol order, sex, and relative strength were considered exploratory and were not independently powered.

Twenty-two resistance trained individuals (n = 13 males, n = 9 females) were recruited to participate in this study (Table 1). Participants were excluded if they had less than six months of training experience, an average training frequency of less than two times a week or if they had reported any contraindications or recent injuries that prevented them from doing the deadlift exercise. This could include but was not limited to low back pain or a severe knee or hip injury. Participants were informed, both verbally and in writing, of the protocol and any possible benefits or risks associated with participation. Additionally, participants were instructed to wear a mask to minimize risk of COVID-19. Further, participants were reminded they were able to withdraw at any point during the study, and all provided written consent to participate. The protocol was approved by the Institutional Review Board (FY2022-009) at Seattle University, in Seattle, Washington. This research was carried out fully in accordance with the ethical standards of the Helsinki Declaration and the International Journal of Exercise Science.[21]

Table 1. Descriptive statistics (mean ± SD) of participants.

	Males (n=13)	Females (n = 9)	Total (N = 22)
Age (years)	26.4 ± 2.6	25.8 ± 3.4	26.1 ± 2.9
Bodyweight (kg)	93.0 ± 12.5	64.1 ± 8.5	81.2 ± 18.1
Height (cm)	174.6 ± 9.1	159.4 ± 6.6	168.4 ± 11.1
Experience (Years)	7.8 ± 4.7	6.1 ± 4.0	7.1 ± 4.4
Frequency (Days/Week)	4.5 ± 0.78	4.1 ± 0.9	4.4 ± 0.9
Deadlift 1RM (kg)	234.4 ± 28.4	146.5 ± 68.5	196.2 ± 60.7
Relative Strength (1RM/BM)	2.6 ± 0.4	2.0 ± 0.3	2.4 ± 0.5

Protocol

The aim of this study was to investigate the acute effects of DJ on velocity performance during the deadlift. A randomized controlled cross-over design was used to compare the LVP of deadlifts with and without performing DJ between sets. Following baseline testing, two sessions including an LVP, one with DJ and one without, were used to evaluate the effectiveness of the intervention. To mitigate chances for an order effect, a random number generator was used to determine the order of completing the intervention and controlled session. Participants were asked to return at the same time of day as the initial session to account for diurnal fluctuations in performance. To minimize additional confounding factors, participants were instructed to avoid caffeine intake, maintain their regular routine and to avoid any strenuous activity 24 - 48 hours prior to each session that would interfere with their performance. Moreover, data collection was conducted under the supervision of a certified strength and conditioning specialist to ensure the safety and effectiveness of each session. Prior to participant arrival, an LPT (GymAware Power Tool, Kinetic Performance Technologies, Canberra, Australia) device was anchored to a 2.27 kg (5 lbs.) plate on the edge of the inner side of the barbell and a Velcro strap attached to one end of a barbell (Texas Power Bar, Texas Power Bars, Texas, United States). Steel calibrated kilogram plates (PR Lifting, Everett, United States) were used for all repetitions.

Upon arrival, participants were informed on the procedures, inherent risk of exercise, and the safety protocols designed to minimize risk. To ensure participant activity readiness, each subject also completed the Physical Activity Readiness Questionnaire (PAR-Q+) form prior to their inclusion. Participants would then self-report their estimated one repetition maximum (1RM) and sign an informed consent.

Participants were instructed to pedal on an assault bike (Assault AirBike, Assault Fitness, California, United States) at 60% perceived effort for 5 minutes. Upon completion, the participant was then led through a 10-minute dynamic warm-up that consisted of 10 repetitions at each goblet squats, single-leg Romanian deadlifts, leg swings, half-kneeling hip-flexor stretch, 90/90 alternating hip stretch, bird-dogs, cat-cows, and glute bridges. These exercises were paired together to promote hip mobility and core stability which are a key characteristics towards proper execution of the deadlift and DJ exercise.[4,22] Upon completion of the warm-up, participants performed ten repetitions with the open bar to calibrate the GymAware device, and to prime the deadlift motor pattern.

For the maximal strength assessment, participants were instructed to deadlift 5 repetitions at 40%, 3 repetitions at 60% of their reported 1RM, followed by 1 repetition each at 70%, 80%, and 90% of their reported 1RM. Between each of these attempts' participants rested for 2 – 5 minutes to guarantee complete recovery.[12,23] Additionally, participants were cued to achieve proper execution of the deadlift exercise. Once participants attempted their reported 1RM, incremental jumps at a minimum of 2.27 kg (5 lbs.) were made until they executed maximal effort or could no longer produce sufficient concentric force in the deadlift to lift the bar. Percentages for the two subsequent sessions were based on the tested 1RM value.

One week following the maximal strength assessment, participants returned for the experimental or control session.[18,24] Percentages of the measured 1RM from the initial session were used to construct the LVP. The LVP was used to both assess their submaximal performance and better understand their performance response to the intervention.[16,20] Participants performed 5 repetitions at 40%, 3 repetitions at 60% of their tested 1RM, followed by 1 repetition each at 70%, 80%, and 90% of their tested 1RM, consistent with previous research.[16,20] Bar-load and mean velocity were recorded for each attempt. For sets with more than one repetition, the average velocity of the entire set was used. In the first session, participants were randomly selected to complete either the DJ or control protocol. If they were selected to perform the DJ protocol first, then the participant would perform three repetitions of a 45.72 cm DJ prior to each deadlift set (Figure 1).[11] After three repetitions of the DJ, the participants would undergo self-selected 2 – 5 minutes of rest to ensure complete recovery.[7,11]

Figure 1. Drop Jump execution. A. Stepping off the 45.72 cm box. B. Counter movement. C. Vertical jump for height.

To ensure complete recovery, the participants would return 72 hours the initial session to complete the remaining condition.[18,24] Participants were instructed not to perform any outside physical exercise between any sessions and maintain consistent nutrition. The volume and load for deadlifts during sessions two and three were identical. If participants were assigned to do the DJ protocol first, they would complete the control condition and vice versa. For the control condition, the participant did not perform any DJs prior to each set and utilized absolute rest. Bar-load and mean velocity were recorded and stored for analysis.

Statistical Analysis

Values for all continuous variables are presented as mean ± standard deviation (m ± SD). Statistical analyses were performed using SPSS version 28 (IBM, Armonk, NY). Relative strength values were calculated by dividing the tested 1RM value by participant bodyweight in kilograms (kg). Participants were then split into a weak (< 2.2 x BW = 1RM), or strong (> 2.2 x BW = 1RM) group based on relative strength, consistent with previously published thresholds.[10,14]
A 2 (condition) × 5 (load) mixed factorial ANOVA was conducted with condition (drop jumps vs. no drop jumps) and load (40, 60, 70, 80, and 90% 1RM) as within-subjects factors, and sex, relative strength group, and session order as between-subjects factors. Violations of sphericity were corrected using Greenhouse-Geisler estimates. Partial eta squared effect sizes were interpreted as small ($\eta_p^2 = 0.01$), medium ($\eta_p^2 = 0.06$) and large ($\eta_p^2 = 0.14$). Alpha level was set to $p < .05$ to indicate statistical significance.

Results

Descriptive statistics (mean ± SD and observed ranges) for each condition and load are presented in Table 2-5. Greenhouse–Geisser corrections were applied to all within-subjects effects to account for violations of the sphericity assumption. The mixed-factor ANOVA revealed no significant condition × load interaction between the DJ and no DJ conditions across the load–velocity profile of the deadlift ($F_{2.91,113.36} = 0.48$, $\eta_p^2 = .01$, $p = .69$) (Table 2, Figure 2A–E). Furthermore, no significant condition x load x grouping variable interactions were observed for sex ($F_{2.91,113.36} = 0.66$, $\eta_p^2 = .01$, $p = .82$; Table 3), relative strength $F_{3,113} = 0.48$, $\eta_p^2 = .02$, $p = .57$; Table 4), session order ($F_{2.91,113.36} = 0.48$, $\eta_p^2 = .01$, $p = .69$; Table 5). In contrast, a significant main effect was observed between load and velocity ($F_{2.91,113.36} = 15.72$, $\eta_p^2 = .29$, $p < .001$), consistent with their respective expected inverse relationship (Table 3, Figure 2A–E). Figure 2A-E provides an individual-level visualization of participant responses across loads and conditions, complementing the group-level inferential analyses.

Table 2. Deadlift barbell mean velocity (mean ± SD) in drop jump (DJ) and control session (no DJ).

	Mean Velocity (m/s)	
%1RM	DJ (n = 22)	Control (n = 22)
40%	0.80 ± 0.09 (0.65–0.96)	0.78 ± 0.09 (0.58–0.96)
60%	0.63 ± 0.06 (0.56–0.74)	0.63 ± 0.07 (0.52–0.74)
70%	0.56 ± 0.08 (0.40–0.72)	0.54 ± 0.09 (0.34–0.75)
80%	0.45 ± 0.07 (0.31–0.60)	0.45 ± 0.07 (0.32–0.58)
90%	0.34 ± 0.07 (0.20–0.46)	0.33 ± 0.07 (0.19–0.45)

Note: %1RM = % 1 Repetition Maximum. Values are presented as mean ± SD, with observed minimum–maximum ranges shown in parentheses.

Table 3. Deadlift barbell mean velocity (mean ± SD) of Male (n = 13) and Female (n = 9) groups in the drop jump (DJ) and control session (no DJ).

	Male (n = 13)		Female (n = 9)	
%1RM	DJ	Control	DJ	Control
40%	0.78 ± 0.09	0.78 ± 0.10	0.82 ± 0.08	0.79 ± 0.08
60%	0.62 ± 0.06	0.62 ± 0.08	0.65 ± 0.07	0.64 ± 0.07
70%	0.54 ± 0.08	0.54 ± 0.10	0.58 ± 0.08	0.53 ± 0.07
80%	0.44 ± 0.08	0.45 ± 0.07	0.47 ± 0.07	0.45 ± 0.08
90%	0.32 ± 0.07	0.32 ± 0.06	0.36 ± 0.07	0.34 ± 0.06

Note: DJ = drop jump condition; Control = no drop jump condition; %1RM = percentage of one-repetition maximum; values are mean ± standard deviation.

Table 4. Deadlift barbell mean velocity (mean ± SD) of Weak (n = 10) and Strong (n = 12) groups in the drop jump (DJ) and control session (no DJ).

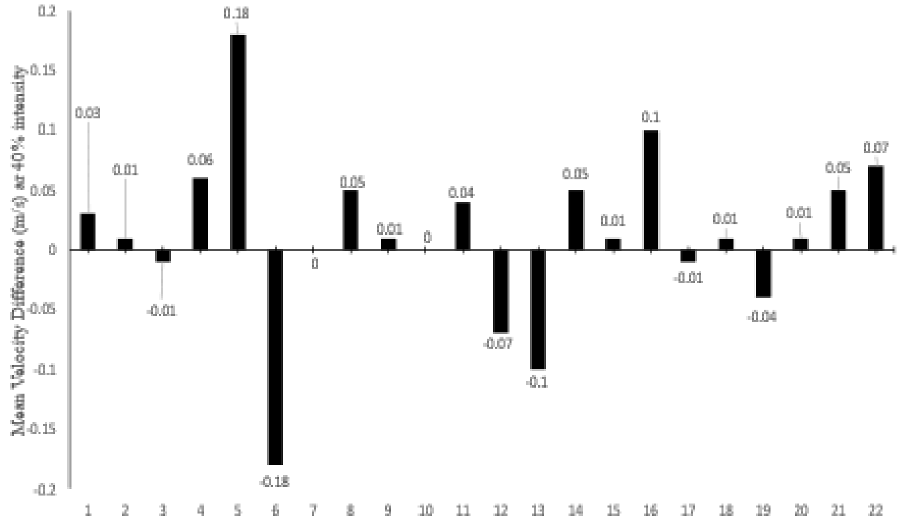
	Weak (n = 10)		Strong (n = 12)	
%1RM	DJ	Control	DJ	Control
40%	0.62 ± 0.07	0.64 ± 0.06	0.80 ± 0.09	0.79 ± 0.11
60%	0.64 ± 0.06	0.62 ± 0.07	0.63 ± 0.06	0.64 ± 0.08
70%	0.55 ± 0.08	0.52 ± 0.07	0.56 ± 0.09	0.55 ± 0.10
80%	0.35 ± 0.06	0.33 ± 0.07	0.45 ± 0.09	0.47 ± 0.07
90%	0.32 ± 0.07	0.32 ± 0.06	0.33 ± 0.08	0.33 ± 0.07

Note: %1RM = % 1 Repetition Maximum; DJ = Drop Jump

Table 5. Deadlift barbell mean velocity (mean ± SD) of Drop Jump First (n = 11) and Control First (n = 11) in the drop jump (DJ) and control session (no DJ).

	DJ First (n = 11)		Control First (n = 11)	
%1RM	DJ	Control	DJ	Control
40%	0.81 ± 0.07	0.79 ± 0.07	0.79 ± 0.01	0.79 ± 0.11
60%	0.65 ± 0.06	0.62 ± 0.08	0.62 ± 0.07	0.63 ± 0.07
70%	0.58 ± 0.07	0.52 ± 0.08	0.54 ± 0.09	0.55 ± 0.01
80%	0.46 ± 0.07	0.43 ± 0.08	0.44 ± 0.08	0.47 ± 0.06
90%	0.34 ± 0.06	0.32 ± 0.06	0.34 ± 0.08	0.34 ± 0.08

Note: %1RM = % 1 Repetition Maximum; DJ = Drop Jump


Mean Velocity Difference (m/s) at 40% intensity
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0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0.03
0.01
-0.01
0.06
0.18
-0.18
0
0.05
0.01
0
0.04
-0.07
-0.1
0.05
0.01
0.1
-0.01
0.01
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0.01
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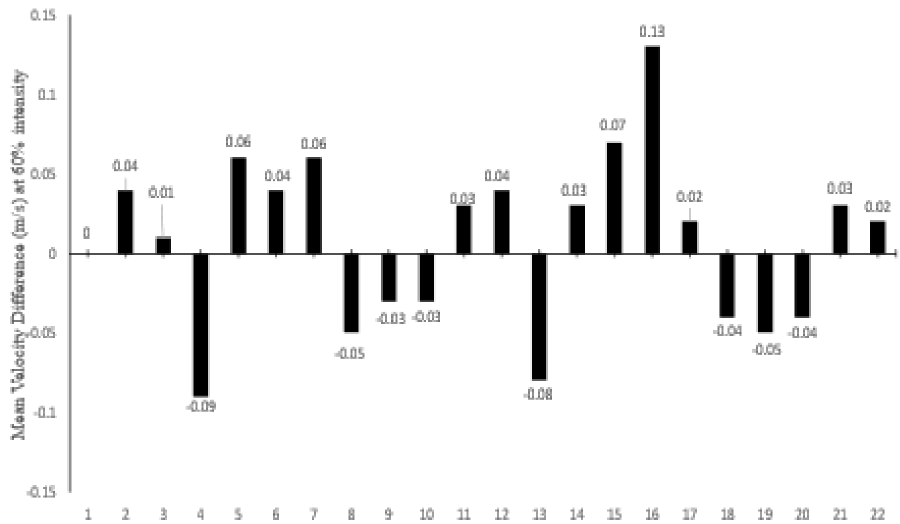
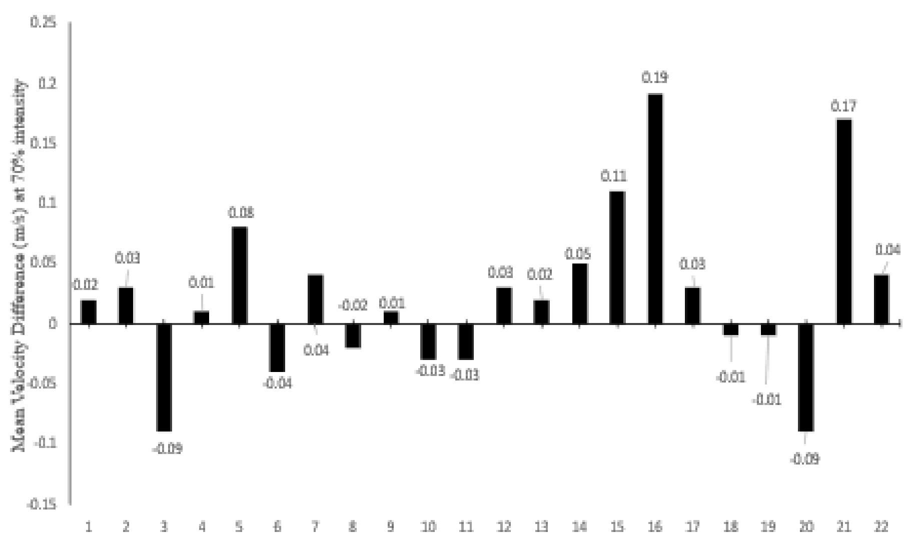
0.07
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

A


Mean Velocity Difference (m/s) at 60% intensity
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0
0.04
0.01
-0.09
0.06
0.04
0.06
-0.05
-0.03
-0.03
0.03
0.04
-0.08
0.03
0.07
0.13
0.02
-0.04
-0.05
-0.04
0.03
0.02
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

B


Mean Velocity Difference (m/s) at 70% intensity
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0.02
0.03
-0.09
0.01
0.08
-0.04
0.04
-0.02
0.01
-0.03
-0.03
0.03
0.02
0.05
0.11
0.19
0.03
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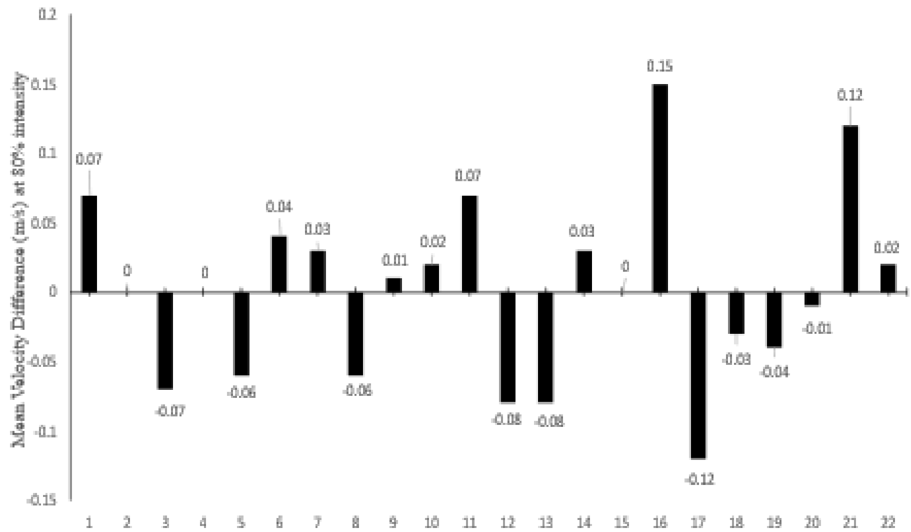
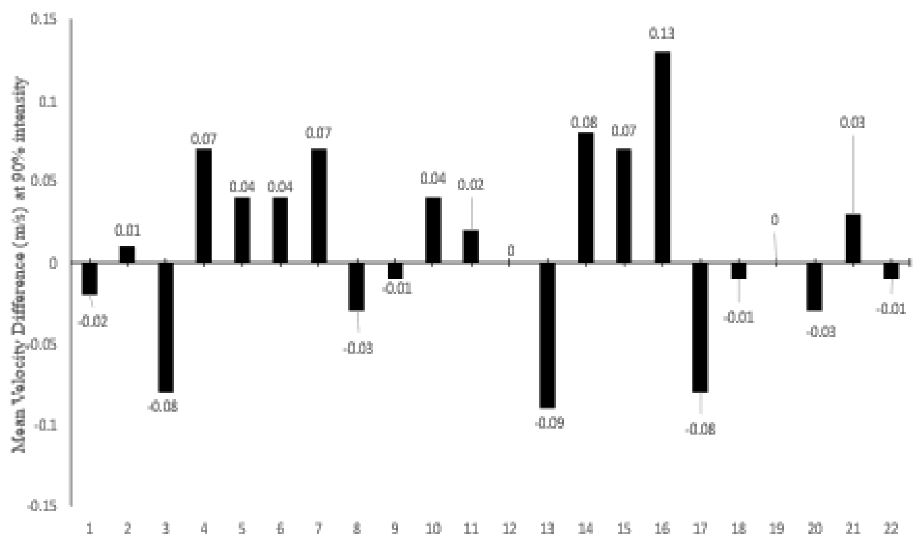
-0.01
-0.09
0.17
0.04
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

C



D



E

Figure 2A-E. Absolute deadlift barbell mean velocity (m/s) difference of the deadlift between drop jump (DJ) and control sessions at 40% (A.), 60% (B.), 70% (C.), 80% (D.), and 90% intensity (E.) for each participant (n = 22).

Note: Positive values indicate greater velocity during the experimental (drop jump) condition, while negative values indicate greater velocity during the control condition. Participant order is consistent across all figures and corresponds to the same intensity levels.

Discussion

The primary objective of this study was to investigate the PAPE phenomenon by evaluating acute mean velocity performance during the deadlift LVP from the addition of between-set DJ exercise. Contrary to our hypothesis, the inclusion of DJs did not result in a statistically significant increase in barbell velocity across loads. Exploratory analyses further indicated that deadlift velocity responses were not meaningfully different when observations were stratified by sex, session order, or relative strength. At the individual level, visual inspection of the data indicated considerable variability in responses to the DJ protocol (Table 2; Figure 2A-E).

This primary finding contrasts with the limited existing literature[9,19] demonstrating improvements in 1RM strength following DJ-based priming protocols. Notably, those studies assessed maximal strength, whereas the current study evaluated barbell velocity across submaximal loads (40–90% 1RM). This methodological difference may partially explain the discrepancy in outcomes.

The non-significant effect of DJs on the deadlift LVP may be attributed to biomechanical and neuromuscular differences between the two exercises. Deadlifts are characterized by slow, high-force output and rely heavily on high-threshold motor unit recruitment,[5,25] whereas DJs are high-velocity, plyometric movements with minimal external load.[22] These differences in kinematic demands and contraction type may reduce the transferability of potentiation effects, particularly in the expression of bar velocity during submaximal deadlifts. Consequently, strength exercises such as the deadlift may be less responsive to plyometric priming strategies like DJs.

Secondary exploratory analyses did not identify statistically significant effects of sex or relative strength on load–velocity profile outcomes. While this contrasts with prior work suggesting stronger individuals may benefit more from PAPE protocols,[14] these differences were not evident in the present study. Consistent with the primary findings, the addition of drop jumps between sets did not produce systematic changes in deadlift velocity at the group level across participant subgroups. Individual-level data further supported this, as some participants demonstrated increased velocity (0.05–0.18 m/s), some decreased (−0.05 to −0.18 m/s), and others showed no meaningful change, suggesting heterogeneous responsiveness to the intervention (Figure 2A–E). These observations are descriptive in nature and highlight the variability of responses rather than providing evidence of subgroup-specific effects.

Several methodological limitations should be acknowledged. First, the use of a standardized 45.72 cm DJ height may not have accounted for individual anthropometric or neuromuscular differences, potentially influencing responsiveness to the priming stimulus.[11] Second, while the 72-hour recovery period between testing sessions aligns with prior studies,[24,26] it may not have been sufficient for all participants, particularly if additional stressors (e.g., academic, occupational, or psychological) were present. Third, the use of variable rest intervals (2–5 min) between the DJ protocol and subsequent deadlift trials may have introduced additional inter-individual variability in the expression of post-activation performance enhancement, as optimal recovery and potentiation timing can differ substantially between individuals. Lastly, although LPTs provide reliable velocity measurements, the absence of additional performance assessments such as force profiling, peak power output, or absolute strength may have limited the ability to fully interpret the mechanisms underlying performance changes.

In conclusion, the implementation of drop jumps had no significant effect on mean barbell velocity during submaximal deadlift loads. Although group-level effects were not observed, notable variability in individual responses (Figure 2A–E) highlights the heterogeneity of potentiation responses and underscores the need for further, *a priori–designed* investigations into potential moderating factors such as anthropometrics, sport background, training experience, and neuromuscular characteristics. These observations should be interpreted as descriptive and hypothesis-generating rather than explanatory. Future research should consider comparing athletic populations to powerlifters, as these groups operate at different ends of the strength–speed continuum.

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