A Preliminary Study: The Effect of Alternative Set Structures and Accentuated Eccentric Loading on Jump Performance in Lower-body Complex Training

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INTRODUCTION

Complex training that incorporates heavy resistance exercises [i.e., back squat (BS)] followed by ballistic movements [e.g., countermovement jump (CMJ)] induces a post-activation performance enhancement (2,7). Alternative set structures (AS) using intra-set rests may expedite recovery after BS (6,9) while accentuated eccentric loading (AEL) with eccentric overload may potentiate the immediate concentric contraction during CMJ (5,10).

PURPOSE

The purpose of this preliminary study was to investigate the synergistic effect of AS and AEL on jump height (JH) and concentric explosive index (EI; JH / concentric contraction time) in lower-body complex training.

METHODS

In this preliminary study, 3 men and 3 women [n = 6; 20.7 ± 0.5 years; 1.62 ± 0.06 m; 67.2 ± 9.7 kg] participated. All subjects had proficient BS and CMJ technique with 113.2 ± 35.5 kg BS one repetition maximum (1RM) and 1.7 ± 0.3 times of body mass strength. On the first visit, subjects completed BS 1RM testing and CMJ familiarization using dumbbells (DB) (≈ 30% of body mass for both sexes) during an eccentric phase. On the second and third visits, all subjects completed one of the following conditions in a randomized and counterbalanced manner.

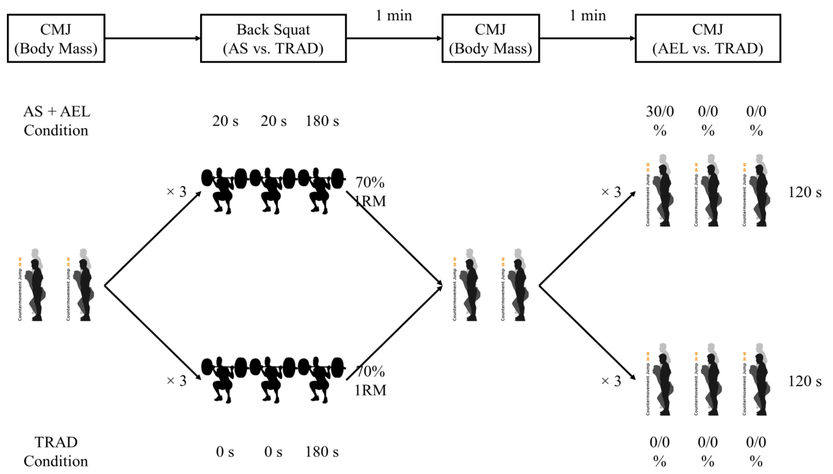
(a) AS + AEL
BS: 3 sets of (3 × 1) repetitions at 70% 1RM with 20 s inter-repetition and 180 s inter-set rests
CMJ: 3 sets of (1 × 3) repetitions with DB at ≈ 30% of body mass on the initial repetition only
(b) traditional methods (TRAD)
BS: 3 sets of (1 × 3) repetitions at 70% 1RM with 180 s inter-set rests
CMJ: 3 sets of (1 × 3) repetitions at body mass for the entire repetition

Data were collected using a linear position transducer (GymAware RS). In both conditions, CMJ was performed without DB before and 1 minute after BS (2 maximal attempts per time point). In an AS + AEL condition, CMJ was performed with DB 2 minutes, 4 minutes, and 6 minutes after BS (3 maximal attempts per time point). Due to the different number of levels across time points and unique study design, separate repeated measures analysis of variance was performed (e.g., 2 conditions × 2 time points × 2 trials for the first two time points and 2 conditions × 3 time points × 3 trials for the last three time points). Data were analyzed using the resampling technique (The R Project for Statistical Computing version 4.3.1). The level of significance was set to 0.05.

RESULTS

Across the first two time points (before BS and 1 minute after BS), there was a main effect of condition for concentric EI (p = 0.003) where AS resulted in greater concentric EI compared to TRAD. Across the last three time points (2, 4, and 6 minutes after BS), there was a condition by trial interaction for JH (p = 0.023) where AEL induced greater JH at the first trial (with DB) but lower JH at the third trial (without DB) compared to TRAD.

EXPERIMENTAL DESIGN



MAIN FINDINGS

Table 1. The results of each trial across the first two time points

	Jump Height (cm)			
	PRE†		1-min Post	
AS†	43.7 ± 10.6	41.7 ± 8.8	40.1 ± 8.1	41.7 ± 8.1
TRAD	41.2 ± 11.4	40.1 ± 9.9	40.6 ± 9.1	39.5 ± 9.9
	Concentric Explosive Index (ratio)			
	PRE		1-min Post†	
AS*‡	0.81 ± 0.15	0.83 ± 0.17	0.82 ± 0.15	0.79 ± 0.10
TRAD	0.79 ± 0.14	0.77 ± 0.16	0.75 ± 0.14	0.74 ± 0.14

* statistically significant (p < 0.05) main effect of condition
† moderate (g = 0.60 – 1.20) and ‡ large (g = 1.20 – 2.00) between-condition effect sizes

Table 2. The results of three trials collapsed across the last three time points

	Jump Height (cm)		
	Trial 1	Trial 2	Trial 3
AEL	42.6 ± 12.0*	39.8 ± 9.3	40.0 ± 9.7*
TRAD	40.0 ± 9.1	41.6 ± 9.4	41.0 ± 8.6
	Concentric Explosive Index (ratio)		
	Trial 1	Trial 2	Trial 3
AEL	0.80 ± 0.18	0.79 ± 0.16	0.76 ± 0.15
TRAD	0.79 ± 0.14	0.80 ± 0.14	0.76 ± 0.12

* statistically significant (p < 0.05) condition by trial interactions

CONCLUSIONS

The results of this preliminary study suggest that AS can expedite recovery (3,4) as early as 1 minute as evidenced by concentric EI maintenance. Moreover, AEL can potentiate JH (1,8) at the repetition with DB but may decrease JH at the repetition where DB is no longer used. A larger sample size is needed to shed light on the synergistic effect of AS and AEL.

PRACTICAL APPLICATIONS

Practitioners may consider twenty seconds of inter-repetition rests during back squat to maintain concentric explosive index during post-exercise countermovement jump. Using dumbbells with thirty percent of body mass during an eccentric phase might need to be integrated into every or every other repetition to extend potentiation.

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REFERENCES

1. Aboodarda, SJ, Yusof, A, Abu Osman, NA, Thompson, MW, and Mokhtar, AH. Enhanced performance with elastic resistance during the eccentric phase of a countermovement jump. *Int J Sports Physiol Perform* 8: 181–187, 2013.
2. Blazevich, AJ and Babault, N. Post-activation potentiation versus post-activation performance enhancement in humans: Historical perspective, underlying mechanisms, and current issues. *Front Physiol* 10: 1359, 2019.
3. Boullosa, DA, Abreu, L, Beltrame, LGN, and Behm, DG. The acute effect of different half squat set configurations on jump potentiation. *J Strength Cond Res* 27: 2059–2066, 2013.
4. Dello Iacono, A, Beato, M, and Halperin, I. The effects of cluster-set and traditional-set postactivation potentiation protocols on vertical jump performance. *Int J Sports Physiol Perform* 1–6, 2019.
5. Handford, MJ, Rivera, FM, Maroto-Izquierdo, S, and Hughes, JD. Plyo-accentuated eccentric loading methods to enhance lower limb muscle power. *Strength Cond J* 43: 54–64, 2021.
6. Jukic, I, Ramos, AG, Helms, ER, McGuigan, MR, and Tufano, JJ. Acute effects of cluster and rest redistribution set structures on mechanical, metabolic, and perceptual fatigue during and after resistance training: A systematic review and meta-analysis. *Sports Med* 50: 2209–2236, 2020.
7. Prieske, O, Behrens, M, Chaabene, H, Granacher, U, and Maffiuletti, NA. Time to differentiate postactivation “potentiation” from “performance enhancement” in the strength and conditioning community. *Sports Med* 50: 1559–1565, 2020.
8. Sheppard, J, Newton, R, and McGuigan, M. The effect of accentuated eccentric load on jump kinetics in high-performance volleyball players. *International Journal of Sports Science & Coaching* 2: 267–273, 2007.
9. Tufano, JJ, Brown, LE, and Haff, GG. Theoretical and practical aspects of different cluster set structures: A systematic review. *J Strength Cond Res* 31: 848–867, 2017.
10. Wagle, JP, Taber, CB, Cunanan, AJ, et al. Accentuated eccentric loading for training and performance: A review. *Sports Med* 47: 2473–2495, 2017.