Hyperventilation-Induced Respiratory Alkalosis Has Little Effect in Attenuating the Reduction of Lifting Velocity During Repeated Maximum Bench Press Throws and Squat Jumps

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Background: Ballistic training with projectile motions has proven to be more effective in improving power compared to the conventional resistance training without projectile motions. This is based on the fact that projectile motions minimize the deceleration of lifting required near the end of each concentric phase for the phase transition, allowing the trainees to exert greater velocity and power output. Recently, hyperventilation-induced respiratory alkalosis has been shown to attenuate performance decrement during repeated high power tasks, such as intermittent short pedaling sprints and heavy-loaded resistance training, via accelerated recovery from severe lactic acidosis. The resulting enhancement of power output during training with the aid of hyperventilation, particularly after fatigue, may increase the effectiveness of power training by incurring greater adaptive stimuli. However, the influence of hyperventilation on lifting velocity during repeated maximum ballistic training has not been studied to date.

Methods: Nine power-trained athletes (two females and seven males) performed maximum bench press throws and squat jumps at 40% 1 RM (12 reps $\times$ 5 sets for both exercises) with (HV) and without hyperventilation (CON). Their 1 RM values were as follows: bench press = 50.0~52.5 kg for females and 110.0~155.0 for males, squat = 75.0~87.5 kg for females and 152.5~200.0 kg for males. The durations of inter-set recovery for bench press throws and squat jumps were respectively 3-min and 5-min. For the CON condition, each exercise set was preceded by spontaneous breathing. For the HV condition, subjects hyperventilated (V_E : 117~120 l/min, resp. rate: 53~56 breaths/min, TV_E : 2,212~2,250 ml) during the last 30-s of inter-set recovery before the 3rd, 4th and 5th sets to render $P_{ET}CO_2$ between 15~25 mmHg. Wireless electro-goniometers were attached about the elbow and the knee joints to calculate the peak and mean concentric joint angular velocities per repetition (V_{peak} and V_{mean} , respectively). Blood $[La^-]$, pH and PCO_2 were examined to report physiological strains of the exercises, and to verify pH recovery and CO_2 excretion resulting from HV.

Results: HV intervention increased blood pH by 0.006~0.078 ($p \leq 0.005$) and lowered PCO_2 by 5.6~8.8 mmHg ($p \leq 0.001$). For bench press throws, the declines in V_{peak} and V_{mean} were similar between the two breathing conditions. For squat jumps, HV showed no effect on V_{peak} . The decline of V_{mean} with reps was, however, smaller for the HV condition. After the exercise, the blood $[La^-]$ was greater (9.46 ± 2.43 vs. 5.54 ± 1.54 mM, $p < 0.001$) and pH was lower (7.280 ± 0.061 vs. 7.372 ± 0.059 , $p < 0.001$) for squat jumps than bench press throws. The increase in blood $[La^-]$ was not interacted by the breathing conditions.

Conclusion: Hyperventilation-induced alkalosis did not enhance peak and mean concentric velocities during repeated bench press throws, but demonstrated small ergogenic effects on the mean concentric velocity during squat jumps, which imposed greater physiological strains than bench press throws. Enhanced glycolytic energy supply, expected from implementing hyperventilation, was not evidenced from the blood $[La^-]$ results.

Key words: ballistic training, power training, hypocapnia, fatigue

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