Caffeine and the Resistance-Trained Athlete

Travis W. Beck, Ph.D.
University of Nebraska-Lincoln
e-mail: tbeck@unlserve.unl.edu
Phone: (402) 472-2690

Acute Effects of Caffeine On Strength and Neuromuscular Function

Mechanisms for Caffeine

1. Central - Increase descending drive from the motor cortex by blocking the inhibitory effects of adenosine. This may improve the ability to achieve maximal muscle activation.
2. Peripheral - Alter excitation-contraction coupling.

Acute Effects of Caffeine On Strength

Kalmar JM, Cafarelli E. Effects of caffeine on neuromuscular function. *J. Appl. Physiol.* 1999;87:801-808

Design = Double-blinded, placebo-controlled

Subjects = Eleven healthy men

Dosage = 6 mg/kg body weight taken 1-hour prior to testing

Placebo = Wheat flour

Dependent variables =

1. Percent voluntary activation of the quadriceps femoris muscles (assessed with twitch interpolation)
2. Unilateral isometric leg extension force
3. EMG amplitude for the vastus lateralis muscle
4. 50% MVC endurance time

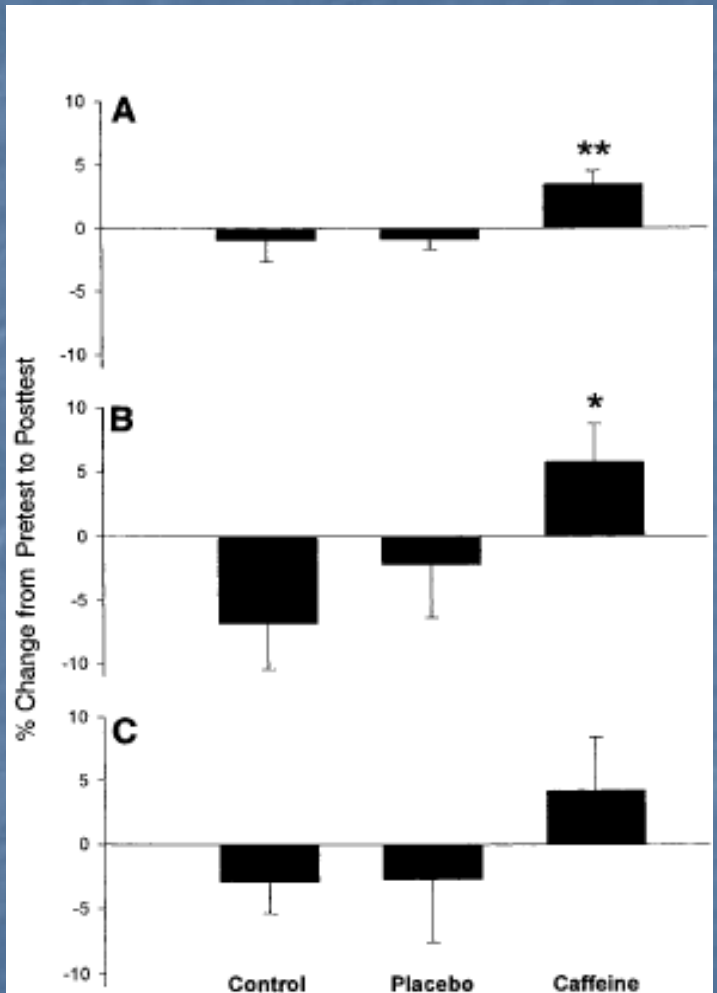


Fig. 3. Voluntary activation, peak force, and maximal EMG (EMG_{max}). Data were collected from *part B* of protocol. Percent change from pretest to posttest is shown for voluntary activation (*A*), MVC (*B*), and vastus lateralis EMG_{max} (*C*). * $P < 0.05$. ** $P < 0.01$.

Acute Effects of Caffeine On Strength

Kalmar JM, Cafarelli E. Effects of caffeine on neuromuscular function. *J. Appl. Physiol.* 1999;87:801-808

Results

1. Caffeine resulted in significant increases in voluntary activation (approx. 3% change), isometric leg extension force (approx. 6% change), and 50% MVC endurance time (25.8% change).

Acute Effects of Caffeine On Strength

Kalmar JM, Cafarelli E. Effects of caffeine on neuromuscular function. *J. Appl. Physiol.* 1999;87:801-808

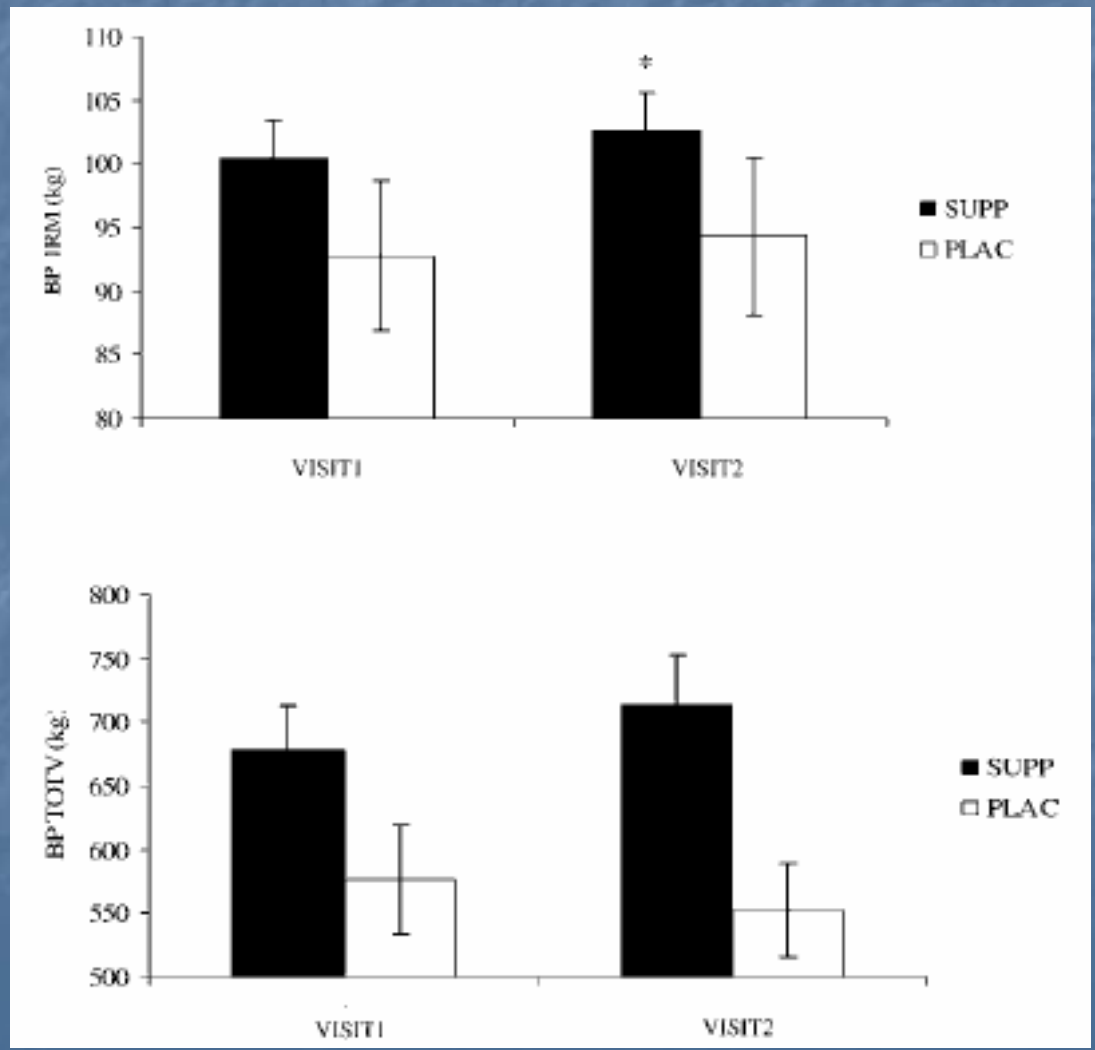
Potential Explanations

1. Peripheral effects of caffeine (i.e., at the muscle fiber level) have only been demonstrated at dosages that would be toxic to humans.
2. Inhibition of adenosine could improve neurotransmitter release and increase neuronal firing rates.
3. There was no change in H-reflex amplitude (used to assess motor neuron excitability). Thus, the changes in muscle activation, strength and endurance were attributed to supraspinal mechanisms.

Acute Effects of Caffeine On Strength

Beck TW, Housh TJ, Schmidt RJ, Johnson GO, Housh DJ, Coburn JW, Malek MH. The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities. *J. Strength Cond. Res.* 2006;20:506-510

- Design = Double-blinded, placebo-controlled
- Subjects = 37 resistance-trained men
- Dosage = 201 mg taken 1-hour prior to testing
- Placebo = Microcrystalline cellulose
- Dependent variables =
  1. One-repetition maximum (1-RM) bench press strength
  2. Bench press total volume (total volume of weight lifted during an endurance test with 80% of the 1-RM)
  3. 1-RM leg extension strength
  4. Leg extension total volume



Acute Effects of Caffeine On Strength

Beck TW, Housh TJ, Schmidt RJ, Johnson GO, Housh DJ, Coburn JW, Malek MH. The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities. *J. Strength Cond. Res.* 2006;20:506-510

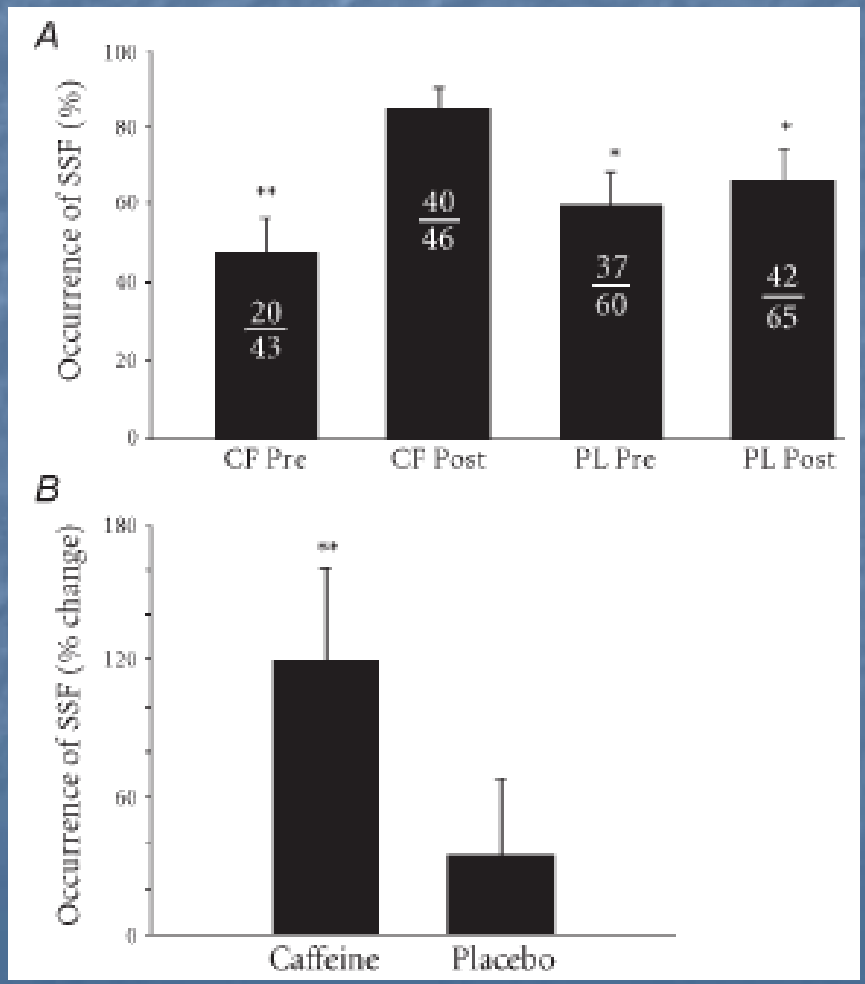
Conclusions

1. The acute effects of caffeine could be influenced by both training status and the type of exercise being performed (upper- vs. lower-body).
2. Caffeine may result in increases in strength, with no changes in muscular endurance.

Acute Effects of Caffeine On Neuromuscular Function

Walton C, Kalmar JM, Cafarelli E. Effect of caffeine on self-sustained firing in human motor units. *J. Physiol*. 2002;545.2:671-679

- Design = Double-blinded, placebo-controlled
- Subjects = Seven healthy men
- Dosage = 6 mg/kg body weight taken 1-hour prior to testing
- Placebo = Wheat flour
- Dependent variable =
  1. Occurrence of self-sustained firing of motor units in the tibialis anterior muscle. Self-sustained firing is the continued firing of a motor unit even with a decrease in synaptic drive (i.e., the motor unit continues firing almost on its own).



Acute Effects of Caffeine On Neuromuscular Function

Walton C, Kalmar JM, Cafarelli E. Effect of caffeine on self-sustained firing in human motor units. *J. Physiol.* 2002;545.2:671-679

Results

1. Caffeine resulted in a significant increase in the occurrence of self-sustained firing when compared to placebo.

Conclusions

1. Caffeine may help to maintain the firing of motor units, even with decreased neural drive from the central nervous system.

Acute Effects of Caffeine On Neuromuscular Function

Walton C, Kalmar J, Cafarelli E. Caffeine increases spinal excitability in humans. *Muscle Nerve* 2003;28:359-364

Design = Double-blinded, placebo-controlled

Subjects = Seven healthy men

Dosage = 6 mg/kg body weight taken 1-hour prior to testing

Placebo = Wheat flour

Dependent variable =

1. Ratio of slopes of H-reflex and M-wave recruitment curves (i.e., used to estimate motor neuron excitability).

Acute Effects of Caffeine On Neuromuscular Function

Walton C, Kalmar J, Cafarelli E. Caffeine increases spinal excitability in humans. *Muscle Nerve* 2003;28:359-364

Results

1. Caffeine resulted in a significant increase in motor neuron excitability.

Explanations

1. Caffeine may increase descending drive to motor neurons.
2. Caffeine may increase the resting membrane potential such that the motor neuron reaches threshold more easily.

Implications

1. Caffeine could make it easier to recruit motor units with very high thresholds. This may improve the ability to maximally activate the muscle, thereby facilitating force production.

Acute Effects of Caffeine on Anaerobic Power

Acute Effects of Caffeine on Anaerobic Power

Anselme F, Collomp K, Mercier B, Ahmaïdi S, Prefaut Ch. Caffeine increases maximal anaerobic power and blood lactate accumulation. *Eur. J. Appl. Physiol.* 1992;65:188-191

Design = Double-blinded, placebo-controlled, crossover

Subjects = Ten men and four women

Dosage = 250 mg taken 30-min prior to testing

Placebo = Lactose

Dependent variables =

1. Maximal power output during 6-sec cycle ergometer sprints at various loads
2. Blood lactate concentration immediately after each sprint
3. Blood lactate concentration 5-min after each sprint

Acute Effects of Caffeine on Anaerobic Power

Anselme F, Collomp K, Mercier B, Ahmaïdi S, Prefaut Ch. Caffeine increases maximal anaerobic power and blood lactate accumulation. *Eur. J. Appl. Physiol.* 1992;65:188-191

Results

1. The mean (± SEM) peak power output for the placebo condition was 903.7 ± 52.62 Watts, while the corresponding peak power output for the caffeine condition was 964.0 ± 65.8 Watts.
2. Caffeine resulted in significant increases in blood lactate concentrations both immediately following, and 5-min after each sprint.

Acute Effects of Caffeine on Anaerobic Power

Anselme F, Collomp K, Mercier B, Ahmaïdi S, Prefaut Ch. Caffeine increases maximal anaerobic power and blood lactate accumulation. *Eur. J. Appl. Physiol.* 1992;65:188-191

Explanations

1. Caffeine may have resulted in high intracellular calcium concentrations. The increased calcium concentrations may have resulted in increased muscle contractility.
2. Caffeine could have improved the process of lactate release from the muscle, thereby increasing both peak power output and blood lactate concentration.

Acute Effects of Caffeine on Anaerobic Power

Collomp K, Ahmaidi S, Audran M, Chanal J-L, Prefaut Ch. Effects of caffeine ingestion on performance and anaerobic metabolism during the Wingate Test. *Int. J. Sports Med.* 1991;12:439-443

Design = Double-blinded, placebo-controlled, crossover

Subjects = Three men and three women

Dosage = 5 mg/kg of body weight taken 1-hour prior to performing a Wingate Test

Placebo = Gelatin

Dependent variables =

1. Peak power output
2. Mean power output
3. Fatigue index
4. Plasma lactate, glucose, insulin, and catecholamine (epinephrine and norepinephrine) concentrations were measured before and immediately after the Wingate Test.

Acute Effects of Caffeine on Anaerobic Power

Collomp K, Ahmaidi S, Audran M, Chanal J-L, Prefaut Ch. Effects of caffeine ingestion on performance and anaerobic metabolism during the Wingate Test. *Int. J. Sports Med.* 1991;12:439-443

Results

1. Caffeine had no effect on peak power output, mean power output, fatigue index, and plasma glucose and insulin levels.
2. Caffeine resulted in increased blood lactate and catecholamine concentrations.

Acute Effects of Caffeine on Anaerobic Power

Collomp K, Ahmaidi S, Audran M, Chanal J-L, Prefaut Ch. Effects of caffeine ingestion on performance and anaerobic metabolism during the Wingate Test. *Int. J. Sports Med.* 1991;12:439-443

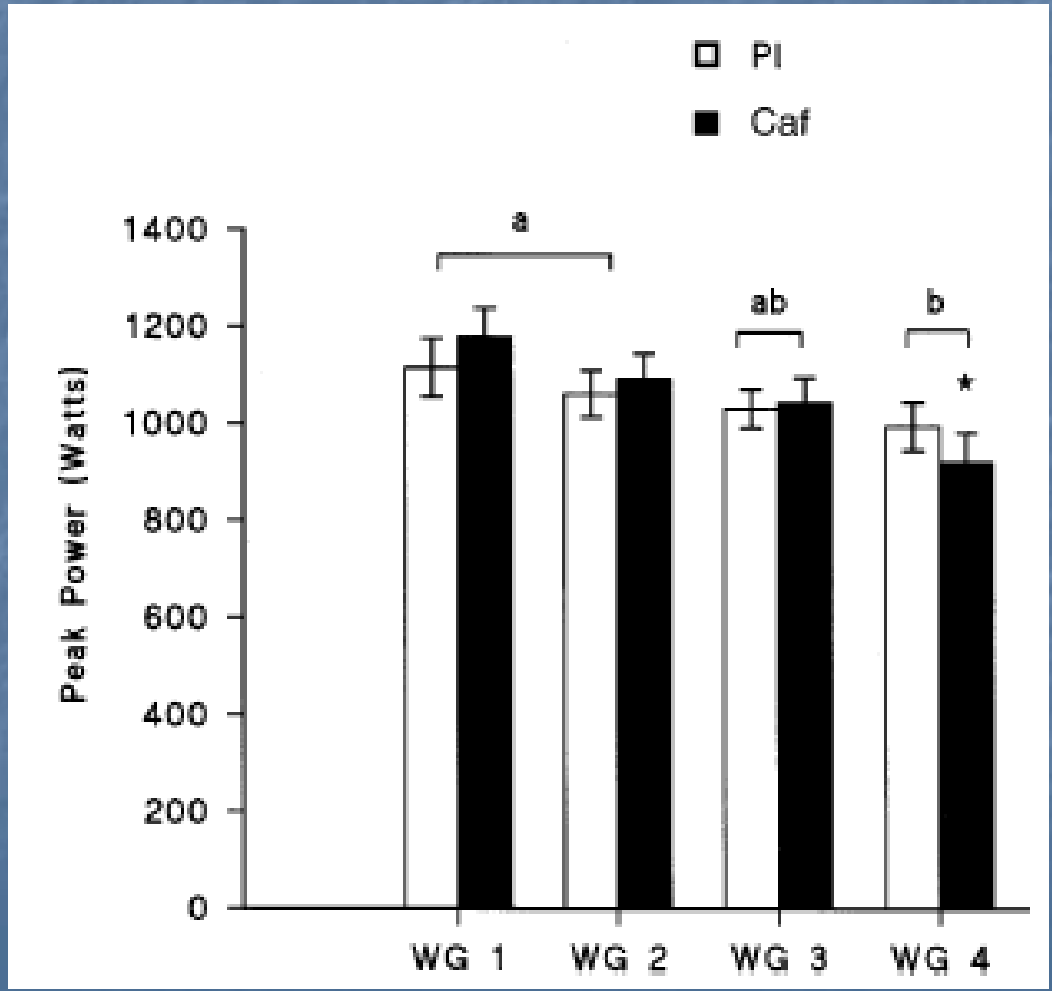
Explanations

1. The increases in blood lactate and catecholamine concentrations, with no changes in the performance variables, suggested that extra pyruvate production during glycolysis may have been converted primarily to lactate.
2. Another potential explanation is that caffeine may enhance performance only for trained subjects.

Acute Effects of Caffeine on Anaerobic Power

Greer F, McLean C, Graham TE. Caffeine, performance, and metabolism during repeated Wingate exercise tests. *J. Appl. Physiol.* 1998;85:1502-1508

- Design = Double-blind, placebo-controlled, crossover
- Subjects = Nine healthy men
- Dosage = 6 mg/kg body weight taken 1-hour prior to testing
- Placebo = Dextrose
- Dependent variables =
  1. Peak power output during 4 Wingate Tests, separated by 4 minutes of rest.
  2. Mean power output during the Wingate Tests
  3. Rate of power loss (W/sec) during the Wingate Tests
  4. Plasma levels of caffeine, epinephrine, norepinephrine, glucose, glycerol, ammonia, potassium, and lactate.
  5. Oxygen consumption rate and the percent aerobic contribution to energy production.



Acute Effects of Caffeine on Anaerobic Power

Greer F, McLean C, Graham TE. Caffeine, performance, and metabolism during repeated Wingate exercise tests. *J. Appl. Physiol.* 1998;85:1502-1508

Results

1. Caffeine had no effect on peak power output, mean power output, rate of power loss, or any of the blood chemistry parameters measured during the Wingate Tests.
2. Caffeine also had no effect on oxygen consumption rate or the percent aerobic contribution to energy production.

Acute Effects of Caffeine on Anaerobic Power

Greer F, McLean C, Graham TE. Caffeine, performance, and metabolism during repeated Wingate exercise tests. *J. Appl. Physiol.* 1998;85:1502-1508

Conclusions

1. Caffeine does not result in acute increases in power output during high-intensity anaerobic exercise.
2. Caffeine also has no effect on anaerobic metabolism during exercise.

Acute Effects of Caffeine on Anaerobic Power

Collomp K, Ahmaidi S, Chatard JC, Audran M, Préfaut Ch. Benefits of caffeine ingestion on sprint performance in trained and untrained swimmers. *Eur. J. Appl. Physiol.* 1992;64:377-380

Design = Double-blind, placebo-controlled, crossover

Subjects = Seven trained swimmers and seven untrained subjects

Dosage = 250 mg taken one hour prior to testing

Placebo = Gelatin

Dependent variables =

1. Average swimming velocity during two separate 100 meter sprints
2. Blood lactate values during rest, as well as immediately after the first and second 100-m sprints.

Acute Effects of Caffeine on Anaerobic Power

Collomp K, Ahmaidi S, Chatard JC, Audran M, Préfaut Ch. Benefits of caffeine ingestion on sprint performance in trained and untrained swimmers. *Eur. J. Appl. Physiol.* 1992;64:377-380

Results

1. Caffeine ingestion resulted in significant increases in mean swimming velocity during both 100 meter sprints for the trained swimmers, but not for the untrained subjects.
2. Caffeine resulted in significant increases in blood lactate values (compared to placebo) after both 100 meter sprints in the trained swimmers and untrained subjects.

Acute Effects of Caffeine on Anaerobic Power

Collomp K, Ahmaidi S, Chatard JC, Audran M, Préfaut Ch. Benefits of caffeine ingestion on sprint performance in trained and untrained swimmers. *Eur. J. Appl. Physiol.* 1992;64:377-380

Conclusions

1. Caffeine may improve anaerobic performance only for trained subjects.
2. Caffeine may increase the rate of anaerobic glycolysis and/or promote lactate release, both of which could increase plasma lactate concentrations.
3. Caffeine may be useful for repeated bouts of anaerobic exercise, which are common in sports such as swimming, track and field, wrestling, football, and basketball.

Acute Effects of Caffeine on Anaerobic Power

Bell DG, Jacobs I, Ellerington K. Effect of caffeine and ephedrine ingestion on anaerobic exercise performance. *Med. Sci. Sports Exerc.* 2001;33:1399-1403

Design = Double-blind, placebo-controlled

Subjects = 16 men

Treatments = Caffeine (5 mg/kg body weight), Ephedrine (1 mg/kg body weight), or Caffeine + Ephedrine

Placebo = Dietary fiber

Dependent variables =

1. Power output at 5-sec increments during a Wingate Test.
2. Blood lactate and glucose concentrations prior to, and 3, 5, and 10 minutes after the Wingate Test
3. Blood catecholamine concentrations (epinephrine, norepinephrine, and dopamine) prior to, and 10 minutes after the Wingate Test

Acute Effects of Caffeine on Anaerobic Power

Bell DG, Jacobs I, Ellerington K. Effect of caffeine and ephedrine ingestion on anaerobic exercise performance. *Med. Sci. Sports Exerc.* 2001;33:1399-1403

Results

1. Ephedrine and Caffeine + Ephedrine resulted in significant increases in power output during the first 10 seconds of the Wingate Test. Caffeine alone, however, had no effect on power output.
2. Both the caffeine and ephedrine treatments resulted in increased blood lactate concentrations after exercise.
3. Caffeine and ephedrine also caused increased plasma glucose levels pre- and post-exercise.
4. The caffeine and caffeine + ephedrine treatments were associated with increased plasma epinephrine levels pre- and post-exercise.

Acute Effects of Caffeine on Anaerobic Power

Bell DG, Jacobs I, Ellerington K. Effect of caffeine and ephedrine ingestion on anaerobic exercise performance. *Med. Sci. Sports Exerc.* 2001;33:1399-1403

Conclusions

1. Caffeine alone had no effect on performance during the Wingate Test, but the combination of caffeine and ephedrine increased power output during the first ten seconds of the Wingate Test.
2. Changes in blood chemistry parameters (e.g., lactate, glucose, and epinephrine) following ingestion of caffeine, ephedrine, or both may not be accompanied by increases in performance during the Wingate Test.

Acute Effects of Caffeine on Anaerobic Power

Beck TW, Housh TJ, Schmidt RJ, Johnson GO, Housh DJ, Coburn JW, Malek MH. The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities. *J. Strength Cond. Res.* 2006;20:506-510

Dependent Variables

1. Peak power output from back-to-back Wingate Tests (separated by 7-min of rest)
2. Mean power output from the two Wingate Tests

Acute Effects of Caffeine on Anaerobic Power

Beck TW, Housh TJ, Schmidt RJ, Johnson GO, Housh DJ, Coburn JW, Malek MH. The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities. *J. Strength Cond. Res.* 2006;20:506-510

Results and Conclusions

1. Caffeine had no effect on peak power or mean power.
2. The acute effects of caffeine on anaerobic power may be influenced by the dosage taken and the type of activity that was performed.