

# Safety and Efficacy of Energy Drinks: Implications on Health and Performance



**Richard B. Kreider, PhD, FACSM, FISSN**  
Professor & Head, Department of Health & Kinesiology  
Thomas A. & Joan Read Endowed Chair for Disadvantaged Youth  
Director, Exercise & Sport Nutrition Lab  
Texas A&M University

[rkreider@hlkn.tamu.edu](mailto:rkreider@hlkn.tamu.edu)  
[ExerciseAndSportNutritionLab.com](http://ExerciseAndSportNutritionLab.com)



COI's: Current research funding from Curves International, Woodbolt International, & Anderson Global Group.  
Former expert witness on behalf of 5-Hour Energy



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# Energy Drinks

- ED's have become a popular pre- and post-exercise drink among athletes
- Hoyte (*J Community Health*. 38(3):575-80, 2013) reported that 85.9% of college students reported using ED's
- Concerns have been raised about excessive use of ED's in children and adolescents; use of ED's with alcohol; and, excessive consumption of ED's in populations with medical conditions (e.g., diabetics, CV disease, hpyertensives, etc.)



# Overview

- Composition of ED's and ES's
- Ergogenic Value of Common Ingredients
- Available Research
- Safety Considerations
- ISSN Position

Campbell et al. *Journal of the International Society of Sports Nutrition* 2013, **10**:1  
<http://www.jissn.com/content/10/1/1>



REVIEW

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## International Society of Sports Nutrition position stand: energy drinks

Bill Campbell<sup>1†</sup>, Colin Wilborn<sup>2†</sup>, Paul La Bounty<sup>3</sup>, Lem Taylor<sup>2†</sup>, Mike T Nelson<sup>4</sup>, Mike Greenwood<sup>5†</sup>, Tim N Ziegenfuss<sup>6</sup>, Hector L Lopez<sup>2</sup>, Jay R Hoffman<sup>7</sup>, Jeffrey R Stout<sup>2</sup>, Stephen Schmitz<sup>8†</sup>, Rick Collins<sup>9†</sup>, Doug S Kalman<sup>10</sup>, Jose Antonio<sup>11\*</sup> and Richard B Kreider<sup>2\*</sup>

### Abstract

**Position Statement:** The International Society of Sports Nutrition (ISSN) bases the following position stand on a critical analysis of the literature on the safety and efficacy of the use of energy drinks (ED) or energy shots (ES). The ISSN has concluded the following. 1. Although ED and ES contain a number of nutrients that are purported to affect mental and/or physical performance, the primary ergogenic nutrients in most ED and ES appear to be carbohydrate and/or caffeine. 2. The ergogenic value of caffeine on mental and physical performance has been well-established but the potential additive benefits of other nutrients contained in ED and ES remains to be determined. 3. Consuming ED 10-60 minutes before exercise can improve mental focus, alertness, anaerobic performance, and/or endurance performance. 4. Many ED and ES contain numerous ingredients; these products in particular merit further study to demonstrate their safety and potential effects on physical and mental performance. 5. There is some limited evidence that consumption of low-calorie ED during training and/or weight loss trials may provide ergogenic benefit and/or promote a small amount of additional fat loss. However, ingestion of higher calorie ED may promote weight gain if the energy intake from consumption of ED is not carefully considered as part of the total daily energy intake. 6. Athletes should consider the impact of ingesting high glycemic load carbohydrates on metabolic health, blood glucose and insulin levels, as well as the effects of caffeine and other stimulants on motor skill performance. 7. Children and adolescents should only consider use of ED or ES with parental approval after consideration of the amount of carbohydrate, caffeine, and other nutrients contained in the ED or ES and a thorough understanding of the potential side effects. 8. Indiscriminate use of ED or ES, especially if more than one serving per day is consumed, may lead to adverse events and harmful side effects. 9. Diabetics and individuals with pre-existing cardiovascular, metabolic, hepatorenal, and neurologic disease who are taking medications that may be affected by high glycemic load foods, caffeine, and/or other stimulants should avoid use of ED and/or ES unless approved by their physician.

### Introduction

According to published research, energy drinks (ED) are the most popular dietary supplement besides multivitamins in the American adolescent and young adult population [1-3]. ED are also reported to be the most popular supplement among British athletes [4]. More recently, energy shots (ES) have also been purported to possess ergogenic value on mental focus and/or performance [5]. It is important to make a distinction between ED,

ES, and sports drinks. Sports drinks are a unique category within the beverage industry and are marketed to consumers with the primary function of promoting hydration, replacing electrolytes and sustaining endurance performance capacity. They typically provide a small amount of carbohydrate (e.g., 6-8 grams/100 ml) and electrolytes (sodium, potassium, calcium, magnesium). ED, on the other hand, typically contain higher amounts of carbohydrate along with nutrients purported to improve perceptions of attention and/or mental alertness. Low calorie ED are also marketed to increase mental alertness, energy metabolism, and performance. Energy shots are typically 2-4 oz. servings of concentrated fluid

\*Correspondence: [kreider@iissn.tamu.edu](mailto:kreider@iissn.tamu.edu)

†Equal contributors

<sup>1</sup>Exercise & Sport Nutrition Lab, Department of Health & Kinesiology, Texas A&M University, College Station, Texas, TX 77843-4243, USA

Full list of author information is available at the end of the article



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Campbell et al. *JISSN*. 10:1, 2013

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# Composition of Energy Drinks and Energy Shots

# Energy Drinks / Shots

- Typically contain water, carbohydrates, vitamins, minerals, and “proprietary blends” of various nutrients purported to increase energy, alertness, metabolism, and/or performance.
- Ingestion of ED or ES prior to, during, and/or following exercise could have some ergogenic value.



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## Example of Energy Drink Ingredients

Ingredient	A	B	C	D	E
Calories	100	110	140	120	140
Carbohydrate	27	28	31	32	30
Calories from Fat	-	-	-	-	-
Vitamin C	-	100 mg	-	100 mg	6.7mg
Thiamin	-	0.1 mg	-	-	0.2 mg
Riboflavin B2	1.7 mg	1.5 mg	3.4 mg	20%	0.2 mg
Niacin B3	20 mg	21.7 mg	20 mg	10%	2.2 mg
Vitamin B6	40 mg	2.1 mg	2 mg	10%	1.5 mg
Vitamin B12	6 mcg	4.5 mcg	6 mcg	10%	4.7 mcg
Pantothenic Acid	-	36 mg	-	10%	1.1 mg
Sodium	180 mg	200 mg	40 mg	75 mg	190 mg
Potassium	-	10 mg	10 mg	-	65 mg
Phosphorus	-	-	-	40 mg	90 mg
Taurine	1,000 mg	600 mg	1000 mg	-	-
Panax Ginseng	200 mg	-	25	-	-
Proprietary Blend	2,500 mg L-Carnitine, Glucose, Caffeine, Guarana, Inositol, Glucuronolactone, Maltodextrin	Caffeine (77 mg)	325 mg Ginko Biloba (150 mg), Caffeine (80 mg), Guarana (25 mg), Inositol (25 mg), L- Carnitine (25 mg), Milk Thistle (20 mg)	Guarana, maltodextrin, caffeine, taurine, panax ginseng, calcium	Citrulline Malate, L- Glutamine, L-Arginine, Quercetin, L-Leucine, L-Valine,

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# Example of Energy Shot Ingredients

Ingredient	A	B	C	D	E
Calories	4	4	20	9	0
Carbohydrate	-	-	4 g	1 g	0
Calories from Fat	-	-	-	-	-
Vitamin C	-	100 mg	-	-	126%
Niacin	30 mg	33 mg	33 mg	-	-
Vitamin B6	40 mg	40 mg	40 mg	-	-
Folic Acid	400 mcg	400 mcg	400 mcg	-	-
Vitamin B12	500 mcg	500 mcg	500 mcg	-	-
Sodium	18 mg	0 mg	0 mg	-	10
Potassium	-	10 mg	10 mg	-	26
Proprietary Blend	1,870 mg Taurine, Glucuronolactone, Malic Acid, N-Acetyl L-Tyrosine, L- Phenylalanine, Caffeine, Citocoline	2,300 mg Glucouronolactone (425 mg), N-Acetyl L- Tyrosine (400 mg), L- Phenylalanine (375 mg), Taurine (350 mg), Malic Acid 300 mg), Caffeine (200 mg), Green Tea Extract (150 mg), Ginseng Extract (150 mg)	2,200 mg Glucouronolactone (420 mg), L-Phenylalanine (380 mg), D-Ribose (350 mg), N-Acetyl L-Tyrosine (325 mg), Malic Acid (300 mg), Caffeine (175 mg), Green Tea Extract (150 mg), Ginseng Extract (100 mg)	910 mg Caffeine Citrate, Caffeine Anhydrous, Evoburn, Octapomine, Gugulsterone E & Z, Yerbe Mate, Green Tea, Synephrine, cAMP, Vinocetine, Yohimbe HCL	527 mg Beta-Alanine, Vitamin C, Caffeine Anhydrous (158 mg), Evoburn, N- Acetyl-L-Tyrosine, Hordinine, 5-Hydroxy-L- Tryptophan (5-HTP), Potassium, N-methyl Tyramine, Sulbutlamine, Vinpocetine, Yohimbine HCl, St. John's Wort Extract

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# Potential Ergogenic Value

# Potential Ergogens

- Caffeine
- Carbohydrate
- Nutrients that promote mental focus / cognition
- Stimulants
- Other Nutrients



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# Caffeine

- Most common ingredient utilized in energy drinks.
- Extracted from the raw fruit of over sixty species of coffee plants (*coffea Arabica*), part of methylxanthine family
- Also extracted from tea, kola nuts, and cocoa
- Quickly absorbed and increases plasma concentrations within 30 – 60 minutes following ingestion and generally has a half-life of 2-10 hours
- Physiological effects vary depending on type and amount ingested and generally last 2-4 hours



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## ISSN Position Stand - Caffeine

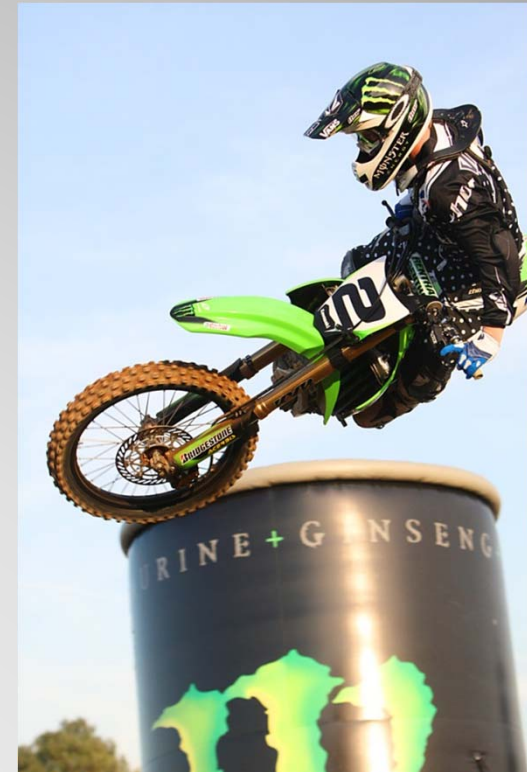


- Caffeine is effective for enhancing sport performance in trained athletes when consumed in low-to-moderate dosages ( $\sim 3\text{-}6$  mg/kg) and overall does not result in further enhancement in performance when consumed in higher dosages ( $\geq 9$  mg/kg).
- Caffeine exerts a greater ergogenic effect when consumed in an anhydrous state as compared to coffee.
- Caffeine can enhance vigilance during bouts of extended exhaustive exercise, as well as periods of sustained sleep deprivation.
- Caffeine is ergogenic for sustained maximal endurance exercise, and has been shown to be highly effective for time-trial performance.

Goldstein et al. JISSN. 7:5, 2010

## ISSN Position Stand - Caffeine

- Caffeine supplementation is beneficial for high-intensity exercise, including team sports such as soccer and rugby, both of which are categorized by intermittent activity within a period of prolonged duration.
- The literature is equivocal when considering the effects of caffeine supplementation on strength-power performance, and additional research in this area is warranted.
- The scientific literature does not support caffeine-induced diuresis during exercise, or any harmful change in fluid balance that would negatively affect performance.



Goldstein et al. JISSN. 7:5, 2010

# Energy Drinks

## *Caffeine Considerations*

- Most provide a similar amount of caffeine as a premium cup of coffee (e.g., 75 – 200 mg serving)
- Use of ED's or ES's prior to and/or during exercise can serve as an effective means of providing caffeine
- Must consider all sources of caffeine and stimulants in drinks/shots
- Must make sure excessive caffeine intake doesn't decrease motor skills
- Caffeine is no longer a banned substance by the IOC or WADA



## Carbohydrate

- ED's typically contain a carbohydrate source (e.g., glucose, sucrose, maltodextrin, etc.) and/or glucuronolactone (an ingredient involved in ascorbic acid synthesis and metabolized into xylulose).
- Ergogenic mechanisms include maintaining blood glucose levels; maintaining high levels of carbohydrate oxidation; and, the sparing of liver and possibly skeletal muscle glycogen during exercise.
- Peak rates of carbohydrate oxidation are commonly around 1 g of carbohydrate per minute or 60 g/hr.
- Glucose, sucrose, maltodextrins and amylopectin are oxidized at high rates, while fructose, galactose and amylose are oxidized at lower rates (approximately 25-50% lower).
- Sports drinks typically contain a mixture of various types of carbohydrates designed to optimize exogenous carbohydrate oxidation.

Campbell et al. JISSN. 10:1, 2013

# Carbohydrate

- ACSM and ISSN recommend ingesting 30-60 g/hr of CHO in a 6-8% solution during prolonged exercise.
- ED's contain approximately 25-30 grams of carbohydrate per 240 mL (10 – 13 grams CHO / 100 ml fluid)
- Ingesting higher percentages of CHO in solution (>10%) has been reported to delay gastric emptying and increase gastrointestinal distress.
- Athletes who want to use ED's as sports drinks may need to dilute the beverage and/or alternate consumption of ED and water during exercise.



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# Energy Drinks

## *Carbohydrate Considerations*

- Source of CHO?
  - Most are high GI and therefore may promote hypoglycemia in some athletes
- Concentration of CHO?
  - Must ingest enough water during exercise to offset higher percentage of CHO in drinks
- Timing of Ingestion?
  - Hypoglycemia?
  - Promote glycogen replenishment after exercise?



# Other Potential Ergogenic Nutrients

## *Cognition / Mental Focus*

Ingredient	Potential Ergogenic Value	Scientific Support
<b>Taurine</b>	Improved mental focus, concentration, serve as antioxidant, glucose homeostasis	Some supportive evidence with ED's and fed animals
<b>Gingko Biloba</b>	Improve memory and mental concentration	Some supportive evidence on memory (e.g., 120 mg/d). Role in ED's unknown.
<b>L-Tyrosine</b>	Prevents depletion of catecholamines, may ameliorate declines in cognition with acute stress	Some supportive evidence on cognition (e.g., 2 g/d, 150 mg acute ingestion with cold exposure). No evidence on improving exercise.
<b>Citocoline</b>	Intermediate in the generation of phosphatidylcholine from choline. Increase dopamine receptor densities and delay memory impairment.	Some supportive evidence with large doses (8.5 g prior to and during exercise) and in fed animals. 0.5 g/d for 6-wks increased brain PCr. Role in ED's unknown.
<b>5-Hydroxy-L-Tryptophan (5-HTP)</b>	Precursor to serotonin. Purported antidepressant, appetite suppressant, & sleep aid.	Some evidence in treatment of depression and 5-HT fed animals on muscle performance. Role on exercise performance and in ED's unknown.
<b>St. John's Wort</b>	Anti-depressant.	Some supportive evidence. No known effects at dosages found in ED's.

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# Potential Ergogenic Nutrients

## *Stimulants*

Ingredient	Potential Ergogenic Value	Scientific Support
<b>Caffeine</b>	Stimulant. Increases metabolism and fat oxidation.	Increases alertness, mood, cognitive function. Increases fat oxidation and spares glycogen utilization.
<b>Guarana</b>	Natural source of caffeine. Similar properties to caffeine.	Similar to caffeine effects.
<b>Green Tea Extract</b>	Contains high amounts of caffeine and catechin polyphenols (e.g., epigallocatechin gallate or EGCG). Serves as antioxidant.	Similar to caffeine effects. Specific role in ED's unknown
<b>Synephrine</b>	Alternative to ephedrine. Naturally derived from <i>Citrus aurantium</i> . Stimulant with less CV effects. Purported to increase metabolism and promote weight loss.	Evidence of a mild stimulant effect on metabolism.
<b>Yerba mate</b>	Contains three xanthines (caffeine, theobromine, and theophylline). Similar properties to caffeine	Similar to caffeine effects. Effects in ED's unknown.
<b>Yohimbine</b>	Alkaloid with stimulant and aphrodisiac properties.	Similar to caffeine effects. Effects in ED's unknown.
<b>Tyramine</b>	Naturally-occurring monoamine derived from tyrosine. Acts as a catecholamine (dopamine, NE, Epi) releasing agent. Degraded to octopine. Increases blood pressure and can serve as neurotransmitter.	CV stimulant. Effects in ED's unknown.
<b>Vinpocetine</b>	Alkaloid of vincamine extracted from periwinkle plant ( <i>Vinca</i> ) minor. Vasodilatory and memory enhancing properties.	No known effects at dosages found in ED's.

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# Potential Ergogenic Nutrients

## *Others*

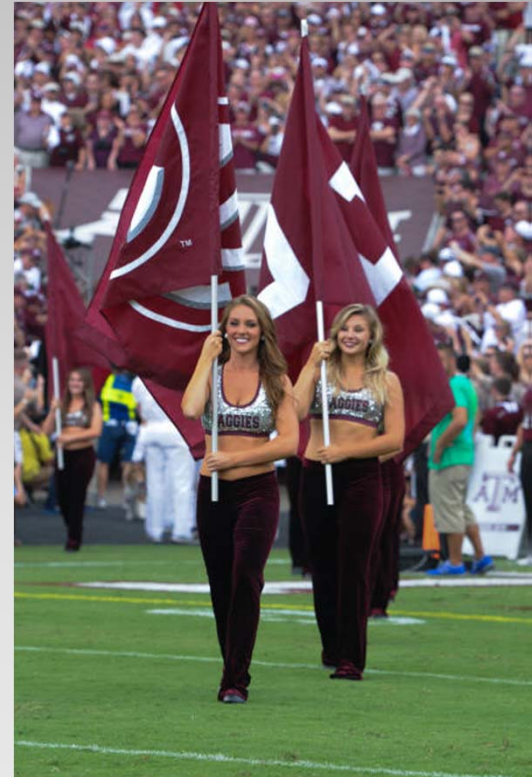
Ingredient	Potential Ergogenic Value	Scientific Support
<b>Panax Ginseng</b>	Contains ginsenosides which are purported to have anti-inflammatory, antioxidant, and anticancer effects. Enhance perceptions of energy, increase stamina and improve nitrogen balance.	Most well-controlled research do not support the ergogenic effects for ginseng. No known effects at dosages found in ED's.
<b>L-Carnitine</b>	Involved in shuttling long chain fatty acids into mitochondria. Purported to promote lipolysis.	Limited supportive evidence. No known effects at dosages found in ED's.
<b>D-Ribose</b>	Involved in ATP synthesis. Theoretically, D-ribose supplementation can increase ATP availability.	Limited evidence even at high doses. No known effects at dosages found in ED's.
<b>Beta Alanine</b>	Increases muscle carnosine levels. Increases muscle buffering.	Growing scientific evidence of improved anaerobic capacity (2-4 g/d). No known effects at dosages found in ED's.
<b>Inositol</b>	Carbohydrate that is not classified as sugar. Involved in insulin signaling, nerve transmission, serotonin modulation, fat oxidation.	No known effects at dosages found in ED's.
<b>Citrulline Malate</b>	Optimizes blood flow via arginine-nitric oxide pathway. Purported to reduce fatigue and buffer acidity during exercise.	Evidence that 6 g/d for 15-d decreased fatigue and 8 g before RE decreased fatigue. No known effects in ED's.
<b>Quercetin</b>	Reported to have antioxidant, anti-inflammatory, antiviral, and immunomodulatory effects.	Several studies indicate that 1 g/d for 7 d increase maximal aerobic capacity and time to fatigue.

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# Energy Drinks

## *Other Ingredient Considerations*

- Some evidence that ED's contain levels of nutrients that can affect cognition, mental focus, memory.
- This could affect exercise performance during prolonged activities/events.
- Most ED's/ES's contain "sprinkled" amounts of other potential ergogenic nutrients.
- Little to no evidence that ingesting low levels of these nutrients provide additive benefits to caffeine ingestion.



Campbell et al. JISSN. 10:1, 2013

# Energy Drinks

## *Potential Uses*

- Pre-Exercise
  - Increase CHO availability
  - Increase mental focus and/or alertness
  - Stimulate fat oxidation to help spare muscle glycogen
- During Exercise
  - Source of CHO and caffeine
- After Exercise
  - Increase insulin
  - Promote glycogen replenishment



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**Available Research**

## A taurine and caffeine-containing drink stimulates cognitive performance and well-being

*Seidl et al. Amino Acids. 19(3-4):635-42, 2000*

- 10 subjects had P300 components of event-related potential (ERP) waveforms, reaction time, and mood state measured at night 1 hour after consumption of RB or a placebo
- P300 latency and motor reaction time were significantly longer in the placebo group while unchanged in the RB group.
- Feelings of well-being, vitality, and social extrovertedness scores were decreased in the placebo group but not changed in the RB group
- RB has positive effects on mental performance and mood

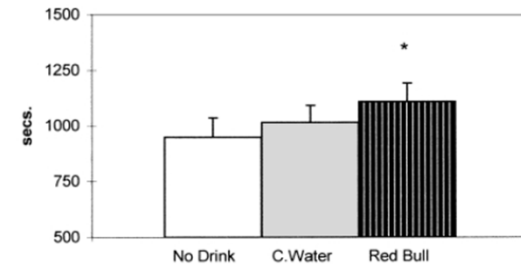




## The effects of red bull energy drink on human performance and mood

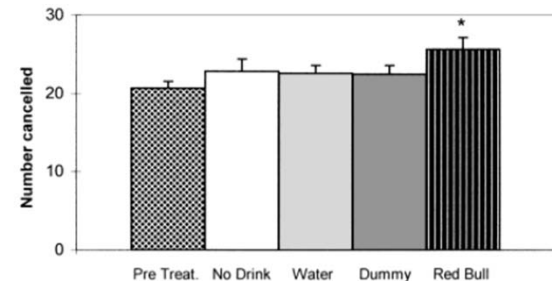
Alford et al. *Amino Acids*. 21(2):139-50, 2001

- 36 subjects ingested a placebo, RB, or no drink 30 min prior to performing a battery of psychomotor and cognitive tasks end endurance exercise
- RB improved aerobic endurance (maintaining 65–75% max HR) and anaerobic performance (maintaining max speed) on cycle ergometers.
- RB improved choice reaction time, concentration (number cancellation) and memory (immediate recall), which reflected increased subjective alertness.



Key: \* =  $P < 0.05$  Vs Carb. Water; Increased score = greater endurance

Fig. 1. Aerobic endurance: 65–75% max. HR means (+SEM)  $n = 14$



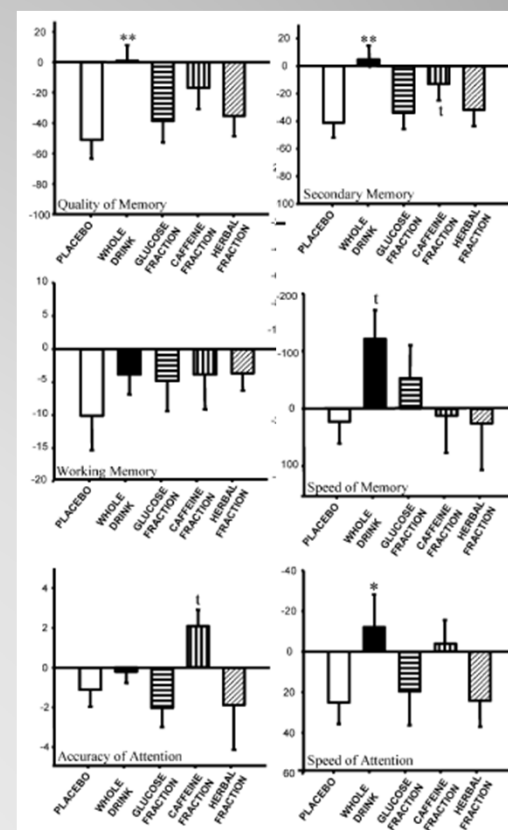
Key: \* =  $t < 0.05$  Vs Dummy Energy Drink; Increased score = better performance

Fig. 2. Concentration task means (+SEM)  $n = 12$

## Cognitive and physiological effects of an “energy drink”: an evaluation of the whole drink and of glucose, caffeine and herbal flavouring fractions

Scholey & Kennedy. *Psychopharmacol.* 176:320-330, 2004

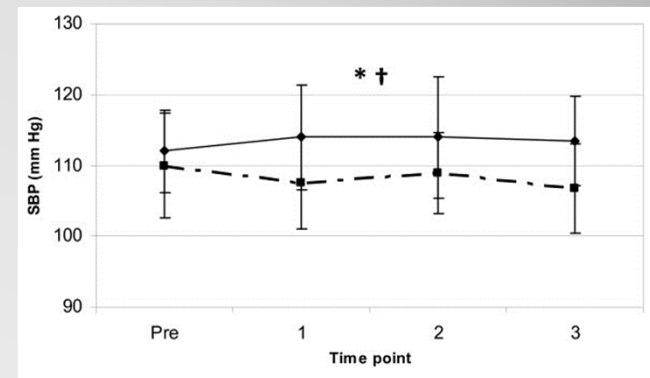
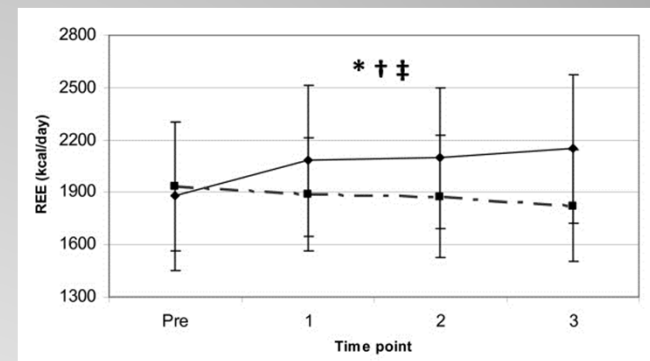
- 20 subjects ingested 250 ml of a placebo or drinks containing glucose (37.5 g), caffeine (75 mg), ginseng (12.5 mg), and ginkgo biloba (2 mg) together and independently.
- Cognitive, psychomotor, and mood assessments were obtained 30-min after consuming drinks.
- Whole drink increased performance of secondary memory and speed of attention factors.
- Results were additive suggesting synergistic effects of consuming glucose and caffeine.



## Acute effects of ingesting Java Fit<sup>®</sup> energy extreme functional coffee on resting energy expenditure and hemodynamic responses in male and female coffee drinkers

Taylor et al. *JISSN*. 4:10, 2007

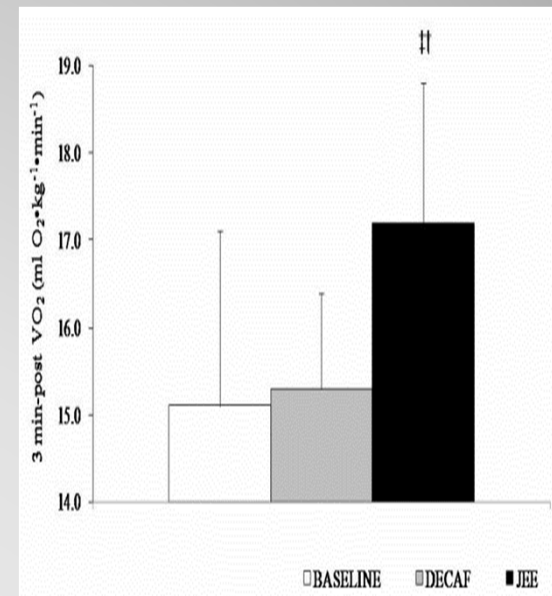
- 5 men and 5 women were assigned to ingest JavaFit<sup>™</sup> Energy Extreme containing ~ 400 mg caffeine, 600 mg green tea, <15 mg garcinia cambogia, and 30 mg niacin or Folgers regular coffee (~ 200 mg caffeine).
- REE, BP, and HR measured for 3 hours
- JF increased mean REE by 14.4%
- Resting SBP, RER, and VO<sub>2</sub> were also marginally higher in JF group.



## Effects of ingesting JavaFit Energy Extreme functional coffee on aerobic and anaerobic fitness markers in recreationally-active coffee consumers

Roberts et al. *JISSN*. 4:25, 2007

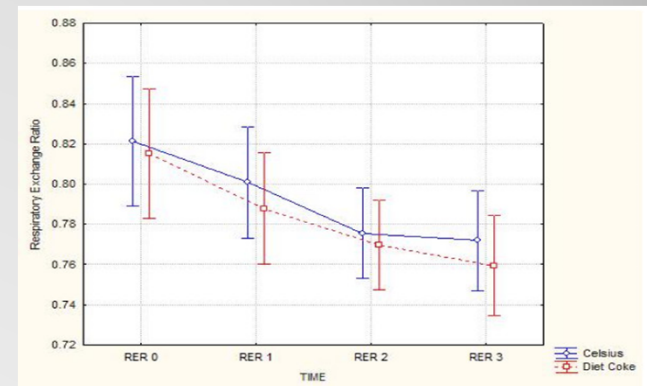
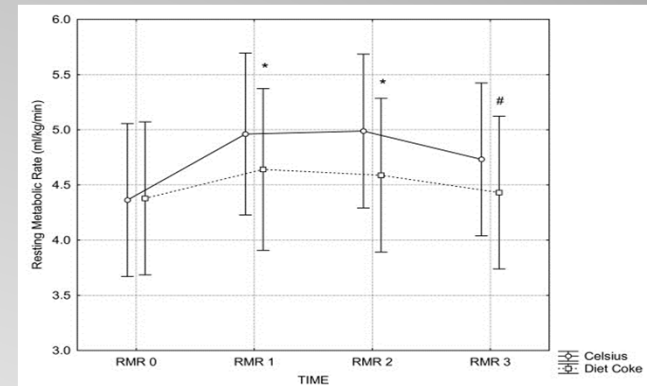
- 5 men and 5 women were assigned to ingest JavaFit™ Energy Extreme containing caffeine (450 mg), garcinia cambogia (1,200 mg), citrus aurantium (360 mg) and chromium polynicotinate (225 mcg) or decaffeinated coffee 15 min before performing a GXT and Wingate ACT.
- No differences were observed between groups in aerobic or anaerobic capacity.
- Exercise HR and post-exercise  $\text{VO}_2$  was greater in JF group.



## Metabolic responses to the acute ingestion of two commercially available carbonated beverages: A pilot study

*Mendel and Hofheins. JISSN. 4:1/17, 2007*

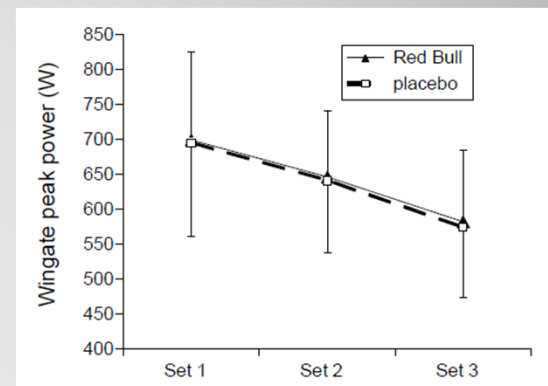
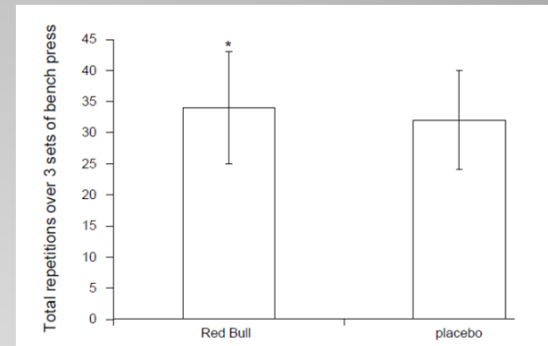
- 20 men and women were assigned to consume one Celsius® containing 1,810 mg of a blend containing taurine, guarana, green tea, and ginger (200 mg caffeine) or a Diet Coke®.
- Resting metabolic rate increased by 13.8, 14.4, and 8.5% at 1, 2, & 3 hrs after ingestion in the ED group.
- No differences in RER



## Effect of Red Bull energy drink on repeated Wingate cycle performance and bench-press muscle endurance

Forbes et al. *Int J Sport Nutr Exerc Metab.* 18(5):542, 2008

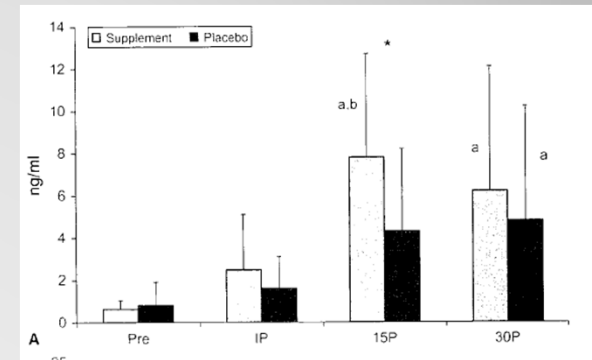
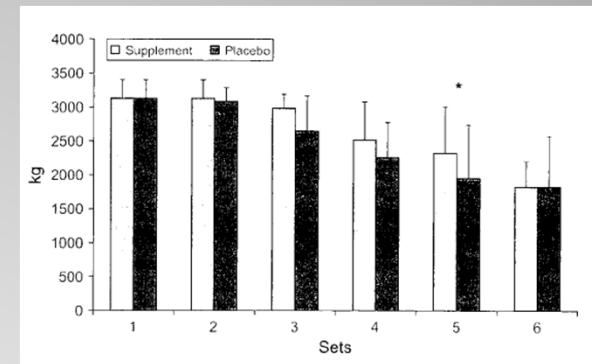
- 15 healthy adults (11 male and 4 female) were randomized to consume RB (2 mg/kg caffeine) or placebo in crossover manner.
- Subjects performed bench press endurance (3 sets at 70% 1RM) and 3 x 30-s Wingate's tests.
- RB increased total BP repetitions over three set ( $34 \pm 9$  vs.  $32 \pm 8$ ) with no effects on Wingate peak power ( $701 \pm 124$  vs.  $700 \pm 132$  W) or average power ( $479 \pm 74$  vs.  $471 \pm 74$  W).



## Effect of a pre-exercise energy supplement on the acute hormonal response to resistance exercise

Hoffman et al. *JSCR*. 22(3):874-82, 2008

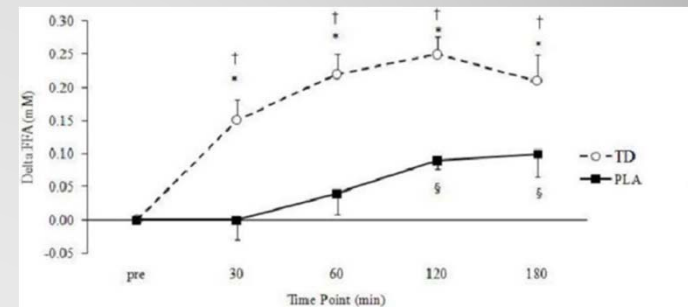
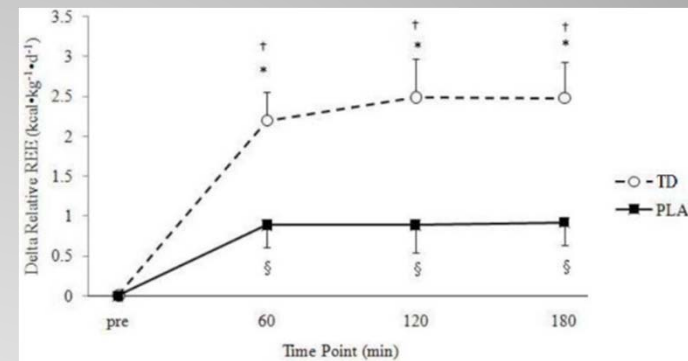
- 8 resistance-trained males ingested a placebo or ED (5.4 g BCAA, 3.2 g EAA, 5 g creatine, 1.5 g taurine, 350 mg glucuronolactone, 110 mg caffeine) or a placebo 10 min prior to performing 6 sets of squats @ 75% 1RM
- Total number of repetitions and training volume tended ( $p=0.08$ ) to be higher with S compared to P.
- Serum growth hormone and insulin concentrations were significantly higher in the S group.



## Acute effects of ingesting a commercial thermogenic drink on changes in energy expenditure and markers of lipolysis

*Dalbo et al. JISSN. 5:6, 2008*

- 30 subjects ingested 336 ml of Celsius with 1,810 mg of a blend containing taurine, guarana, green tea, and ginger (200 mg caffeine) or a placebo.
- HR, BP, REE, RER, glycerol and FFA determined.
- ED increased REE by an average of 10.5% (132 kcals/d) and FFA levels.
- Authors suggested use of this ED several times per day could help promote weight loss.

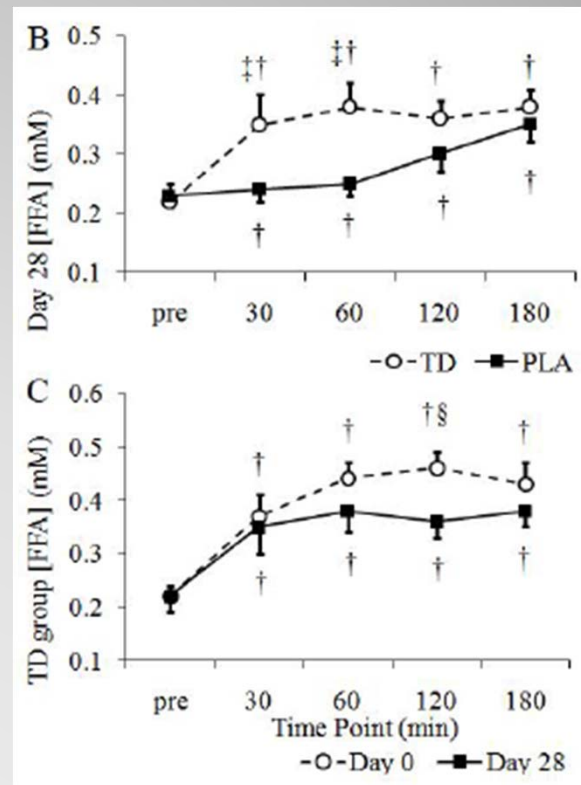




## Efficacy and safety of a popular thermogenic drink after 28 days of ingestion

Roberts et al. *JISSN*. 5:19, 2008

- 60 subjects ingested one Celsius ED per day containing 1,810 mg of a blend containing taurine, guarana, green tea, and ginger (200 mg caffeine) or a placebo.
- Fat mass was significantly decreased in ED group (-0.6 kg) compared to P (+0.3 kg).
- FFA levels were higher in ED while REE was not affected.



## Pre-workout consumption of Celsius® enhances the benefits of chronic exercise on body composition and cardio-respiratory fitness

*Sout et al. JISSN. 5:S1-P8, 2008*

- 20 men and 18 women were assigned to consume one Celsius ED containing 1,810 mg of a blend containing taurine, guarana, green tea, and ginger (200 mg caffeine) or a placebo prior to training for 10-weeks.
- Changes in fat mass (-6.5% vs. =0.35%),  $VO_{2peak}$  (13.8% vs. 5.4%), and time to exhaustion (19.7% vs 14.0%) were greater in the ED group.



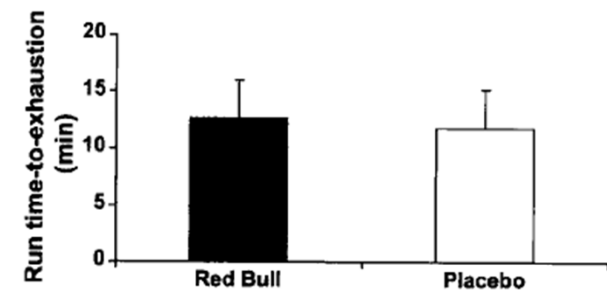
## Effect of sugar-free Red Bull energy drink on high-intensity run time-to-exhaustion in young adults

*Candow et al. JSCR: 23(4):1271-75, 2009*

- 17 active college students performed a run to exhaustion (RTE) at 80% of  $\text{VO}_2$  max.
- Subjects consumed sugar free Red Bull (2 mg/kg caffeine and 25 mg/kg taurine) or a placebo 1-hr before exercise in a randomized and cross-over manner.
- No significant differences between groups in RTE, RPE, or blood lactate.
- Sugar-free RB provided no ergogenic benefit on RTE.

**TABLE 1.** Sugar-free Red Bull energy drink ingredients.

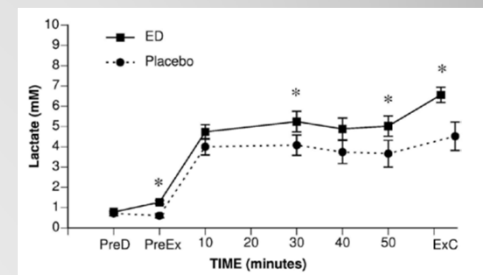
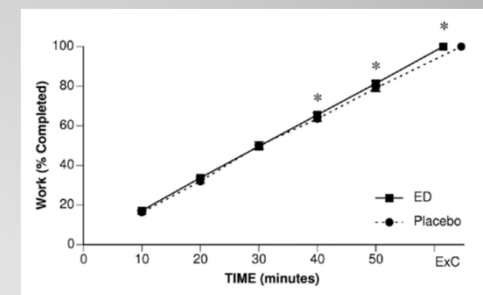
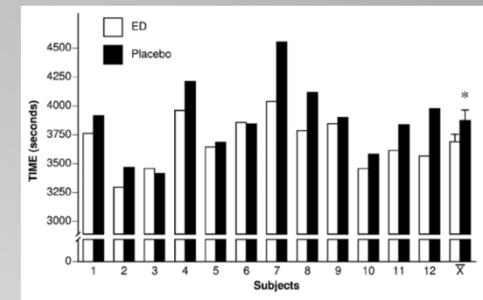
Ingredient	Supplement
Nonmedicinal ingredients	
Aspartame	0.01 mg·kg <sup>-1</sup>
Medicinal ingredients	
Caffeine	2.0 mg·kg <sup>-1</sup>
Taurine	25 mg·kg <sup>-1</sup>
Glucuronolactone	15 mg·kg <sup>-1</sup>
Niacin	0.45 mg·kg <sup>-1</sup>
Pantothenic acid	0.15 mg·kg <sup>-1</sup>
Vitamin B <sub>6</sub>	0.05 mg·kg <sup>-1</sup>
Riboflavin	0.04 mg·kg <sup>-1</sup>
Vitamin B <sub>12</sub>	0.025 mcg·kg <sup>-1</sup>



## Improved cycling time-trial performance after ingestion of a caffeine energy drink

Ivy et al. *Int J Sport Nutr Exerc Metab.* 19(1):61-78, 2009

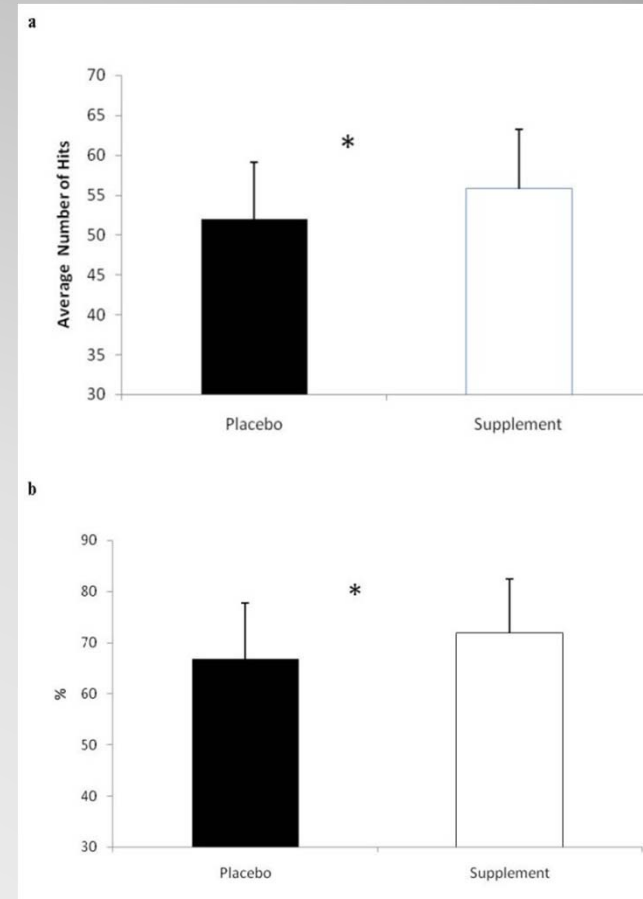
- 6 male and 6 female cyclists consumed 500 ml of either flavored placebo or RB ED 40-min before a simulated cycling time trial (70% Wmax).
- Performance improved with ED (3,690±64 vs. 3,874±93 s) with no difference in RPE.
- $\beta$ -endorphin levels increased during exercise, with the increase for ED approaching significance over P ( $p=0.10$ ).
- No difference in substrate utilization



## Examination of a pre-exercise, high energy supplement on exercise performance

Hoffman et al. *JISSN*. 6(6):2, 2009

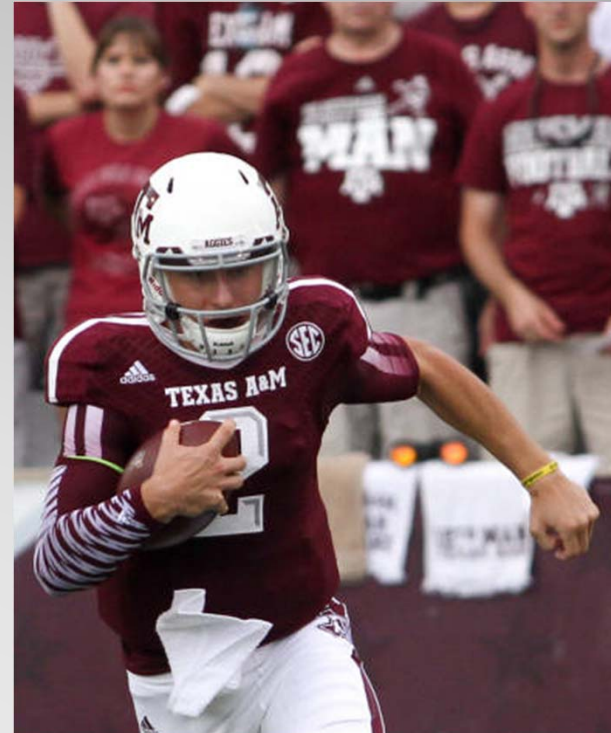
- 12 resistance-trained athletes ingested a P or 120 ml of Redline Extreme<sup>®</sup> (caffeine, beta alanine, N-Acetyl-Tyrosine, Hordinine, 5-HTP, N-methyl Tyramine, sulbutiamine, vinpocetine, yohimbine, and St. John's Wort) 10 min before performing 3 reaction tests and Wingate tests.
- Average number of targets struck and percent targets struck was significantly better in S group.
- No differences were observed in anaerobic capacity between groups.
- Subjective feelings of energy and focus better in S group.



## Improved time to exhaustion following ingestion of the energy drink Amino Impact

*Walsh et al. JISSN: 7:14, 2010*

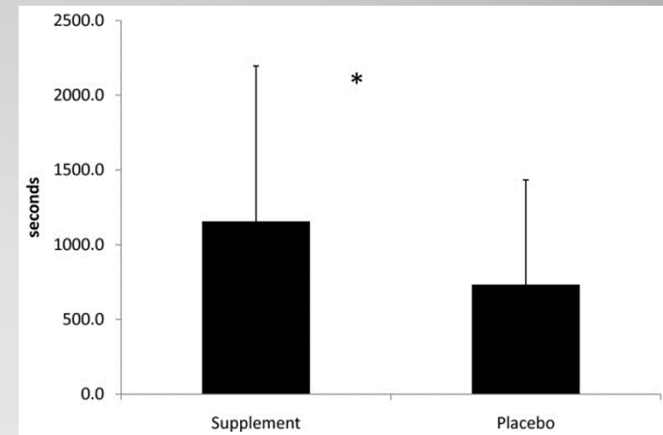
- 15 subjects (9 male, 6 female) performed participated in two exercise testing sessions.
- Subjects ingested a placebo or a 500 ml of an ED containing 2.05 g of caffeine, taurine, and glucuronolactone; 7.9 g of BCAA, L-arginine, and L-glutamine; 5 g of di-creatine citrate; and, 2.5 g of  $\beta$ -alanine
- Subjects performed treadmill runs to exhaustion @ 70% of  $VO_2$  max.



## Improved time to exhaustion following ingestion of the energy drink Amino Impact

*Walsh et al. JISSN: 7:14, 2010*

- Time to exhaustion was significantly greater with ED.
- Subjects consuming ED were able to run 12.5% longer than P.
- Subjects in ED group reported greater focus, energy, and less fatigue before exercise.
- Subjects in the ED group reported greater focus and energy at 10-min of exercise
- No differences were seen after exercise in focus, energy, or fatigue.



## **Acute effects of a glucose energy drink on behavioral control**

*Howard et al. Exp Clin Psychopharmacol. 18(6):553-61, 2010*

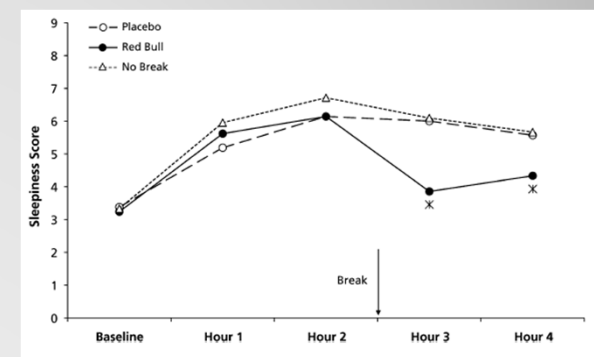
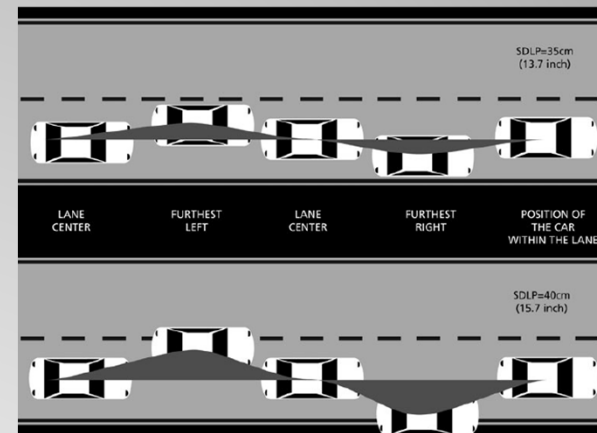
- 80 subjects were randomly assigned to consume 1.8, 3.6, or 5.4 ml/kg of ED, a placebo, or no drink.
- Participants completed a behavioral control task (the cued go/no-go task) and subjective measures of stimulation, sedation, and mental fatigue before and 30-min after ingestion of ED
- ED doses decreased reaction times on the behavioral control task, increased subjective ratings of stimulation and decreased ratings of mental fatigue.
- Greatest improvements in reaction times and subjective measures were observed with the lowest dose and improvements diminished as the dose increased.
- ED consumption can improve cognitive performance on a behavioral control task.



## Positive effects of Red Bull® Energy Drink on driving performance during prolonged driving

*Mets et al. Psychopharmacol. 214(3):737-45, 2011*

- 24 subjects ingested RB or a placebo after 2 h of simulated highway driving and then drove 2 additional hours.
- RB consumption improved lateral weaving during the 3<sup>rd</sup> and 4<sup>th</sup> hour of driving, the standard deviation of speed, subjective driving quality, and reduced mental effort to perform the test during the 3<sup>rd</sup> hour of driving.
- Subjective sleepiness was significantly decreased during both the 3<sup>rd</sup> and 4<sup>th</sup> hour of driving after RB ingestion.



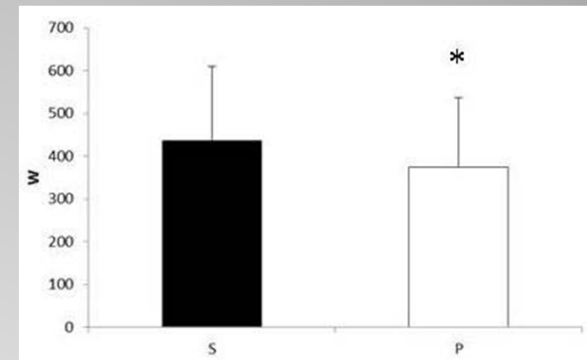
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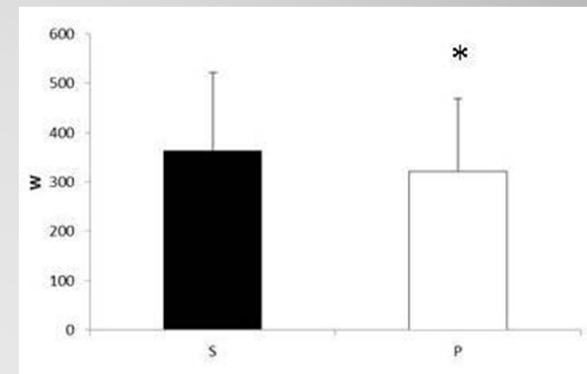
## Effect of a pre-workout energy supplement on acute multi-joint resistance exercise

Gonzalez et al. *J Sports Sci Med.* 10:261-66, 2011

- 8 resistance trained men ingested a P or ED containing 2.05 g of caffeine, taurine, and glucuronolactone; 7.9 g of BCAA, L-arginine, and L-glutamine; 5 g of di-creatine citrate; and, 2.5 g of  $\beta$ -alanine 10 min prior to resistance-training.
- Subjects performed 4 sets of up to 10 repetitions of barbell squat or BP.
- S increased the number of repetitions successfully performed ( $26.3 \pm 9.2$  vs.  $23.5 \pm 9.4$ ).
- Average peak and mean power performance for all four sets was significantly greater in S compared to P.
- No effects observed on feelings of energy, focus, or fatigue.



Average peak power

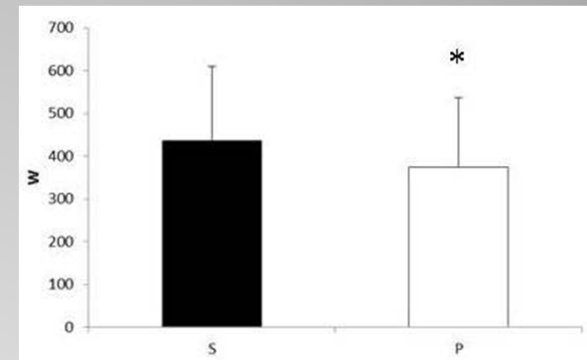


Average mean power

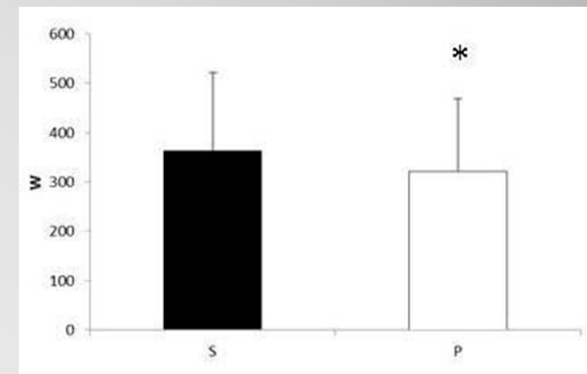
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Average peak power

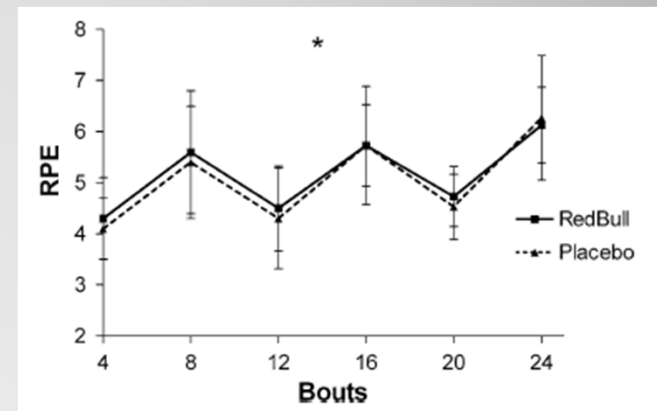
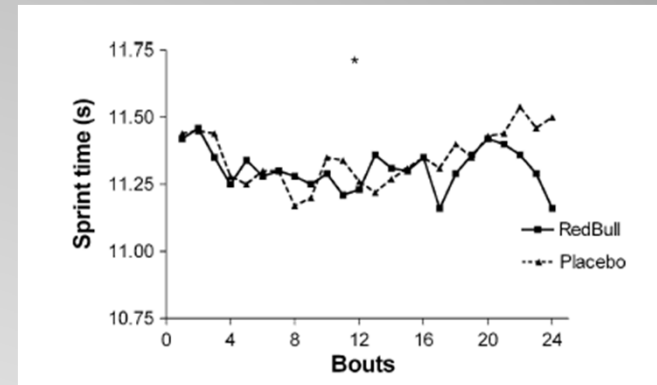


Average mean power

## Effects of red bull energy drink on repeated sprint performance in women athletes

*Astorino et al. Amino Acids: 42(5), 1803-8, 2012*

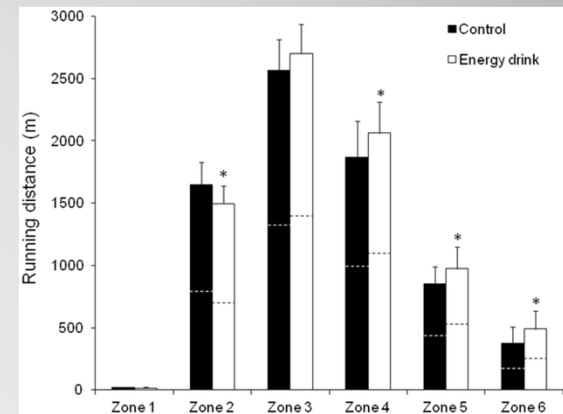
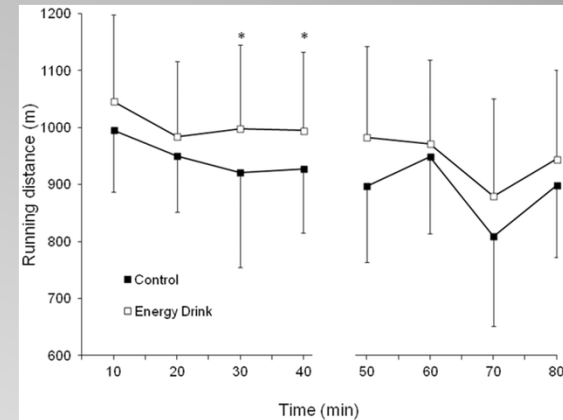
- 15 female college soccer players performed 3 x 8 sets of sprint t-test
- Subjects consumed Red Bull (1.3 mg/kg caffeine and 1 g taurine) or a placebo 1-hr before exercise in a randomized and cross-over manner.
- No significant differences between groups on sprint time, HR, or RPE responses.
- One serving of RB prior to sprint-exercise provided no ergogenic benefit in female athletes.



## Effects of a caffeine-containing energy drink on simulated soccer performance

*Del Coso et al. PLoS One 7(2), e31380, 2012*

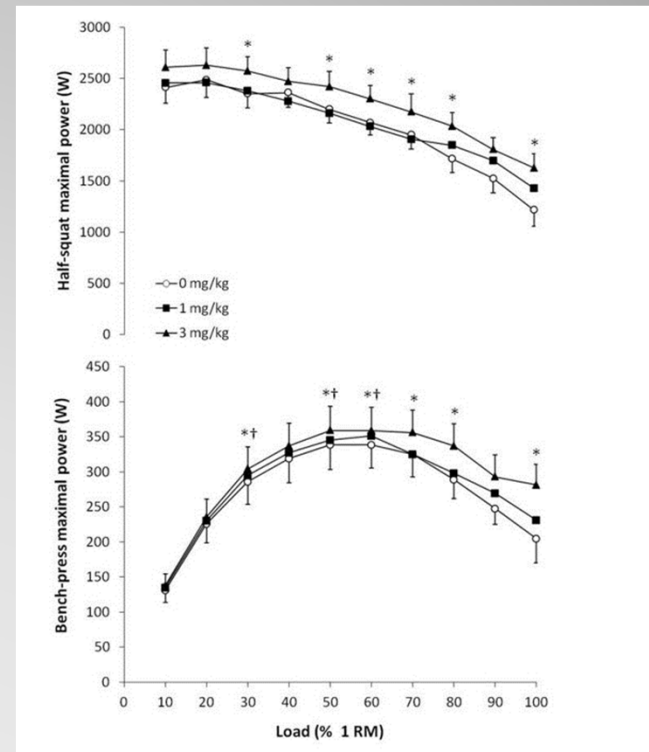
- 19 semi-pro soccer players sugar-free ED (Red Bull) providing 3 mg/kg caffeine or a placebo 1-hr before exercise in a randomized and cross-over manner.
- After 60-min, subjects performed a 15-s maximal jump test, a repeated sprint test (7×30 m; 30 s of active recovery) and played a simulated soccer game.
- ED ingestion increased mean jump height ( $34.7 \pm 4.7$  v  $35.8 \pm 5.5$  cm;  $P < 0.05$ ), mean sprint running speed ( $25.6 \pm 2.1$  v  $26.3 \pm 1.8$  km · h<sup>-1</sup>;  $P < 0.05$ ); total distance covered at a speed > 13 km/h during the game ( $1205 \pm 289$  v  $1436 \pm 326$  m;  $P < 0.05$ ); and, the number of sprints during the whole game ( $30 \pm 10$  v  $24 \pm 8$ ;  $P < 0.05$ ).



## Dose response effects of a caffeine-containing energy drink on muscle performance: a repeated measures design

*Del Coso et al. JISSN. 9.1.21, 2012*

- 12 active subjects ingested an ED containing 1 or 3 mg/kg caffeine or a placebo 1-hr before exercise in a randomized and cross-over manner.
- After 60-min, subjects had REE, HR & BP, and performed half-squat and bench press tests with loads from 10 to 100% 1RM.
- ES slightly increased MAP (82 to 90 mmHg) and HR (57 to 62 bpm) in a dose response manner with no effect on REE.
- Ingestion of 3 mg/kg increased maximal power in the half-squat by about 6.7% (2554 to 2726 W) and bench-press power by 7.4% (349 to 375 W) with no effects of ingesting the ED with 1 mg/kg.



## The acute effect of a caffeine-containing energy drink on mood state, readiness to invest effort, and resistance exercise to failure

*Duncan et al. JSCR. 26(10): 2858-65, 2012*

- In a double blind, randomized, and repeated measures manner, 13 resistance-trained men ingested an ED containing 179 mg of caffeine or a placebo solution 60 minutes before completing a bout of resistance exercise comprising bench press, deadlift, prone row, and back squat exercise to failure at an intensity of 60% 1-repetition maximum.
- Participants completed significantly greater repetitions to failure, irrespective of exercise, in the energy drink condition ( $p = 0.015$ ).
- RPE was significantly higher in the placebo condition ( $p = 0.02$ ).
- Readiness to invest mental effort was greater with the energy drink condition ( $p = 0.04$ ), irrespective of time.
- Results suggest that acute ingestion of a caffeine-containing ED can enhance resistance exercise performance to failure and positively enhance psychophysiological factors related to exertion in trained men.

## Differential cognitive effects of energy drink ingredients: caffeine, taurine, and glucose

*Giles et al. Pharmacol Biochem Behav. 102(4):569-77, 2012*

- Using a randomized, double-blind, mixed design, 48 habitual caffeine consumers (18 male, 30 female) who were 24-hour caffeine deprived received one of four treatments (200 mg caffeine/0 mg taurine, 0 mg caffeine/2000 mg taurine, 200 mg caffeine/2000 mg taurine, 0 mg caffeine/0 mg taurine), on each of four separate days, separated by a 3-day wash-out period.
- An attention task was administered 30-minutes post-treatment, followed by a working memory and reaction time task 60-minutes post-treatment.
- Caffeine enhanced executive control and working memory, and reduced simple and choice reaction time. Taurine increased choice reaction time but reduced reaction time in the working memory tasks. Glucose alone slowed choice reaction time. Glucose in combination with caffeine, enhanced object working memory and in combination with taurine, enhanced orienting attention.
- Caffeine, not taurine or glucose, is likely responsible for reported changes in cognitive performance following consumption of energy drinks, especially in caffeine-withdrawn habitual caffeine consumers.



## Acute effects of a caffeine-aurine energy drink on repeated sprint performance of American college football players

Gwacham, N. *Int J. Sport Nutri. Exerc. Metab.* 22(2):109-16, 2012

- 20 football players (age 19.7 +/- 1.8 yr, height 184.9 +/- 5.3 cm, weight 100.3 +/- 21.7 kg) participated in a double-blind, randomized crossover study in which they received the energy drink or an isoenergetic, isovolumetric, non-caffeinated placebo in 2 trials separated by 7 days.
- The Running Based Anaerobic Sprint Test, consisting of six 35-m sprints with 10 s of rest between sprints, was used to assess anaerobic power.
- Sprint times were recorded with an automatic electronic timer.
- The ED treatment did not significantly affect power ( $F = 3.84$ ,  $p = .066$ ) or sprint time ( $F = 3.06$ ,  $p = .097$ ). However, there was a significant interaction effect between caffeine use and the beverage for sprint times ( $F = 4.62$ ,  $p = .045$ ), as well as for anaerobic power ( $F = 5.40$ ,  $p = .032$ ), indicating a confounding effect.
- In conclusion, a caffeine-aurine energy drink did not improve the sprint performance or anaerobic power of college football players, but the level of caffeine use by the athletes likely influenced the effect of the drink.

## Acute Ingestion of Sugar-free Red Bull Energy Drink has no Effect on Upper Body Strength and Muscular Endurance in Resistance Trained Men

*Eckerson et al. JSCR. 27(8):2248-54, 2013*

- In a double blind, randomized, and repeated measures manner, 17 males randomly received: (A) 500 ml of SF-RB containing CAF (160 mg) and taurine (2000 mg); (B) 500 ml of a SF drink containing CAF only (160 mg); or (C) a SF, CAF-free 500 ml PL drink 60 min prior to testing on three separate occasions.
- Following a standard warm-up, the 1RM was determined and subjects then completed repetitions to failure at 70% of their 1RM.
- Neither SF-RB nor the CAF drink had any effect on 1RM BP (115.1 +/- 16 kg and 114.9 +/- 16 kg, respectively) or lifting volume (1173 +/- 171 kg and 1164 +/- 147 kg, respectively) compared to PL (1RM = 114.1 +/- 16 kg; VL= 1141 +/- 193 kg).
- These findings suggest that SF-RB providing about 2 mg/kg of caffeine has no effect on upper body 1RM strength or lifting volume in resistance trained men.

## Energy drink ingredients. Contribution of caffeine and taurine to performance outcomes

*Peacock et al. Appetite. 64:1-4, 2013*

- Using a double-blind, placebo-controlled, crossover, within-subjects design, female undergraduates (N=19) completed a visual oddball task and a stimulus degradation task 45min post-ingestion of capsules containing: (i) 80mg caffeine, (ii) 1000mg taurine, (iii) caffeine and taurine combined, and (iv) matched placebo.
- No significant treatment effects were recorded for reaction time in the visual oddball task, facilitative caffeine effects were evident in the stimulus degradation task, with significantly faster reaction time in active relative to placebo caffeine conditions.
- There was a trend towards faster mean reaction time in the caffeine condition relative to the taurine condition and combined caffeine and taurine condition.
- Treatment effects were task-dependent, in that independent caffeine administration exerted a positive effect on performance, and co-administration with taurine tended to attenuate the facilitative effects of caffeine in the stimulus degradation task only.

## **An evaluation of the cognitive and mood effects of an energy shot over a 6h period in volunteers: a randomized, double-blind, placebo controlled, cross-over study**

*Wesnes et al. Appetite. 67:105-13, 2013*

- This randomized, double-blind, placebo-controlled, crossover study compared the acute effects of the energy shot with a matching placebo in 94 healthy volunteers.
- Cognitive function was assessed with a widely used set of automated tests of attention and memory. Mood was assessed with the Bond-Lader, Beck Anxiety Index, Beck Depression Index, Chalder Fatigue Scales (CFS), and the POMS.
- The volunteers were requested to limit their sleep to between 3 and 6h the night before each testing day.
- Compared to the placebo, the energy shot significantly improved 6 validated composite cognitive function measures from the CDR System as well as self-rated alertness; the benefits on 4 of the cognitive measures still remaining at 6h. The overall effect sizes of the performance improvements were in the small to medium range and thus notable in this field.

## Do the noncaffeine ingredients of energy drinks affect metabolic responses to heavy exercise?

*Pettitt et al. JSCR. 27(7):1994-9, 2013*

- In double-blind, counterbalanced, and crossover fashion, 8 recreationally trained individuals completed a graded exercise test to determine the gas exchange threshold (GET).
- Subjects returned on 2 separate occasions and ingested either a 245 ml serving of RB or a control (CTRL) drink with the equivalent caffeine before engaging in two 10-minute constant-load cycling bouts, at an intensity equivalent to GET, with 3 minutes of rest between bouts.
- Accumulated liters of O<sub>2</sub> (10 minutes) were higher for the first bout (17.1 +/- 3.5 L) vs. the second bout (16.7 +/- 3.5 L) but did not differ between drinks.
- Excess post-exercise oxygen consumption was higher after the initial bout (RB mean, 2.6 +/- 0.85 L; CTRL mean, 2.9 +/- 0.90 L) vs. the second bout (RB mean, 1.5 +/- 0.85 L; CTRL mean, 1.9 +/- 0.87 L) but did not differ between drinks.
- No differences occurred between drinks for measures of heart rate or rating of perceived exertion.
- Results indicate that the secondary ingredients contained in a single serving of RB do not augment aerobic metabolism during or subsequent to heavy exercise.

## The effects of caffeinated "energy shots" on time trial performance

*Schubert et al. Nutrients. 5(6):2062-75, 2013*

- Six male runners (mean +/- SD age and VO<sub>2</sub>max: 22.5 +/- 1.8 years and 69.1 +/- 5.7 mL.kg<sup>-1</sup>.min<sup>-1</sup>) completed three trials [placebo (PLA; 0 mg caffeine), Guayaki Yerba Mate Organic Energy Shot (YM; 140 mg caffeine), or Red Bull Energy Shot (RB; 80 mg caffeine)].
- Treatments were ingested following a randomized, placebo-controlled crossover design.
- Participants ran a five kilometer time trial on a treadmill.
- No differences ( $p > 0.05$ ) in performance were detected with RB (17.55 +/- 1.01 min) or YM ingestion (17.86 +/- 1.59 min) compared to placebo (17.44 +/- 1.25 min).
- Overall, energy shot ingestion did not improve time-trial running performance in trained runners.

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# **Safety Considerations**

## Safety Considerations

- Most concerns related to excessive caffeine intake and/or potential deleterious effects of mixing ED with alcohol.
- Most concerns based on case studies or adverse event reports that have documented a potential association, but does not establish causality.
- There are currently only a few studies (acute or long term) that have investigated the side effects of ED.



Campbell et al. JISSN. 10:1, 2013



# Safety Considerations

- Individuals with certain medical conditions (e.g., metabolic syndrome or diabetes mellitus) should avoid consumption of high glycemic drinks and/or foods and therefore should not consume the high calorie versions of ED.
- It would be prudent for individuals with known cardiovascular disease to avoid altogether their use of ED and/or ES, or other products with known cardio-stimulant effects.
- Since ED often contain several nutrients that contain caffeine and/or other stimulants, care should be taken to make sure that an excessive number of ED are not consumed within a short period of time.



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## **Position Stand**

## ISSN Position Stand – ED's

- Although ED and ES contain a number of nutrients that are purported to affect mental and/or physical performance, the primary ergogenic nutrients in most ED and ES appear to be carbohydrate and/or caffeine.
- The ergogenic value of caffeine on mental and physical performance has been well-established but the potential additive benefits of other nutrients contained in ED and ES remains to be determined.
- Consuming ED 10-60 minutes before exercise can improve mental focus, alertness, anaerobic performance, and/or endurance performance.



Campbell et al. JISSN. 10:1, 2013

## ISSN Position Stand – ED's



- Children and adolescents should only consider use of ED or ES with parental approval after consideration of the amount of carbohydrate, caffeine, and other nutrients contained in the ED or ES and a thorough understanding of the potential side effects.
- Indiscriminant use of ED or ES, especially if more than one serving per day is consumed, may lead to adverse events and harmful side effects.
- Diabetics and individuals with pre-existing cardiovascular, metabolic, hepatorenal, and neurologic disease who are taking medications that may be affected by high glycemic load foods, caffeine, and/or other stimulants should avoid use of ED and/or ES unless approved by their physician.

Campbell et al. JISSN. 10:1, 2013

## ISSN Position Stand – ED's



- Many ED and ES contain numerous ingredients; these products merit further study to demonstrate their safety and potential effects on physical and mental performance.
- There is some limited evidence that consumption of low-calorie ED during training and/or weight loss trials may provide ergogenic benefit and/or promote a small amount of additional fat loss. However, ingestion of higher calorie ED may promote weight gain if the energy intake from consumption of ED is not carefully considered as part of the total daily energy intake.
- Athletes should consider the impact of ingesting high glycemic load carbohydrates on metabolic health, blood glucose and insulin levels, as well as the effects of caffeine and other stimulants on motor skill performance

Campbell et al. JISSN. 10:1, 2013

# Safety and Efficacy of Energy Drinks: Implications on Health and Performance



**Richard B. Kreider, PhD, FACSM, FISSN**

Professor & Head, Department of Health & Kinesiology  
Thomas A. & Joan Read Endowed Chair for Disadvantaged Youth  
Director, Exercise & Sport Nutrition Lab  
Texas A&M University



[rkreider@hlkn.tamu.edu](mailto:rkreider@hlkn.tamu.edu)  
[www.ExerciseAndSportNutritionLab.com](http://www.ExerciseAndSportNutritionLab.com)

