Energy drinks: Unwanted side effects and Performance Outcomes

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No conflicts of interest
OUTLINE

Energy drinks; kidney effects

Performance enhancing effects
Historical Perspective

In 60’s Dr. Cade formulates Gatorade

Introduction of Red Bull in the Austrian market in 1987

Arrives to the USA in 1997

4.6 billion cans sold in 2011

51% college students are consumers (1-4 times per month)

Most Common Ingredients Today

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% of Energy Products 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B12</td>
<td>45%</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>40%</td>
</tr>
<tr>
<td>Caffeine</td>
<td>35%</td>
</tr>
<tr>
<td>Vitamin B3</td>
<td>30%</td>
</tr>
<tr>
<td>Taurine</td>
<td>25%</td>
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</tbody>
</table>
Red Bull

Red Bull

Amount in 1000 mL (g)

Taurine  Glucuronolactone  Caffeine  Carbohydrates  Vitamin B

X 4
Red Bull vs. diet

Amount in grams

<table>
<thead>
<tr>
<th></th>
<th>Amount 1 Red Bull can (g)</th>
<th>Normal diet (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taurine</td>
<td></td>
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<tr>
<td>Glucuronaloctone</td>
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</table>
Caffeine content

- Can of Rockstar 2x Energy Drink
- Can of Monster Energy Drink
- Can of Red Bull
- Can of Coca-Cola Classic
Vitamin B and Glucose

In people without diabetes the concentrations in these drinks will not cause renal problems. Vitamin B is water soluble and in high doses may cause excessive urination.
D-Glucurono-lactone

Its hydrolysis produces glucoronic acid

In 2003 concerns about the safety based on a rat study of 13 wks of supplementation causing kidney lesions

Rat is not a good model since it can metabolize it into vitamin C

Follow up study demonstrate no effects in rats. Safety dose of 1 g/kg/day

The EFSA Journal, 935, 1-31 (2009)
Patients with end-stage renal disease are taurine depleted but supplementation produces dizziness and vertigo (neurological disarrangements) in association with large increases of taurine in muscle and plasma.

Suliman et al., Neph Dial Transplant, 2002

Intravenous infusion of 1 g of taurine provokes diuresis in liver cirrhosis patients.

Gentile et al., Life Sci, 1992
Taurine diuresis

Cross-over, randomized and blind design

After 12 h fast, ingest (9 am) 750 mL of 4 drinks in thirty min. Collect urine for 6 hours

Riesenhuber et al., Amino Acids, 2006
Taurine has no diuretic or nautriuretic effect on moderately dehydrated young consumers.

Riesenhuber et al., Amino Acids, 2006
Caffeine

Antagonizes adenosine receptors and inhibits phosphodiesterase

The antagonism of adenosine 1 receptors explain the diuretic and natriuretic effects of caffeine (knockout mice)

*Rieg et al., J Pharm Exp Therap, 2005*

Increased diuresis and natriuresis from the inhibition of proximal tubular reabsorption of \( \text{Na}^+ \) (no effects on vasopressin)
Caffeine

Administration of 400 mg to healthy humans causes 1.5 fold increase in Na\(^+\) excretion

Shirley et al., Clin Sci 2002

It does not alter basal renal plasma blood flow in humans measured by clearance techniques

Beutler et al., J Pharm Exp Ther 1990

Unlike in rats, in humans caffeine in moderate doses (250 mg) does not cause increase in renin levels or hyperthension

Nussberger et al., J Cardiovas Pharmacol 1990
Caffeine

In water balance studies it has been proposed ingestion of 1.1 ml per mg caffeine to compensate its diuretic effects.

Stookey. Eur J Epidemiol 1999

It may be a threshold for the diuretic effect of caffeine 250 mg.

Maughan and Griffin, J Hum Nutr Dietet, 2003

<table>
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<tr>
<th>Caffeine dose (mg)</th>
<th>Diuretic effect</th>
<th>Reference</th>
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<tr>
<td>642</td>
<td>Yes</td>
<td>Neuhauser-Berthold et al. (1997)</td>
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<td>586</td>
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<td>Wemple et al. (1996)</td>
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<td>360</td>
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<td>Passmore et al. (1987)</td>
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<tr>
<td>250</td>
<td>Yes</td>
<td>Nussberger et al. (1990)†</td>
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<td>250</td>
<td>Yes</td>
<td>Robertson et al. (1978)</td>
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<td>300</td>
<td>No</td>
<td>Dorfman &amp; Jarvik (1970)</td>
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<td>253</td>
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</table>
Ingestion of 1 Red Bull (80 mg caffeine in 250 mL of drink) started mildly dehydrated with Usg of 1.020 during the first hour little urination.

Ragsdale et al., Amino Acids, 38, 2010
Caffeine during exercise

During exercise renal flow is reduced with increases in heart rate due to duration, intensity or dehydration

Rowell, Human Circulation, 1986
Caffeine during exercise

To determine if the diuretic effects of caffeine will counter the effects of a rehydration drink.

- Water + Caff
- 2.4 L
- 2 hours

 CES + Caff

[Image of people exercising on stationary bikes]
Caffeine increases urine production during exercise.
Caffeine increased sweat sodium concentration

Coso, Mora-Rodriguez MSSE, 2009
Internal Temperature

Coso, Mora-Rodriguez  MSSE , 2009
Caffeine tended to increase rectal temperature when combined with CES

Coso, Mora-Rodriguez MSSE, 2009
Energy Drinks: Caffeine Rehydrating

- Sweat rate
- Fluid balance
- Core temperature

- Caffeine increases Na\(^+\) losses in sweat
- Caffeine is mildly diuretic even during exercise
- Caffeine when combined with carbohydrates tends to be thermogenic
Gaps

Very prolonged activity (military op, tournaments, two-a-day workouts)
Targeted to street, extreme sports
Performance effects

Double blind, randomized, placebo-controlled
Difficult to mask the Energy Drink
Control exercise and diet the prior day
Light caffeine consumers
Some ask to refrain from caffeine day before
Most gave the drink 30-60 min before the effort
Most studies focus on sprint and power, some in endurance
Football

240 mL of 1 packet of AdvoCare Spark, 120 mg caffeine or Placebo flavoured water with glucose 60 min after ingestion Running Anaerobic Sprint Test (6 * 35 m sprints)

No differences in time in any of the sprints

(no taurine or glucuronolactone)

Women soccer players

1 can of Red Bull
Canada Dry (caff free). 11 out of 15 could identify drinks

3*8 all-out sprints (60 m), 30 s recovery and 5 min between sets

College Resistance Trained

Sugar free Red Bull (500 mL, 160 mg caff)
Sugar free drink containing similar caffeine
Sugar free-caffeine free drink

College Moderately-Trained

Red Bull (2 mg caffeine per kg)
Caffeine-free Mountain Dew

3 * 30-s Wingate test
70% 1RM BP to failure

Forbes et al. IJ Sport Nutr Exer Met, 17, 2007
College Moderately-Trained

Sugar free Red Bull (2 mg caffeine per kg)
Sugar free caffeine-free drink

Run at 80% VO$_2$max in an inclined treadmill until exhaustion

Figure 1. Run time-to-exhaustion (minutes) for sugar-free Red Bull and placebo. Values are means ± SD.

Competitive cyclists

60 min cycling 70% VO$_2$max + ride to exhaustion

500 mL 30 min into the ride

Sugar and Caffeine (U1)
Sugar (U2)
Red Bull (U3)

*Geiß et al., Amino Acids 7, 1994*
Competitive cyclists

Red Bull (500 mL)  
Water dextrose

Time trial to complete a amount of work = 60 min at 70% VO\textsubscript{2}max

Ivy et al., IJ Sport Nutr Exer Met, 19, 2009
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<th>Study</th>
<th>Caff (mg/kg peso)</th>
<th>Type of Performance</th>
<th>Ergogenic</th>
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<tr>
<td>Eckerson et al., 2013</td>
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Dose-response effect of Caffeine

Measuring movement velocity

Pallares, Mora-Rodriguez, et al., MSSE, May 10, 2013
Dose-response effect of Caffeine

Pallares, Mora-Rodriguez, et al., MSSE, May 10, 2013
Dose-response effect of Caffeine

Need a high dose when overcoming high inertia
Circadian rhythm

With time-of-day there are changes in our core temperature, blood pressure, hormonal milieu, trunk flexibility, power and strength.
Circadian rhythm

Circadian rhythm

Circadian rhythm

Caffeine at 3 mg/kg reversed the morning effects of reducing strength

*Mora-Rodriguez, et al., PlosOne, 7, 2012*
To improve maximal force and peak power you need a drink with a high caffeine dose (6-9 mg/kg).

These doses are accompanied by side effects.

Caffeine could alter your circadian rhythm.
Thank you