Effect of Energy Drink Consumption on Power and Velocity of Selected Sport Performance Activities

Bert H. Jacobson,[1] Garrett M. Hester,[2] Ty B. Palmer,[3] Kathryn Williams,[1] Zachary K. Pope,[1] John H. Sellers,[4] Eric C. Conchola,[1] Conrad Woolsey,[4] and Carlos Estrada[1]

[1]Department of Health and Human Performance, Oklahoma State University, Stillwater, Oklahoma; [2]Department of Exercise Science and Sport Management, Kennesaw State University, Kennesaw, Georgia; [3]Department of Kinesiology and Sport Management, Texas Tech University, Lubbock, Texas; [4]U.S. Army Research Center, Natick, Massachusetts; and [5]College of Chiropractic University of Western States, Portland, Oregon

Abstract

Jacobson, BH, Hester, GM, Palmer, TB, Williams, K, Pope, ZK, Sellers, JH, Conchola, EC, Woolsey, C, and Estrada, C. Effect of energy drink consumption on power and velocity of selected sport performance activities. *J Strength Cond Res* 32(6): 1613–1618, 2018—Energy drinks (ED) comprise a multibillion dollar market focused on younger, active, and competitive individuals. Marketing includes claims of improved alertness and performance. The purpose of this study was to assess power (W) and velocity ($m \cdot s^{-1}$) of a simulated, isolated forehand stroke (FHS), and a countermovement vertical jump (CVJ) before and after ingestion of a commercially available energy shot (ES) or a placebo (PL). Healthy college-aged men and women ($N = 36$) volunteers were randomly placed in the ES or PL. Before and 30 minutes after ingesting either the ES or PL, participants performed 3 FHSs and CVJs. Power and velocity of each performance was measured using a linear velocity transducer and the highest value for each measure was used for subsequent analysis. The ES group demonstrated a significant ($p = 0.05$) increase in velocity and W for the FHS, but not for the CVJ. All measures remained unchanged in the PL group for both, the FHS and CVJ. Females demonstrated a significant increase in velocity over males in FHS, but not in CVJ. It was concluded that while the dose of stimulants in the ES was adequate to improve performance of smaller muscle groups, it may not have been sufficient to affect the larger muscle groups of the lower legs which contribute to the CVJ. While the ES used in the present study contained a caffeine dosage within the NCAA limit and did improve performance for the upper body, it must be noted that there are health risks associated with ED consumption.

Key Words muscle, speed, movement, vertical jump

Introduction

Energy drink (ED) manufacturers claim their product is related to improved sport performance presumably because of the inclusion of caffeine and other active ingredients in the drink. Hence, a variety of competitive events such as X games, skateboarding, snowboarding, and other extreme sports vividly reflect ED sponsorship thereby glamorizing the product. The ED market was expected to reach 10.8 billion in sales in 2015. Indeed, 6 billion EDs were sold in the United States in 2010 (14) and one early survey estimated that 32% of high school athletes use EDs (25).

EDs often contain caffeine, guarana, ginseng, ginkgo biloba, and yerba mate which are typically labeled as an "energy blend" without actually indicating the exact amount each in the beverage. While caffeine comprises a proportion of the stimulants in the "energy blend," other stimulants such as yerba mate, guarana, which contains a higher concentration of caffeine than coffee. EDs often contain the herb ginseng which has also been believed to increase energy and to have antifatigue assets. It has been widely known that moderate to a high dose of caffeine had pronounced effects on physical performance (27). However, little is known of the synergistic or additive effect the potential "energy blend" may have. More recently a concentrated version of EDs has appeared on the market as energy shots (ESs), and these small doses contain as much or more of the aforementioned ingredients in a much smaller dose (57 ml).

Much more than many of the other ingredients in EDs, the ergogenic effects of caffeine have been investigated. For example, while caffeine has been shown to enhance endurance, fewer studies have examined the effect of caffeine

Address correspondence to Bert H. Jacobson, bert.jacobson@okstate.edu.

32(6)/1613–1618

Journal of Strength and Conditioning Research

consumption on anaerobic performance (4), fewer studies have examined the effect of caffeine on anaerobic performance. Research investigating caffeine supplementation and anaerobic performance has primarily focused on tasks such as maximal cycling or sprinting (2,11,15,31), and on single-movement tasks (4,9,17,18).

It has been suggested that the primary mechanism by which caffeine improves strength is thought to be through increased motor unit recruitment (29), thus resulting in greater force output. To date there is little evidence regarding the effects of EDs on power (W) output or velocity during a single, explosive task. Hoffman et al. (16), found that EDs improved reaction time among male strength athletes (16), and other researchers (22,24) found that the combination of caffeine and taurine, a common ingredient in ESs, improves reaction time (15). Previous anaerobic-based assessments comprising EDs and 1RM strength (11,31), the Wingate test (7), and sprints (3) have resulted in mixed conclusions. One study found that an ED had no effect on W output during an explosive move when lighter loads were used; however, W output was improved when heavier loads were used (8). In assessing sports it has been found that ED consumption significantly improved performance in female volleyball players (26) and tennis players (12).

Because of the physical expectations associated with ED and ES use among college-aged individuals, it is important to determine what effect, if any, ESs have on functional performance in this population. While caffeine has been shown to produce an ergogenic effect during physical performance, the combination of the previously mentioned "energy blend" ingredients has not been investigated thoroughly. To our knowledge, there has been no previous attempt to determine the effect of an ES on W and velocity in a single, explosive movement. Based on the advertised claims of EDs in general, the purpose of this study was to assess the effects of a commercially available ES on velocity ($m \cdot s^{-1}$) of the small muscle group that is used in shoulder rotation such as those recruited in a simulated, isolated forehand stroke (FHS) and the W and velocity of a large muscle group such as those recruited in a countermovement vertical jump (CVJ).

Methods

Experimental Approach to the Problem

A randomized, double-blind, placebo (PL)-controlled design was used to investigate the acute effects of a commercial ES on rapid muscle contraction during simple activity-related movement. Participants were randomly assigned to either a treatment (ES) or PL group, based on their assigned participant number and corresponding randomized code. Before testing, the participants were to be 48 hours caffeine free and 6 hours without food. Each participant was familiarized with the protocols by performing practice FHSs and CVJs at submaximal speed. Following familiarization and a 5 minutes rest, participants completed 3 FHSs and 3 CVJs followed by random oral administration of either an ES or PL beverage, both of which were supplied in small cups. The PL was mixed to be similar in color and taste to the ES. After administration of either of the beverages participants rested quietly for 30 minutes to allow for peak blood caffeine concentrations to be reached before being post-tested in an identical manner as the pretest. During the absorption period participants were instructed to not compare taste of the beverages or to speculate on what they had consumed.

Subjects

Participants consisted of healthy, active male (n = 17) and female (n = 19) undergraduate students (age range = 19–26 years) at a Midwestern University. Subjects were briefed on the objectives and task of the study prior to choosing to volunteer and before reading and signing an Oklahoma State University-approved IRB written informed consent form. Participants completed a brief questionnaire in which age, height, body mass, and typical caffeine intake was included. While all of the subjects had knowledge and experience in jumping, none of them were actively engaged in racquet sports. Furthermore, any prospective participant who consumed over 90 mg caffeine daily was eliminated from the study. Before testing,

Table 1. Demographic characteristics (mean ± *SD*) for the energy shot and placebo groups.

Group	Variable	Mean	*SD* (±)
Energy shot	Age (y)	23.07	2.36
Placebo	Age (y)	21.40	1.35
Energy shot	Body mass (kg)	76.96	16.76
Placebo	Body mass (kg)	76.61	15.19
Energy shot	Height (cm)	172.30	12.02
Placebo	Height (cm)	175.26	5.09
Energy shot	Caffeine per day (mg)	65.33	51.96
Placebo	Caffeine per day (mg)	78.05	77.34

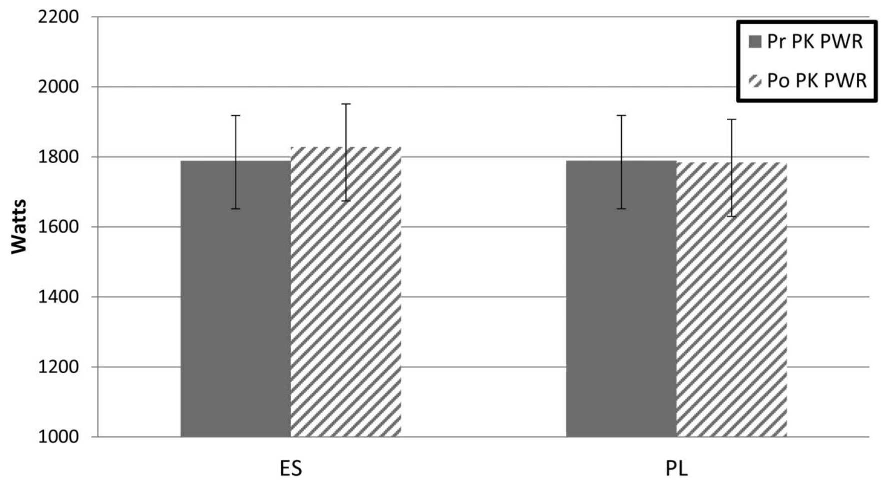

Figure 1. Pre- and post-test vertical jump peak power by group. ES = energy shot; PL = placebo.

participants were asked to abstain from consuming caffeine-containing beverages for 48 hours and food for 6 hours.

Procedures

For the FHS, the subject's dominant upper arm was isolated to the torso by a Velcro strap in order to avoid shoulder movement other than rotation. Subjects faced away from the timing equipment with the elbow flexed at 90° while a cord from a linear velocity transducer (Tendo Speed Analyzer; Tendo Sports Machines, Trencin, Slovak Republic) was attached to the subject's thumb. Further, subjects were asked to externally rotate the shoulder as far as comfortable. At the prompt of a light stimulus situated directly in front of them, they were instructed to internally rotate the shoulder as quickly as possible. The transducer was interfaced with a computer that recorded peak and average velocity ($m \cdot s^{-1}$) during internal rotation of the FHS. Each subject performed 3 separate trials with 15 seconds rest intervals. For the CVJ, subjects completed 3 CVJs separated by 15 seconds rest intervals in which peak W and peak velocity during the concentric phase were recorded via a second linear velocity transducer. During the CVJs, participants stood on the floor with feet shoulder-width apart, and hands positioned on the hips. Participants were not allowed to take any steps before performing the CVJ, and a quick descending quarter-squat countermovement was allowed before the ascending takeoff phase. The participants were instructed to jump as explosively as possible with both feet at the same time and land on the floor in the starting position.

Following pretesting, subjects consumed either a commercially available ES (5-hour ENERGY, Living Essentials LLC) or a PL in a double-blind format. The one 5-hour ES (57 ml) contained approximately 240 mg caffeine, taurine, glucoronolactone, malic acid, N-Acetyl L-tyrosine, L-phenylalanine, and citicoline labeled as "Energy Blend – 2000 mg." Subjects were instructed to drink the "shot" quickly and to not discuss or compare taste or assumptions of what was ingested. Following consumption of either the ES or PL,

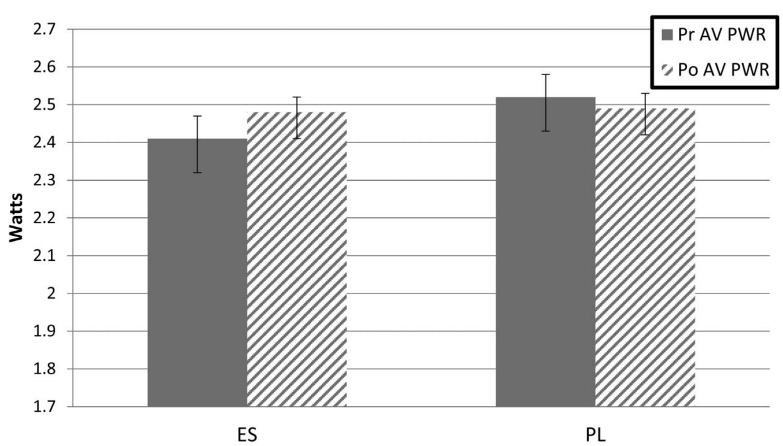

Figure 2. Pre- and post-test vertical jump peak velocity by group. ES = energy shot; PL = placebo.

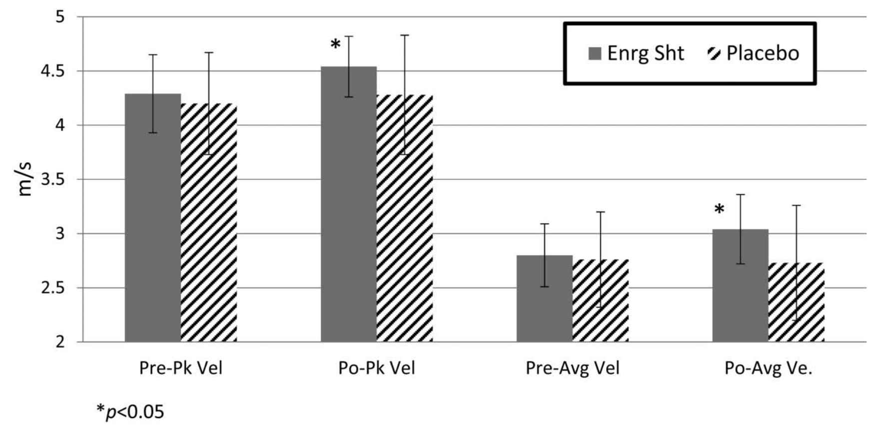

Figure 3. Pre- and post-test forehand stroke peak and average velocity by group ($m \cdot s^{-1}$).

subjects underwent a quiet 30 minutes absorption period. Post-testing consisted of identical assessments of FHS and CVJs.

Statistical Analyses

Independent samples *t*-tests were used to compare pretest values and demographic characteristics between the ED and PL groups. Repeated measures ANOVAs (group [ES vs. PL] × time [pre vs. post]) with SPSS 21.0 were used to analyze between-group and within-group differences for each dependent variable. Posthoc analyses of data were done with Neuman-Keuls posthoc tests. An alpha level of $p \leq 0.05$ was set to determine statistical significance.

Results

There were no significant ($p \leq 0.05$) differences between the ES and PLA groups for age, body mass, height, or caffeine intake (Table 1). Average caffeine intake by the participants was approximately 58 $mg \cdot d^{-1}$ primarily coming from EDs or caffeinated soda. Repeated measures ANOVA for the CVJ yielded no significant difference ($p > 0.05$, ES = 0.29) between the ES and PL groups for peak W, nor was there a significant difference ($p > 0.05$, ES = 0.24) between the ES and PL groups for peak velocity (Figures 1 and 2). However, the ES group posted a slight increase in peak W compared with the PL group (+2.3 vs. −0.2% respectively) (Figure 1) and a slight increase in peak velocity (+2.9 vs. −0.1%, respectively) over the PL group (Figure 2). A comparison of gender with a Newman-Keuls posthoc test yielded no significant ($p > 0.05$) difference in either peak W or peak velocity in either the PL or ES groups.

A repeated measure ANOVA for FHS yielded significant ($p \leq 0.05$, ES = 0.20) between-group differences in peak velocity (Figure 3), with the ES group increasing 5.9% and the PL group declining by 1.9%. A comparison of gender with a Newman-Keuls posthoc test yielded significantly ($p \leq 0.05$) greater pre- to post-test peak velocity in women who were in the ES group, but not in men in the ES group (Figure 4), thus the female participants contributed primarily to the overall group effect in producing significant improvement between the ES group over the PL group for peak velocity (Figure 1).

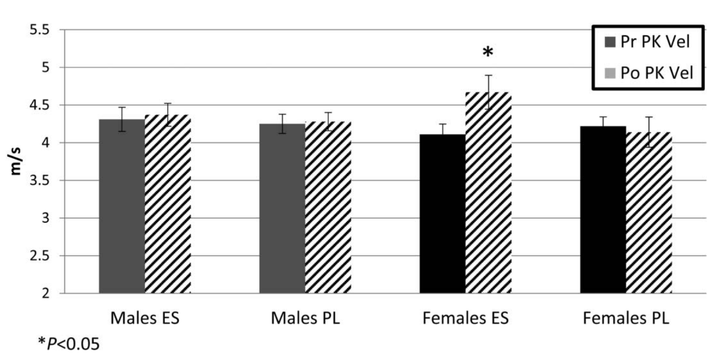

Figure 4. Pre-to post-test forehand stroke peak velocity means by group and gender. ES = energy shot; PL = placebo.

Similarly, the ES group resulted in a significantly ($p \leq 0.05$, ES = 0.23) greater

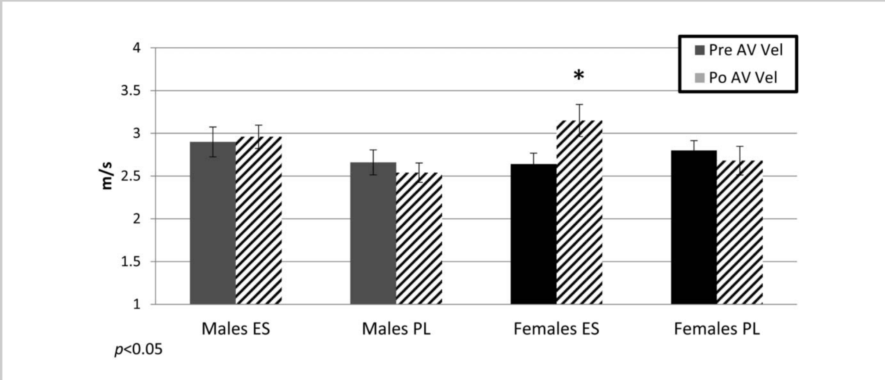

Figure 5. Pre-to post-test forehand stroke average velocity by group (ES & PL) and gender. ES = energy shot; PL = placebo.

improvement in average velocity (Figure 3) with the ES group improving 8.6% and the PL group declining by 1.1%. Again, in a breakdown of gender, women in the ES group registered significantly ($p \leq 0.05$) faster average velocities than men, thereby resulting in making the whole ES group significantly faster than the PL group (Figure 5).

Discussion

There are over 40 commercially available EDs/ESs available to the consumer with the most popular brand amassing over a billion dollars in sales (13). Typically the most common stimulant in ESs is caffeine; however, the "energy blend" contains several ingredients that can trigger neurological and physiological elements. With caffeine being a large contributor to the "energy blend" it has been suggested that caffeine may result in potentiation of muscle contractility through the induction of the sarcoplasmic reticulum (SR) calcium release (21). While several studies have noted that EDs can provide some physical improvement in selected areas such as endurance (28) and strength (9), others have failed to find significant improvement in these areas (10,11). Furthermore, to our knowledge, no study has attempted to determine the potential effects of ESs on movement velocity and W during a singular explosive motion. The significant improvements of W and velocity in the FHS found in the current study are similar to those of Del Coso and associates (8) who found an increase in muscle performance after consumption of an energy beverage. Regarding W output, researchers in separate studies (7,11,15) reported no effect on anaerobic peak or average W. While we failed to find a significant improvement in the CVJ, the ES group significantly outperformed the PLA group in both peak and average FHS velocity.

Given that caffeine (1,3,7 trimethylxanthine) produces muscle contracture because of a release of calcium in the SR (30) it is possible that caffeine may contribute to a more rapid muscular contraction (20). Blinks and associates (6) suggested that caffeine exerts effects on excitation-contraction coupling in 2 ways: the inhibition of calcium sequestration by the SR and increased cell membrane permeability leading to increased calcium entry.

Regarding these findings, the CVJ requires the use of a group of very large muscles which is in contrast with the fewer number of smaller muscle required for the FHS. It is possible that the dose of caffeine in the ES was not sufficient to enhance performance of the large lower body muscles, but was adequate to impact the smaller muscles required for shoulder rotation. This is also evident in the comparison of gender. Presumably, the effect of caffeine and the accompanying active ingredients are relative to body mass (BM) since caffeine is distributed in various tissues in proportion to their water content (5). With muscle containing approximately 75% caffeine, those with greater muscle mass may need a larger dose of "energy blend" than smaller individuals in order to elicit similar effects. The BM of men and women were 84.4 ± 13.6 and 60.1 ± 6.5 kg, respectively, thus, the men were over 23% heavier than the women allowing perhaps, greater concentration of "energy blend" in the women. Given that the ES contained about 240 mg caffeine, the men received an average dose of 2.8 $mg \cdot kg^{-1}$ and the women received an average dose of nearly 4.0 $mg \cdot kg^{-1}$. Thus, it is plausible that this is why women in the ES group outperformed men in the FHS velocity trials.

With regards to greater muscle activation (i.e., increased motor unit recruitment), the same task-dependent rationale could be proposed as the mechanism by which performance was improved during the FHS but not the CVJ. However, since there were no measures of cellular or neuromuscular responses in this study it is unknown what mechanism(s) contributed to the task-dependent effects of ES used in the present study. These results correspond to several other studies that have found EDs to improve anaerobic performance (1), muscle endurance (11), movement time (18,19), and strength (31). In conclusion, while EDs and ESs may provide some ergogenic effect in sport and competitive performance, consumption of such beverages is not without risk. It is not unusual for competitive individuals to overextend doses of particular supplements for the benefit of improved performance. Such practice should be strictly discouraged since reports of serious health complications after consumption of EDs have surfaced. For instance, Meier (23) claims that the Food and Drug Administration has found ESs to be associated with 13 deaths and over 90 lifethreatening events. As the popularity and use of EDs is likely to increase, further research is needed to ascertain both the benefits and risks of long-term use.

Practical Application

ESs contain more active ingredients than just caffeine, but it should be mentioned that while caffeine has been removed as a banned substance by the International Olympic Committee, it remains on its monitoring list. In contrast, the National Collegiate Athletic Association currently allows caffeine to a maximum of 15 $\mu g \cdot ml^{-1}$. The caffeine content of the ES used in the present study was below the NCAA limit, yet quantity of caffeine and other ingredients of the ES used in the current study seems to enhance a certain velocity-related activity in smaller muscles in those with less BM. Coaches and athletes should know that while these ESs may be beneficial for some physical performance, before recommending use it must be noted that EDs/ESs should be used only in moderation if at all.

References

1. Alford, C, Cox, H, and Wescott, R. The effects of red bull energy drink on human performance and mood. *Amino Acids* 21: 139–150, 2001.
2. Anselme, F, Collomp, K, Mercier, B, Ahmaiedi, S, and Prefaut, C. Caffeine increases maximal anaerobic power and blood lactate concentration. *Eur J Appl Physiol Occup Physiol* 65: 188–191, 1992.
3. Astorino, TA, Matera, AJ, Basinger, J, Evans, M, Schurman, T, and Marquez, R. Effects of red bull energy drink on repeated sprint performance in women athletes. *Amino Acids* 42: 1803–1808, 2012.
4. Astorino, TA and Roberson, DW. Efficacy of acute caffeine ingestion for short-term high-intensity exercise performance: A systematic review. *J Strength Cond Res* 24: 257–265, 2010.
5. Axelrod, J and Reichenthal, J. The fate of caffeine in man and a method for its estimation in biological material. *J Pharmacol Exp Ther* 107: 519–523, 1953.
6. Blinks, JR, Olson, CB, Jewell, BR, and Bravený, P. Influence of caffeine and other methylxanthines on mechanical properties of isolated mammalian heart muscle: Evidence for a dual mechanism of action. *Circ Res* 30: 367–392, 1972.
7. Campbell, BI, Kilpatrick, M, Wilborn, C, La Bounty, P, Parker, B, Gomez, B, Elkins, A, Williams, S, and dos Santos, MG. A commercially available energy drink does not improve peak power production on multiple 20-second Wingate tests. *J Int Soc Sports Nutr* 7: 1–2, 2010.
8. Del Coso, J, Salinero, JJ, González-Millán, C, Abián-Vicén, J, and Pérez-González, B. Dose response effects of a caffeine-containing energy drink on muscle performance: A repeated measures design. *J Int Soc Sports Nutr* 9: 21, 2012.
9. Duncan, MJ, Thake, CD, and Downs, PJ. The effect of caffeine ingestion on torque and muscle activity during resistance exercise men. *Muscle Nerve* 50: 523–527, 2014.
10. Eckerson, JM, Bull, AJ, Baechle, TR, Fischer, CA, O'Brien, DC, Moore, GA, Yee, JC, and Pulverenti, TS. Acute ingestion of sugar-free red bull energy drink has no effect on upper body strength and muscular endurance in resistance trained men. *J Strength Cond Res* 27: 2248–2254, 2013.
11. Forbes, SC, Candow, DG, Little, JP, Magnus, C, and Chilibeck, PD. Effect of red bull energy drink on repeated wingate cycle performance and bench-press muscle endurance. *Int J Sport Nutr Exerc Metab* 17: 433–444, 2007.
12. Gallo-Salazar, C, Areces, F, Abián-Vicén, J, Lara, B, Salinero, JJ, Gonzalez-Millán, C, Portillo, J, Muñoz, V, Juarez, D, and Del Coso, J. Enhancing physical performance in elite junior tennis players with a caffeinated energy drink. *Int J Sports Physiol Perform* 10: 305–310, 2015.
13. Goel-lal, G. *Energy Drinks and Energy Shots*: Mintel Group Ltd, 2012. pp. 1.
14. Goel-lal, G. *Mintel Energy Drink and Energy Shots-US-June 2012*: Mintel Group Ltd, 2012.
15. Gwacham, N and Wagner, DR. Acute effects of a caffeine-taurine energy drink on repeated sprint performance of American college football players. *Int J Sport Nutr Exerc Metab* 22: 109–116, 2012.
16. Hoffman, JR, Kang, J, Ratamess, NA, Hoffman, MW, Tranchina, CP, and Faigenbaum, AD. Examination of a pre-exercise, high energy supplement on exercise performance. *J Int Soc Sports Nutr* 6: 1–8, 2009.
17. Jacobson, B, Weber, M, Claypool, L, and Hunt, L. Effect of caffeine on maximal strength and power in élite male athletes. *Br J Sports Med* 26: 276–280, 1992.
18. Jacobson, BH and Edgley, BM. Effects of caffeine in simple reaction time and movement time. *Aviat Space Environ Med* 58: 1153–1156, 1987.
19. Jacobson, BH, Hughes, PP, Conchola, EC, Hester, GM, and Woolsey, CL. Effect of energy drinks on selected fine motor tasks. *Percept Mot Skills* 121: 170–178, 2015.
20. Lüttgau, HC and Oetliker, H. The action of caffeine on the activation of the contractile mechanism in striated muscle fibres. *J Physiol* 194: 51–74, 1968.
21. Magkos, F and Kavouras, SA. Caffeine use in sports, pharmacokinetics in man, and cellular mechanisms of action. *Crit Rev Food Sci Nutr* 45: 535–562, 2005.
22. Matinuzzi, V, Peterson, D, Iacobone, S, and Badjou, S. *Effects and Effectiveness of Energy Drinks*. U Mass Lowell: for the ASEE Northeast Section Conference, April 27–28, 2012.
23. Meier, B. Caffeinated Drink Cited in Reports of 13 Deaths. *New York Times*, November 14, 2012. Available at: http://www.nytimes.com/2012/11/15/business/5-hour-energy-is-cited-in-13-death-reports.html. Accessed June 23, 2017.
24. Peacock, A, Martin, FH, and Carr, A. Energy drink ingredients. Contribution of caffeine and taurine to performance outcomes. *Appetite* 64: 1–4, 2013.
25. Reynolds, G. Phys Ed: Do Energy Drinks Improve Athletic Performance. *New York Times*, December 8, 2010. Available at: https://well.blogs.nytimes.com/2010/12/08/phys-ed-do-energy-drinks-improve-athletic-performance/. Accessed July 27, 2017.
26. Salinero, JJ, Abian-Vicne, J, Valades, D, Lara, B, Hernandez, C, Areces, F, and Del Coso, J. Caffeinated Energy Drinks Improve Volleyball Performance in Elite Female Players. *Med Sci Sports Exerc* 47: 850–856, 2015.
27. Spriet, LL. Exercise and sport performance with low doses of caffeine. *Sports Med* 44: 175–184, 2014.
28. Walsh, AL, Gonzalez, AM, Ratamess, NA, Kang, J, and Hoffman, JR. Research Article improved time to exhaustion following ingestion of the energy drink amino impact. *J Int Soc Sports Nutr* 7: 1550–2783, 2010.
29. Warren, GL, Park, ND, Maresca, RD, McKibans, KI, and Millard-Stafford, ML. Effect of caffeine ingestion on muscular strength and endurance: A meta-analysis. *Med Sci Sports Exerc* 42: 1375–1387, 2010.
30. Weber, A and Herz, R. The relationship between caffeine contracture of intact muscle and the effect of caffeine on reticulum. *J Gen Physiol* 52: 750–759, 1968.
31. Woolf, K, Bidwell, WK, and Carlson, AG. The effect of caffeine as an ergogenic aid in anaerobic exercise. *Int J Sport Nutr Exerc Metab* 18: 412, 2008.