Effect of energy drink dose on exercise capacity, heart rate recovery and heart rate variability after high-intensity exercise

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(Received: 2014/01/20, Revised: 2014/02/10, Published online: 2014/02/11)

**[Purpose]** The purpose of this research was to investigate the effects of exercise capacity, heart rate recovery and heart rate variability after high-intensity exercise on caffeine concentration of energy drink. **[Methods]** The volunteers for this study were 15 male university students. 15 subjects were taken basic physical examinations such as height, weight and BMI before the experiment. Primary tests were examined of VO2max per weight of each subject by graded exercise test using Bruce protocol. Each of five subject was divided 3 groups (CON, ECG I, ECG II) by matched method based on weight and VO2max per weight what gained of primary test for minimize the differences of exercise capacity and ingestion of each groups. For the secondary tests, the groups of subjects were taken their materials before and after exercise as a blind test. After the ingestion, subjects were experimented on exercise test of VO2max 80% by treadmill until the all-out. Heart rate was measured by 1 minute interval, and respiratory variables were analyzed VO2, VE, VT, RR and so on by automatic respiratory analyzer. And exercise exhaustion time was determined by stopwatch. Moreover, HRV was measured after exercise and recovery 3 min. **[Results]** Among the intake groups, ECG II showed the longest of exercise exhaustion time more than CON group (p = .05). Result of heart rate during exercise according to intake groups, there was significant differences of each time (p < .001), however, not significant differences of each groups and group verse time (p > .05). Result of RPE during exercise according to intake groups, there was significant differences of each time (p < .001), however, not significant differences of each groups and group verse time (p > .05). **[Conclusion]** In conclusion, EDG II showed the significant increase of exercise exhaustion time more than CON group (p = .05) and not significant differences in HR, RPE, RER, HRV, HRR, blood pressure (p > .05). Therefore, 2.5 mg/kg-1 ingestion of energy drink might be positive effect to increase exercise performance capacity without side-effect in cardiovascular disease. **[Keyword]** Energy Drink, Caffeine, HRV, HRR, Exercise, Cardiovascular

**INTRODUCTION**

Necessity and purpose of the study

Among energy drinks available in Korean market, ‘Hot Six,’ an energy drink from Lotte Chilsung, marked 250 million won sales in Jan. 2011. Since 2012, its sales have recorded more than 3 billion won every month, indicating rapid growth of energy drink market in Korea. A sales analysis on the market showed that energy drinks are sought mostly by young people - those in their teens and 20s accounted for 23% and 41% of the consumers respectively. Energy drinks are known to boost mental and physical energy of those who drink them [1]. Caffeine, taurine and citric acid are considered primary ingredients that boost mental and physical energy in consumers [2]. The primary ergogenic ingredient in the drinks is known to be caffeine [3].

The caffeine level in energy drinks makes a whole lot of difference [4]. Caffeine is readily accessible in everyday life and consumed through various drinks and foods [5,6]. However, too much caffeine consumption can cause a range of side effects - anxiety, insomnia, accelerated heartbeat, caffeine addiction, caffeine withdrawal, etc. [7]. Considering these adverse effects, Korea’s Ministry of Food & Drug Safety made caffeine content warning label mandatory for all drinks except green tea and coffee. The label warns people that beverages containing more than 0.15 mg/mL level of caffeine are classified as a high caffeine drink and should be avoided by those sensitive to caffeine such as children and pregnant woman [8].

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When caffeine is absorbed in the body, it stimulates sympathetic nervous system and results in a rise in plasma catecholamine that allows the body to adapt to the stress created by physical exercise. In the heart, it prompts secretion of norepinephrine and epinephrine to increase the rate and force of the muscle’s contractions. They raise the rate and force of the heart, thereby increasing the blood pressure and make the heart beat faster [9]. Catecholamine production increases the availability of free fatty acids as muscle substrates during work, thus allowing glycogen sparing, improving physical performance [10,11]. Since Costill et al. [12] reported the improvement of physical performance after intake of caffeine, many studies have reported the same and claimed that ergogenic effect of caffeine was seen in people who had at least more than 2.5 mg/kg\(^{-1}\) dose of caffeine intake [13,14]. However, caffeine intake of more than 3 mg/kg\(^{-1}\) or 200 mg/kg\(^{-1}\) resulted in side effects such as stomach pain, anxiety, hypersensitiveness, faster heartbeats, etc. [15]. As concerns grow bigger over increasing caffeine intake due to increasing consumption of energy drinks, studies that investigate the effects of caffeine intake on physical performance within the safe caffeine limit that would not cause side effects is needed. Also, dose of caffeine intake needs to be analyzed by physique of each person in order to ensure safety and establish systematic data. Thus, this study intends to analyze the effects of caffeine-containing energy drink consumption on physical performance during high intensity exercise and hear rate recovery (HRR) and heart rate variability (HRV). It also aims to Fig. out the dose of caffeine intake which may improve physical performance without triggering side effects.

**METHODS**

**Subjects**

15 male students at Department of Social Physical Education of K University became the subjects of this study. In order to make sure that participants’ in each group are similar in their VO\(_{2}\)max, height, weight, etc., matching methods were used to group the 15 participants into three groups (5 per each group) - control group that drank water without caffeine (0 mg/kg\(^{-1}\) caffeine), ECG (energy consumption group) I that drank energy drinks with 1.25 mg/kg\(^{-1}\) dose of caffeine and ECG (energy consumption group) II that drank energy drinks with 2.5 mg/kg\(^{-1}\). Physical characteristics of the participants is summarized in the <Table 1>.

### Table 1. Physical characteristic of subjects

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Age (yrs)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m(^2))</th>
<th>VO(_{2})max (mL/kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>5</td>
<td>21.20 ± 1.79</td>
<td>177.60 ± 6.54</td>
<td>72.20 ± 4.09</td>
<td>23.20 ± 1.64</td>
<td>57.20 ± 10.76</td>
</tr>
<tr>
<td>ECG I</td>
<td>5</td>
<td>21.40 ± 1.14</td>
<td>177.60 ± 4.39</td>
<td>73.20 ± 5.22</td>
<td>23.40 ± 1.14</td>
<td>59.20 ± 5.63</td>
</tr>
<tr>
<td>ECG II</td>
<td>5</td>
<td>20.20 ± 0.45</td>
<td>175.20 ± 5.27</td>
<td>72.60 ± 4.04</td>
<td>23.40 ± 0.89</td>
<td>59.60 ± 2.88</td>
</tr>
<tr>
<td>F</td>
<td>1.319</td>
<td>.312</td>
<td>.063</td>
<td>.042</td>
<td>.159</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>.303</td>
<td>.738</td>
<td>.939</td>
<td>.959</td>
<td>.855</td>
<td></td>
</tr>
</tbody>
</table>

Values are Mean ± Standard deviation

CON : control group, ECG I : energy drink 1.25 mg/kg\(^{-1}\) consumption group, ECG II : energy drink 2.5 mg/kg\(^{-1}\) consumption group

**Measuring instruments and methods**

**Measurement of physiques**

Subjects were not allowed to eat or exercise for six hours before the test and they were told to urinate and defeate before the test. They wore shorts and short sleeve T-shirt when measuring their height using a height machine (Health mate 9600A, Sewoo, Seoul, Korea) and weight and body composition with body composition analyzer (Inbody 720, Biospace, Seoul, Korea).

**Exercise load method**

In order to serve the purpose of this study, two tests - preliminary test and primary test - were conducted at one-week interval in a way to get rid of any possible influence. All subjects were told not to drink alcohol or caffeinated drink or food on the previous day. They fasted for six hours before the tests which were conducted at the same time of the day. Subjects arrived at the test room two hours before the test and had their body composition measured and sat on chairs until the test. Burce protocol was used to measure their VO\(_{2}\) max while they ran on treadmill (Cosmed T150, Rome, Italy) until they reach their maximum, Automatic metabolic gas analyzer (Tru One 2400, Parvo Medics, UT, USA) was used to measure gas during exercise. A 5-minute warm-up - starting from 1.7mph to gradually reach less than 70% of VO\(_{2}\) max - was conducted based on a study by Darren et al. [16] and then each subject ran at 80% of his/her VO\(_{2}\) max. Respiratory parameters, heart rate, and rating of perceived exertion (RPE) were checked every minute during the exercise. Gas analysis