EFFECTS OF ACUTE SUPPLEMENTATION OF CAFFEINE AND PANAX GINSENG ON ENDURANCE RUNNING PERFORMANCE IN A HOT AND HUMID ENVIRONMENT

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INTRODUCTION

Various studies have demonstrated the ergogenic effects of caffeine on endurance performance (Anderson et al., 2000; Birnbaum and Herbst, 2004; Bell and McLellan, 2002; Bell and McLellan, 2003; Graham, 2001; Kovacs et al., 1998; Norager et al., 2005; Van Soeren and Graham, 1998). It has been reported that 89% and 73% of the athletes were using caffeinated substances in the 2005 Triathlon World Championships and 2005 Ironman Triathlon World Championships, respectively, with the target to enhance their endurance performance (Desbrow and Leveritt, 2006; Desbrow and Leveritt, 2007). The medical Council of International Olympic Committee (IOC), allowed caffeine ingestion in sports as long as its urinary excretion level is below 12 µg/ml (Kovacs et al., 1998). Ingestion of 3-6 mg of caffeine per kg of body weight exerts an equivalent ergogenic effect to its higher doses (Graham et al., 1998) and it has been recommended that caffeine dose should be limited to 7 mg per kg of body weight or less to avoid the chance of the positive drug test. However,
ingestion of 5 mg caffeine per kg of body weight has the most consistent effect to improve endurance performance (Trice and Haymes, 1995; Ransley et al., 2005).

On the other hand, *Panax ginseng* (Family - Araliaceae), the most widely used best grade of ginseng compared to the other species (Gyllenhal et al., 2000), is used as a dietary and medicinal herb in different parts of the world. In the Western countries, it is frequently used as a performance enhancer because it restores Qi, i.e., life energy (Gyllenhal et al., 2000; Bucci, 2000; Kennedy and Scholey, 2003). It is a globally popular perennial herb due to its medicinal and energy enhancing property without teratogenic or mutagenic trait (Yun, 2001; Monteiro et al., 2002; Hobbs, 1996). Since it is not included among the banned stimulants for athletes (Bahrke and Morgan 1994; Hasegawa et al., 1996; Cui et al., 1997), there is no risk of disqualification from using *Panax ginseng* by the sportspersons.

The acute supplementation of *Panax ginseng* did not influence the endurance performance in Malaysian recreational runners in hot and humid environment (Wong et al., 2010a). Alternatively, ingestion of 5 mg of caffeine per kg of body weight improved the endurance running performance in heat-acclimated recreational Malaysian runners in a hot and humid condition, but it did not impose any significant effect on other individual cardiorespiratory parameters (Wong et al., 2010b).

It has been reported that supplementation of other herbs like mahuang, ephedrine and related alkaloids did not enhance the endurance performance; but if they are supplemented along with caffeine then they could augment the endurance performance (Bucci, 2000). Though acute supplementation of *Panax ginseng* did not improve endurance performance (Wong et al., 2010a), but in the light of the literature of Bucci (2000), it may be speculated that if ginseng is supplemented along with caffeine then it might improve the endurance capacity. Moreover, relevant literature in the concerned field is unavailable.

The present study was therefore aimed to examine the effects of acute supplementation of caffeine and *Panax ginseng* on endurance running performance in heat-adapted Malaysian male recreational runners under the hot and humid environment.

**METHODS**

**Selection of Subjects:** Nine male subjects belonging to 20–40 years of age were recruited in this study by random sampling method from the recreational runners who jog at least 30 minutes, 2 times per week or more with at least a minimum of 30 minutes per session (Jackson, 1995) from the Malaysian students and staff of the Universiti Sains Malaysia, Kota Bharu, Kelantan, Malaysia. The mean age, body mass and body height were $25.4\pm 6.9$ years, $57.6\pm 8.4$ kg and $168.3\pm 7.6$ cm, respectively. Individuals with hypertension, asthma, diabetes, bronchitis, anaemia, cardiac problems, kidney or liver diseases and or any other major diseases were excluded from the study. The entire experimental protocol was explained to each subject and written informed consent was obtained from them. The research was approved by the Research and Human Ethics Committee of the Universiti Sains Malaysia.

**Test procedures**

**Experimental design:** The subjects were evaluated in a randomized placebo-controlled double blind method. Each subject came to the laboratory for 5 times. The first three visits were spent for some preliminary tests whereas the final two visits comprised of actual experimental trials (Fig. 1). The first pre-trial visit involved the measurement of sub-maximal oxygen consumption while second pre-trial visit included the measurement of $VO_{2max}$. These two trials were conducted to determine the exact treadmill speed that corresponds to the 70% of the subject’s $VO_{2max}$ which was set as the exercise trial speed. In the third pre-trial visit, the subjects were familiarized with the tests for experimental trials in the hot and humid environment ($31^\circ C$, 70% relative humidity). Then, the two experimental trials with either placebo (Pl) supplementation or combined dose of caffeine and *Panax ginseng*
supplementation (CPG) were carried out with a 7-days gap between trials. The subjects reported to the laboratory after an overnight fast of 10 hours. All the experimental trials were conducted at 8.00 am.

**Fig. 1. Experimental Design of the Study.**

**Preparation of the subjects:** The subjects were requested to record their food intake for 3 days prior to the first trial and repeated the same diet over 3 days before the days of consecutive trials to minimize the variation in pre-exercise muscle glycogen status. They were asked to refrain from heavy exercise for 24 hours prior to the tests.

On arrival in the laboratory, the subjects underwent a physical examination that included the measurement of body weight, pre-exercise heart rate and body fat percentage by bio-electrical impedance analysis (Tanita, Japan). After that, 4 skin thermistors (Yellow Springs instrument, USA) were attached to the chest, biceps, thigh and calf of the subject’s body for recording the mean skin temperature (Ramanathan, 1964). A rectal probe was inserted to a depth of 10 cm beyond the anal sphincter for the determination of core temperature of the body throughout the trial. Core and skin temperatures were recorded on a temperature monitor (Libra Medical ET 300R, USA).

A heart rate monitor (Sport Tester PE3000, Polar, Finland) was secured on the subject’s chest to monitor the heart rate. An indwelling cannula was inserted into a subcutaneous forearm vein and an extension tube was connected to it to facilitate repeated blood withdrawals. Patency of the cannula was maintained with heparinised saline. A standardized breakfast of 500 ml of water and a piece of bread was given to the subject 2 hours before the trial (Wong et al., 2010a; Wong et al., 2010b). The subject ingested the capsule containing either the placebo (Pl) or the combined dose of caffeine (5 mg.kg⁻¹ body weight) and *Panax ginseng* (200 mg) one hour before the experimental trials (Reay et al., 2006; Fredholm et al., 1999; Wong et al., 2010a; Wong et al., 2010b).

**Procedure of the submaximal exercise test:** After 5 min warm up at a treadmill speed of 6–7 km.h⁻¹, subject was asked to wear a mouthpiece, a nose clip and a heart rate sensor (Sport Tester PE3000, Polar, Finland). A head gear was fitted to support a two-way non-re-breathing valve (Hans Rudolph 2700 series, USA) attached to the mouthpiece. The gas collection was started when the pre-calibrated gas analyser system reached the steady state. The subjects ran on a motorised treadmill (Quinton 18-60, USA) for four minutes each at four different speeds (7, 8, 9 and 10 km.h⁻¹, respectively). The speed was increased by 1 km.h⁻¹ at the end of each 4 min.

Expired air during the test was passed through a mixing chamber where sensors to the pre-calibrated paramagnetic oxygen and infrared carbon dioxide analyzers (Sensormedic 2900, USA) were used to determine the percentages of oxygen and carbon dioxide in the expired air. Both the analysers were calibrated using two nitrogen based calibration gases (26% oxygen in nitrogen...
mixture, and 4% carbon dioxide and 16% oxygen in nitrogen mixture). The outputs from the gas analyser were processed using a computer for the calculation of oxygen consumption (VO$_2$) and carbon dioxide production (VCO$_2$). Expired gas was measured every twenty seconds by the analyser. Heart rate and rate of perceived exertion were measured during the final minute of each 4 min of the increment.

**Measurement of VO$_{2\text{max}}$:** Maximum oxygen uptake was determined using the modified Astrand protocol (Heyward, 1991) where the subjects ran to volitional exhaustion during a continuous incremental run on a motorised treadmill. The subjects were initially allowed to warm up for 5 minutes at a slow speed (6-7 km.h$^{-1}$). After warm up, the subjects were fitted with the headgear, mouthpiece, nose clip and heart rate sensor as in the sub-maximal test. An appropriate speed (8-12 km.h$^{-1}$) was selected and the test began with a grade of 0% for 3 minutes. Thereafter, the grade was increased by 2½ % every 2 minutes and the subject was encouraged to run until exhaustion.

Expired air samples were analysed at the end of each 2 min stage by following the same method as mentioned in the procedure of submaximal exercise procedure. Heart rate responses were also measured at the end of each 2 min stage. The maximum oxygen uptake (VO$_{2\text{max}}$) value was accepted when the following criteria were met (ACSM 2006):

i) Attainment of a plateau in oxygen uptake despite increasing the workload;
ii) Heart rate within 10 beats.min$^{-1}$ of age-predicted maximum heart rate, i.e., 220 beats. min$^{-1}$ – age (years);
iii) A respiratory exchange ratio of $> 1.15$.

The first pre-trial visit was conducted to determine the correlation between oxygen uptake and running speed. The VO$_{2\text{max}}$ was determined in the second pre-trial visit. The data from these 2 trials were used to determine the running speed that would elicit 70% of their respective VO$_{2\text{max}}$ during the experimental trials.

**Experimental trial:** The subjects ran on the treadmill at 70% of VO$_{2\text{max}}$ “to voluntary exhaustion” that was determined as the point when they indicated that they could no longer run at the required speed (Graham et al., 1998). At the point of exhaustion and to ensure that the subjects were truly fatigued, the running speed was reduced to elicit 60% of VO$_{2\text{max}}$ for 2 minutes. Thereafter, the speed was returned to the prescribed speed (70% of VO$_{2\text{max}}$) and the subjects were encouraged to run as long as possible. Verbal encouragement was given to the exercising subjects to ensure their maximum effort.

**Data collection during the experimental trials:** Blood samples were collected and oxygen consumption was measured at an interval of 20 min throughout the running trials. Heart rate, skin temperature, rectal temperature, room temperature, relative humidity and RPE (by Borg’s Scale 1998) were noted at an interval of 10 min. Cool water (4-8°C) @ 3ml per kg of body weight was given to the subjects at an interval of 20 minutes to avoid any possible adverse effects of dehydration (Coyle, 1994; Carter et al., 2003; Wong et al., 2010a; Wong et al., 2010b).

**Biochemical analysis of blood parameters:** Plasma glucose concentration was determined by the enzymatic oxidation method. Enzyme-amplified chemiluminescent technology and commercially available immunoassay kits (Siemens Medical Solution Diagnostics, 2007) were used to perform immunoassays of serum insulin level. Plasma lactate was analysed using the YSI 1500 SPORT Lactate analyser (YSI incorporated, Yellow Spring, Ohio, United States).

**Statistical analyses**

Statistical Programme for the Social Sciences version 14.0 (SPSS Incorp, United States) was used for the statistical treatment of the data. All the parameters were expressed as mean and standard deviation (±S.D.). Shapiro-Wilk Test was used to check the normality of the population (Field 2000, Rosytton 1992). 2 – way repeated measure ANOVA was used followed by post-hoc analysis to observe the significant difference at P<0.05 level. The paired-t test was used to compare the difference between means. Ratings of perceived exertion (RPE) were analysed using the Wilcoxon signed rank test. The level of significance was set at p<0.05.
RESULTS

The body mass index (20.2±1.9 kg.m⁻²) and body fat percentage (15.6±2.8 %) indicated that the subjects were under the normal category (Brown, 2005). Mean VO₂max (51±8.3 ml.kg⁻¹.min⁻¹) reflected that the subjects had good cardiorespiratory fitness (McArdle et al., 2000). The pre-exercise heart rate and the maximum heart rate of the subjects were 67±5.7 beats.min⁻¹ and 197±6.5 beats.min⁻¹, respectively.

There was no significant (P>0.05) alteration in room temperature (31.0±0.2 °C and 31.0±0.1 °C, respectively) and relative humidity (69.0±0.8% and 68.0±1.4%, respectively) between the two trials. Running time to exhaustion was significantly different (P<0.05) between CPG and Pl trials (107.3±33.2 min and 83.6±21.4 min, respectively).

Heart rate, oxygen consumption, skin temperature and core body temperature significantly (P<0.05) increased over time in the same experimental trial compared to the respective resting value (Table 1). However, no significant difference (P>0.05) was observed in these parameters between the two trials.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Duration of Exercise (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate (beats.min⁻¹)</td>
<td>0  10  20  30  40  50  60  84  110</td>
</tr>
<tr>
<td>Pl</td>
<td>67 ± 5.7 157±18.3* 162±16.8* 165±16.8* 167±15.2* 169±14.6* 170±13.7* 172±9.6*</td>
</tr>
<tr>
<td>CPG</td>
<td>67 ± 7.6 158±12.1* 165±11.5* 168±11.1* 169±10.2* 170±14.1* 175±9.8* 185±8.01*</td>
</tr>
<tr>
<td>VO₂ (mL.kg⁻¹.min⁻¹)</td>
<td>7.3 ± 1.3 34.0±5.4* 34.9±5.1* 35.21±5.3* 35.82±5.0*</td>
</tr>
<tr>
<td>Pl</td>
<td>7.7 ± 1.6 33.95 ± 5.2* 34.82 ± 5.8* 35.65 ± 5.2* 35.78 ± 4.4*</td>
</tr>
<tr>
<td>CPG</td>
<td>36.46±0.3 37.06±0.5* 37.55±0.7* 37.96±0.8* 38.31±0.8* 38.42±0.8* 38.56±0.8* 39.18±0.3*</td>
</tr>
<tr>
<td>Core body Temperature (°C)</td>
<td>36.66±0.3 37.24±0.4* 37.62±0.5* 38.06±0.6* 38.28±0.6* 38.43±0.7* 38.57±0.7* 39.62±0.4*</td>
</tr>
<tr>
<td>Pl</td>
<td>33.04±0.7 33.96±0.7* 34.18±0.6* 33.78±0.8* 33.68±0.9* 33.53±0.8* 33.56±0.8* 33.82±0.7*</td>
</tr>
<tr>
<td>Skin temperature (°C)</td>
<td>33.2±0.9* 33.97±0.6* 34.1±0.5* 34.08±0.8* 33.81±0.9* 33.72±1.12* 33.69±0.8* 34.13±0.8*</td>
</tr>
</tbody>
</table>

Values are expressed as mean ±SD. CPG = Caffeine and Panax ginseng trial, Pl = Placebo trial. *p<0.001, **p<0.01 when compared with the pre-exercise (0 min) value in the same trial.

Plasma lactate, blood glucose, insulin and free fatty acid concentrations during rest and exercise trials were presented in Table 2. Repeated measure ANOVA showed that there was a significant (P<0.05) main effect of time on plasma lactate concentration, but there was no significant difference in the plasma lactate (P>0.05) concentration between the trials. This finding is in agreement with other studies with different doses of ginseng supplementation (Engels and Wirth, 1997; Allen et al., 1998; Kulaputana et al., 2007).

Repeated ANOVA analyses exhibited a significant (P<0.05) main effect of time on plasma glucose and insulin concentrations. However, there was no significant variation (P>0.05) in these parameters between the trials. There have been a main effect of time and a significant difference in plasma free fatty acid concentrations between the trials (P<0.05).

The subjects expressed their feelings on a numerical scale (RPE by Borg’s Scale) to indicate the fatigue level. The data of RPE were presented in Table 3. RPE increased significantly (P<0.05) with the progression of exercise in both the trials, but no significant variation (P>0.05) was found in this parameter when compared between the Pl and CPG trials.
Panax ginseng had long been used as an ergogenic herb for its beneficial psychophysiological effects which improve the endurance capacity, strength, neural functions, immune system and psychological parameters without any harmful effects to the body (Hobbs, 1996; Talbott, 2003).

Regarding the effects of chronic supplementation of Panas ginseng on endurance performance...

### Table 2. Values of different blood parameters during the experimental trials (n = 9).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Duration of Exercise (min)</th>
<th>Time to Exhaustion</th>
<th>Difference (Δ) between Pre- and Post-Exercise Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Plasma Lactate (mmol.L⁻¹)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.52±0.31</td>
<td>5.15±2.19**</td>
<td>4.52±2.42**</td>
</tr>
<tr>
<td></td>
<td>1.88±0.74</td>
<td>5.02±2.09**</td>
<td>4.78±2.12**</td>
</tr>
<tr>
<td>Plasma Glucose (mmol.L⁻¹)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.24±0.7</td>
<td>5.47±0.82**</td>
<td>6.28±1.51**</td>
</tr>
<tr>
<td></td>
<td>5.98±0.66**</td>
<td>5.78±0.59**</td>
<td>6.23±1.34**</td>
</tr>
<tr>
<td>Plasma insulin concentrations (µm.L⁻¹)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.32±4.37</td>
<td>4.01±2.24**</td>
<td>3.85±2.01**</td>
</tr>
<tr>
<td></td>
<td>8.17±4.06</td>
<td>4.76±2.26**</td>
<td>4.44±2.44**</td>
</tr>
<tr>
<td>Plasma Free Fatty Acid (mmol.L⁻¹)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.36±0.25</td>
<td>0.42±0.23**</td>
<td>0.49±0.15**</td>
</tr>
<tr>
<td></td>
<td>0.69±0.2</td>
<td>0.71±0.15**</td>
<td>0.75±0.19**</td>
</tr>
</tbody>
</table>

Values are expressed as mean±SD. CPG = Caffeine+ Panax ginseng trial, PI = Placebo trial **p<0.001, *p<0.01 when compared with the pre-exercise (0 min) value in the same trial.

### Table 3. Rate of perceived exertion (RPE) of the subjects (n=9) during exercise in different trials.

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Time (min)</th>
<th>CPG trial</th>
<th>Placebo trial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>10.5 ± 2.2</td>
<td>10.6 ± 2.4</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>11.2 ± 2.3</td>
<td>12.0 ± 2.3</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>12.1 ± 2.1</td>
<td>13.0 ± 2.6</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>12.7 ± 2.5</td>
<td>14.2 ± 2.5</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>14.1 ± 2.7</td>
<td>15.3 ± 2.7</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>15.2 ± 2.6</td>
<td>16.7 ± 2.6</td>
</tr>
<tr>
<td>End time to exhaustion</td>
<td>19.8 ± 0.5</td>
<td>19.6 ± 0.5</td>
<td></td>
</tr>
</tbody>
</table>

Values are expressed as mean±SD.

### DISCUSSION

Panax ginseng had long been used as an ergogenic herb for its beneficial psychophysiological effects which improve the endurance capacity, strength, neural functions, immune system and psychological parameters without any harmful effects to the body (Hobbs, 1996; Talbott, 2003).

Regarding the effects of chronic supplementation of Panas ginseng on endurance performance...
exhibited conflicting results (McNaughton et al., 1989; Pieralisi et al., 1991; Cherdrungsi and Rungreong, 1995; Engels and Wirth, 1997; Allen et al., 1998; Kulaputana et al., 2007; Morris et al., 1996; Engels et al., 2001). Single dose of 200mg of Panax ginseng supplementation one hour prior to the experimental trial did not impose any effect on the endurance running performance and other selected physiological parameters in recreational male Malaysian runners in the hot and humid environment (Wong et al., 2010a). But, caffeine supplementation at a dose of 5 mg per kg of body weight one hour before the experimental trial significantly improved the endurance time in nonusers of caffeine and heat-acclimatised recreational Malaysian runners in a hot and humid environment (Wong et al., 2010b). Similar findings were reported in sportspersons and sedentary individuals (Trice and Haymes, 1995; Bell and McLellan, 2003; Dodd et al., 1993; Millard-Stafford et al., 2007). Caffeine trial demonstrated significant improvement in endurance time among rowers, well trained runners, recreational runners, as well as in 70 years’ old male subjects (Norager et al., 2005; O’Rourke et al., 2007).

There was a gradual increase in heart rate during exercise in both the trials. The exercise heart rates did not show any significant difference between the CPG and PI trails. However, in both the trials the peak heart rate was significantly higher (P<0.001) than the corresponding resting heart rate. Such gradual increase in heart rate over time was to meet the increasing requirement of the body during the endurance exercise. There was no significant difference in the working heart rate between the two running trials.

Values of oxygen uptake during different trials are presented in Table 1. In both the exercise trials, oxygen uptake increased significantly (P<0.001) compared to the corresponding resting values to meet the excess metabolic demands of the exercising muscles during the endurance running performances. However, oxygen uptake during the exercise did not show any significant difference (P>0.05) between the two trials. This finding could be attributed to the hypothesis that caffeine sustains the cardiovascular and respiratory functions during endurance exercise in the hot and humid environment (Millard-Stafford et al., 2007).

In the present study, acute supplementation of caffeine along with Panax ginseng did not induce any change in the cardiorespiratory parameters, plasma lactate, blood glucose and insulin concentration. A significant increase (P<0.001) in plasma lactate concentration was noted during exercise in both the trials compared to the corresponding resting values. In both the trials, blood lactate started to increase from the onset till exhaustion. This could be due to increased lactate production or its decreased clearance or combination of both or due to increased contribution of non-oxidative energy pathways imposed by insufficient oxygenated blood flow to the exercising muscles (Wong et al., 2010a; Wong et al., 2010b).

No significant difference (P>0.05) in the core body temperature and in the skin temperature was found during the exercise trials. It indicated that combined supplementation of caffeine and Panax ginseng did not affect the body’s temperature regulation mechanism during endurance performance (Falk et al., 1990). However, in both the trials skin and core body temperature were significantly higher (P<0.001) during the exercising condition than the corresponding resting value. The subjects were supplemented with cool water (4–8°C) @ 3ml per kg of body weight every 20 minutes and this amount of fluid intake might have played a role to avoid any possible adverse effect of dehydration (Coyle, 1994, Carter et al., 2003, Wong et al., 2010a, Wong et al., 2010b).

The study also exhibited a significant increase (P<0.001) in blood glucose concentration from resting value to 40 - 60 minutes in both the trials followed by gradual decrease that was probably because of gradual fall in the availability of glucose from the storage pools. But there was no significant difference (P>0.05) in plasma glucose concentration between CPG and PI trials. Corresponding changes were noted in the plasma insulin concentration, i.e., a significant decrease (P<0.001) in plasma insulin concentration was noted during the exercise in both the trials compared to the corresponding resting values. However, these were not different between the trials.

Plasma free fatty acid is the most important energy source to sustain prolonged endurance activity. In the present investigation, the fatty acid concentration increased from the onset of the
exercise till the end time to exhaustion. There was a significant (P<0.001) increase in plasma free fatty acid at the end of the exercise trial compared to their corresponding resting values in both the trials. Such steady increase indicated the availability of the substrate (fat) for its utilisation as the major energy source during the endurance running trials. The CPG trial reported significant difference (P<0.05) in plasma free fatty acid concentration in comparison with Pl trial during endurance performance.

RPE increased significantly (P<0.001) from 10 minutes of the trials till the end of the tests in the both the exercise trials. The CPG trial depicted almost similar RPE in comparison with Pl trial during running endurance performance. There was no significant difference in RPE between the two trials as also reported in other previous investigations (Engels and Wirth, 1997; Allen et al., 1998; Wong et al., 2010a; Wong et al., 2010b).

The reason why there were no significant changes in the studied parameters might be attributed to the acute supplementation regimen of caffeine and *Panax ginseng* (1 h prior to the experimental trial). In previous studies, the significant effect of caffeine and *Panax ginseng* was observed when the supplementation period was longer (Bahrke and Morgan, 1994; Liang et al., 2005; Birnbaum and Herbst, 2004; Kovacs et al., 1998; Bell and McLellan, 2002; Bell and McLellan, 2003; Norager et al., 2005; Anderson et al., 2000; Graham, 2001; Van Soeren and Graham 1998). Hence, we postulate that when caffeine and *Panax ginseng* were supplemented together then their active ingredients were either not sufficiently absorbed or could not elicit their ergogenic effects within one hour after their ingestion during the trials in our subjects who were recreational runners.

From the present investigation, it may be concluded that acute supplementation of a combined dose of 5 mg.kg⁻¹ body weight of caffeine and 200 mg of *Panax ginseng* one hour prior to the exercise test affect positively on the physiological parameters measured during the endurance running performance in healthy recreational runners in a hot and humid environment. Further research may be undertaken to explore the effects of such supplementation with different doses at different times prior to the exercise performance.

**ACKNOWLEDGEMENT**

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