EFFECTS OF CAFFEINE AND GINSENG SUPPLEMENTATION ON ENDURANCE PERFORMANCE IN THE HEAT

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LIST OF ABBREVIATIONS

$Beats.min^{-1}$	beats per minutes
BMI	body mass index
C	caffeine trial
cm	centimeter
CPG	combination of caffeine and *Panax ginseng* trial
kg	kilogram
mg	milligram
$mg.day^{-1}$	milligram per day
min	minute
mL	milliliter
$mg.day^{-1}$	milligram per day
$milimol.L^{-1}$	milimol per liter
$mL.kg^{-1}.min^{-1}$	mililiter per kiligram per minute
$mol.L^{-1}$	mol per liter
$\mu g.mL^{-1}$	microgram per milliliter
PG	*Panax ginseng* trial
PI	placebo trial
RPE	rate of perceived exertion
S.D	standard deviation
USM	Universiti Sains Malaysia
VO_{2max}	maximum oxygen uptake

KESAN PENGAMBILAN KAFEINA DAN GINSENG TERHADAP KETAHANAN PRESTASI LARIAN DALAM KEADAAN YANG PANAS

ABSTRAK

Atlet Malaysia bersukan dalam keadaan panas dan lembap disebabkan cuaca semulajadi di negara ini. Kajian tentang pengambilan kafeina secara akut dan kronik terhadap ketahanan prestasi larian pernah dikaji dikalangan pelbagai populasi tetapi masih belum dijalankan ke atas populasi di Malaysia. Kesan mengambil *Panax ginseng* secara kronik terhadap ketahanan peningkatan prestasi larian mempunyai kesimpulan kajian yang bercanggahan. Walaubagaimana pun, masih terdapat kekurangan data terhadap pengambilan *Panax ginseng* secara akut terhadap ketahanan prestasi larian. Justeru, gabungan pengambilan kefeina dan *Panax ginseng* terhadap ketahanan prestasi larian masih belum dikaji sebelum ini. Melalui kajian ini, kami menguji kesan penggambilan 5 mg kafeina per kilogram berat badan (C), 200 mg *Panax ginseng* (PG), campuran 5 mg kafeina per kilogram berat badan dan 200 mg *Panax ginseng* (CPG) atau placebo (PI) satu jam sebelum senaman terhadap ketahanan prestasi larian. Pengambilan suplemen ini adalah dalam bentuk kapsul dengan cara kaedah kedua-dua tertutup dan secara rawak. Sembilan pelari rekreasi yang biasa berlari dalam keadaan panas dan lembap, (berumur: 25.4 $\pm$ 6.9 tahun) dan bukan pengguna kafeina (23.7$\pm$ 12.6 mg per hari) menyertai kajian ini. Peserta berlari dengan 70% VO_{2max} di atas treadmill dalam makmal yang bersuhu (31°C, 70% relatif kelembapan). Peserta minum 3 mL air sejuk per kilogram berat badan pada setiap 20 minit semasa

experimen dijalankan bagi mengelakkan dehydrasi berlaku. Denyutan jantung, purata suhu kulit (dada, lengan, paha dan betis), suhu dubur dan RPE diambil pada setiap 10 minit. Pengambilan oksigen, skala sensori minuman dan plasma darah diambil pada setiap 20 minit. Eksperimen menunjukkan perbezaan bererti C (P=0.04) dalam masa larian ketahanan sehingga penat berbanding dengan eksperimen PI. Eksperimen CPG gagal mencapai perbezaan bererti (P=0.07) dalam masa ketahanan larian sehingga penat berbanding dengan eksperimen PI. Eksperimen PG menunjukaan tiada perbezaan bererti PG (P=0.75) dalam masa larian sehingga penat berbanding dengan eksperimen PI. Eksperimen C, CPG, dan PG menunjukkan denyutan jantung, purata suhu kulit, suhu dubur, pengambilan oksigen, plasma insulin, plasma glukosa dan plasma lactic tiada perbezaan bererti berbanding dengan eksperimen PI. Eksperimen C dan CPG menunjukkan perbezaan bererti dalam plasma asid lemak berbanding dengan eksperimen PI. RPE adalah terendah dalam eksperimen C dan diikuti dengan eksperimen CPG, PG dan PI . Semua eksperimen menunjukkan denyutan jantung, purata suhu kulit, suhu dubur, pengambilan oksigen, RPE, plasma insulin, plasma glukosa, plasma lactic dan plasma asid lemak mempunyai perbezaan bererti dari masa rehat sehingga ke masa penat. Semua eksperimen tidak menunjukkan sebarang gangguan gastrointestinal semasa larian ketahanan. Berdasarkan kepada kajian ini sebagai kesimpulan, pengambilan 5 mg kafeina per kilogram berat badan dapat meningkatkan prestasi larian ketahanan di kalangan pelari rekreasi yang bukan pengguna kafeina dan kebiasaan dengan iklim yang panas dan lembap.

EFFECTS OF CAFFEINE AND GINSENG SUPPLEMENTATION ON ENDURANCE PERFORMANCE IN THE HEAT

ABSTRACT

Athletes in Malaysia need to perform in a hot and humid environment due to the climatic nature of the country. Alteration in endurance performance following acute and chronic supplementation of caffeine has been studied in different populations but concurrent research in the Malaysian context has not been attempted before. Equivocal findings of the ergogenic properties of *Panax ginseng* in enhancing physical performance were reported. However, data on the effect of acute supplementation of *Panax ginseng* on physical performance among Malaysian population is still lacking. Furthermore, combination of caffeine and *Panax ginseng* has never been investigated before on endurance running performance in the heat. In the present study, we examined the effect of acute supplementation of 5 mg caffeine per kg of body weight (C), 200 mg *Panax ginseng* (PG), combination of 5 mg caffeine per kg of body weight and 200 mg *Panax ginseng* (CPG) or placebo (PL) consumed one hour prior to the endurance performance. Supplements and placebo were given in the form of capsules in a randomised double blind cross-over trial. Nine heat acclimated recreational runners (aged: 25.4 $\pm$ 6.9 years) as well as nonusers of caffeine (23.7$\pm$ 12.6 mg per day) participated in this study. Subjects ran at 70% of their VO_{2max} on a motorised treadmill in a heat-controlled laboratory (31°C, 70% relative humidity). Subjects drank 3 mL of cool water per kg of body weight every 20 minutes during the trials

to avoid the possibility of dehydration. Heart rate, mean skin temperature (chest, arm, thigh and calf), rectal temperature and RPE were recorded at an interval of 10 minutes. Oxygen consumption, fluid sensory scale and blood samples were collected at intervals of 20 minutes. Running time to exhaustion was significantly longer ($p=0.04$) in C trial compared to PI trial. However, the longer time to exhaustion in the CPG trial did not reach statistical significance ($P=0.07$). Exhaustion time in PG trial showed no significant difference ($P=0.75$) in comparison with PI trial. Heart rate, rectal temperatures, mean skin temperature, oxygen uptake, plasma insulin, glucose, lactate in the C, CPG and PG were not significantly different from the PI trial. Plasma free fatty acid in the C and CPG trial were significantly higher in comparison with PI trials. RPE were lowest in C trial and followed by CPG, PG and PL trials. Heart rate, rectal temperature, mean skin temperature, oxygen uptake, plasma insulin, glucose, lactate and fatty acid increased significantly during exercise from their respective resting values in all trials. Gastrointestinal discomfort was not reported during endurance performance in all trials. From the current study, it could be concluded that ingestion of 5 mg of caffeine per kg of body weight has an ergogenic effect on the nonusers of caffeine and heat-acclimatised recreational runners in a hot and humid environment.

CHAPTER 1

INTRODUCTION

Nutritional ergogenic aids are substances which enhance the athletic performance by influencing physiological as well as psychological process (Brouns, 2002). The term "ergogenic aids" was derived from the Greek words "ergon" meaning "work" and "gennan" meaning "to produce" (Antonio and Stout, 2001). Ergogenic aids may be of several forms, e.g., nutritional, pharmacological, physiological, biomechanical and psychological (Williams, 2002). Endurance athletes such as marathon runners and triathlons were known to use supplements to enhance their performance. Endurance supplements may enhance endurance performance by increasing the body glycogen storage and the available free fatty acid (Antonio and Stout, 2001).

Caffeine is a naturally contained chemical substance in over 60 different plant species and it is the second most traded commodity worldwide (Birubaum and Herbst, 2004). Caffeine improves alertness, concentration, reaction time and promotes lipolysis which ultimately improves endurance performance (Antonio and Stout, 2001). It also acts as a stimulant for the central nervous system (Brouns, 2002). Beverages which contain caffeine include coffee, tea, soft drinks, energy drinks, etc. Exercise performance was shown to increase following ingestion of 5 mg of caffeine per kg of body weight one hour before the exercise tests (Bell and Mclellen, 2002). Caffeine is a banned substance by the Medical Commission of the

International Olympic Committee (IOC) but it is permitted in sports as long as the caffeine urinary concentration is less than 12μg.mL^{-1} (Antonio and Stout, 2001).

According to Graham and Spriet (1995), low to moderate doses of caffeine (3 to 10 mg of caffeine per kg of body weight) are nontoxic. The amount of caffeine excretion in urine has been reported in various studies which used caffeine doses up to 9 mg per kg of body weight that significantly improved the endurance performance keeping the urinary caffeine level well below the International Olympic Committee threshold of 12μg.mL^{-1} (Van et al., 1993; Graham and Spriet, 1995; Kovacs et al., 1998). Other studies reported the urine concentration of caffeine as 6.8 μg.mL^{-1} after ingesting 6 mg caffeine per kg of body weight (Conway et al., 2003) and 4.8 μg.mL^{-1} following ingestion of 5 mg caffeine per kg of body weight (Pasman et al., 1995).

Ginseng, an ergogenic herb, is available in the form of whole root, root powder and standardised root extracts (capsule). It is categorised as an 'adaptogen' that helps to adapt against higher levels of stress and increases endurance performance (Phillips, 2002). *Panax ginseng* is the most commonly used ginseng in the diet and medicine in many Asian countries, especially in China. Ginseng supplementation for 6 to 8 weeks improves the recovery pattern after exercise performance (Phillips, 2002), increases plasma free fatty acid level, maintains plasma glucose level during exercise, increases glycogen store in the liver and skeletal muscle and ultimately improves endurance performance (Pieralisi et al., 1991; Wang and Lee, 1998; Bucci, 2000).

In general, animal toxicity studies found that ginseng is very safe with no teratogenicity or mutagenicity (Hobbs, 1996). Ingestion of ginseng does not result any positive indication for any banned substances in the urine of elite athletes even though ginsenosides and their metabolites are detectable in the serum and urine of athletes after ingestion of ginseng products (Hasegawa et al., 1996; Cui et al., 1997). Ingestion of 200mg of *Panax ginseng* per day has been recommended as safe (Talbott, 2003).

Some other studies showed that supplementation of other herbs including mahuang, ephedrine and related alkaloids will not enhance the endurance performance on their own; but if they are supplemented along with caffeine then they can increase the endurance performance (Bucci, 2000). Therefore, it is quite justified to speculate that supplementation of ginseng along with caffeine might further enhance the endurance performance. Available literatures support that prolonged supplementation of ginseng increased the endurance performance (Banerjee and Izquiredo, 1982; Forgo and Schimert, 1985; McNaughton et al., 1989; Pieralisi et al., 1991).

But, till date, literatures are lacking regarding the effect of acute supplementation of (i) ginseng or (ii) caffeine or (iii) a combination of ginseng and caffeine on endurance performance, especially in the heat. Moreover, the reports on the gastrointestinal tolerance of caffeine and ginseng are also scanty. Study on efficacy of these supplementations on Malaysian population under a hot temperature has not been attempted before.

1.1 OBJECTIVE

The present study was conducted with the following aims:

1. To investigate the effects of acute supplementation of caffeine and / or *Panax ginseng* on endurance performance in the heat.
2. To determine the physiological changes in exercise performance following caffeine and/or *Panax ginseng* supplementation during the endurance performance in the heat.
3. To examine the gastrointestinal tolerance of the caffeine and/or *Panax ginseng* supplementation during endurance performance in the heat.

1.2 PURPOSE OF THIS STUDY

Research is essential to investigate the effects of acute supplementation of caffeine and/or *Panax ginseng* on endurance performance in the heat. Besides, the study will reflect how justified it would be to supplement ginseng in combination with caffeine to improve endurance performance, particularly in the heat. The purpose is also to select the best one out of these three supplementations that may be prescribed to the endurance athletes for the betterment of their performance without any gastrointestinal problems. Thus it would contribute towards the development of athletic performance of Malaysian sportspersons.

1.3 OPERATIONAL DEFINITIONS

1.3.1 Caffeine Extract Powder:

Extract of caffeine from coffee beans in powder form.

1.3.2 *Panax ginseng* Extracts Powder:

Extract of *Panax ginseng* from its root in powder form.

1.3.3 Placebo:

Artificial sweetener was used as placebo which did not contain any caloric substance.

1.3.4 Running Performance:

Time in minutes taken to run and to reach exhaustion at intensity of 70% VO_{2max} in a hot and humid environment (31°C, 70% relative humidity).

1.3.5 Hot Environment:

The laboratory temperature of 31°C and the relative humidity of 70% were maintained throughout the experiment trials.

1.3.6 Double Blind Experiment:

Neither the subjects nor the researchers knew the content of the capsule (caffeine and/or *Panax ginseng* or Placebo) that was given 1 hour before the experiment.

1.3.7 Random Sampling

Subjects were randomly selected from students or staff of USM who are recreational runners without any bias.

1.4 SIGNIFICANCE OF THIS STUDY

Research on caffeine and *Panax ginseng* is essential to investigate the effects of the acute supplementation of caffeine and/or *Panax ginseng* on endurance performance in the heat. According to Bucci (2000), supplementation of other herbs like mahuang, ephedrine and related alkaloids can not enhance the endurance performance unless they are supplemented along with caffeine. It is quite justified to speculate that combined supplementation of caffeine and *Panax ginseng* might further enhance the endurance performance. The purpose of the study was to select the best one out of these three supplementations (caffeine *Panax ginseng*, caffeine plus *Panax ginseng*) that might be prescribed to the endurance athletes for the betterment of their performance without any gastrointestinal problems.

1.5 Hypothesis

1. Significant increase in endurance performance in the heat following caffeine and/or *Panax ginseng* supplementation compared to the placebo group.

2. Difference in change of physiological parameters following supplementation of *Panax ginseng* and /or caffeine compared to the placebo group during endurance performance in the heat.

3. The study will reveal the gastrointestinal tolerance of the supplementations depending on the subjective feeling.

BAB 2

LITERATURE REVIEW

Caffeine is a common ergogenic supplement in endurance sports (Desbrow and Leveritt, 2006). Many researchers had demonstrated that caffeine could increase endurance performance (Denadai et al., 1998; Greer et al., 2000; Birnbaum and Herbst, 2004). It is known that caffeine was widely used by endurance athletes because of its known properties to reduce fatigue (Brouns, 2002). It is a substance that is ingested daily by many endurance athletes and most frequently used as a stimulant worldwide (Brouns, 2002). In a prevalence survey done by Desbrow and Leveritt (2006), 89% of the athletes were found to use a caffeinated substance in the 2005 Triathlons World Championships. A recent study by Desbrow and Leveritt (2007) reported that 73% of the 140 athletes at the 2005 Ironman Trriathlon World Championships believed that caffeine is an ergogenic aid to enhance their endurance performances. Caffeine intake was number one on the list among Canadian survey in which teenagers were asked about which aid they had used during the past 12 months with the objective to improve their performance. (Melia et al., 1996).

Ginseng is widely used as part of dietary and medicinal custom in many Asian countries, especially in China. Ginseng is the most studied herbs for human physical performance and is the king of herbs (Lee, 1992). Ginseng had been used medicinally in the Far East for several millennia and is currently one of the most

widely taken herbal products throughout the world (Kennedy and Scholey, 2003). Ginseng was used for thousands of years in the East as a 'tonic', and in recent years its usage had extended to Western societies (Wilkie, 1994). The traditional use of ginseng was to restore Qi, i.e., life energy (Bucci, 2000). According to Gyllehaal et al. (2000), ginseng is frequently used in the West as a performance enhancer.

2.1 ENDURANCE PERFORMANCE IN THE HEAT AND HUMIDITY

Endurance exercise includes activities such as running, cycling, rowing, swimming, cross-country skiing, and triathlon. It involves glycolysis and oxidative phosphorylation during the breakdown of substrates for energy production in these types of prolonged activities. A number of studies demonstrated the ergogenic effects of caffeine (Graham, 2001; Bell and Mclellan, 2002; Birnbaum et al., 2004; Norager et al., 2005) and *Panax ginseng* (Forgo, 1983; McNaughton et al., 1989; Pieralisi et al., 1991; Cherdrungsi and Rungroeng, 1995) in enhancing endurance performances. However, there are limited studies to investigate the effectiveness of these substances on endurance performance in the heat and humidity. Since the environment of Malaysia is hot and humid throughout the years (Ismail and Zakari, 2006), it is important to investigate whether the usage of caffeine and/or *Panax ginseng* is as effective as any ergogenic aids in endurance performance.

According to Cohen et al. (1996), a hot and humid environment could be detrimental to performance. It had been observed that the performance of