5. เอกสารอ้างอิง

1. กลุ่มงานพัฒนาวิชาการแพทย์แผนไทยและสมุนไพร สถาบันการแพทย์แผนไทย กรมพัฒนาการแพทย์แผนไทยและการแพทย์ทางเลือก กระทรวงสาธารณสุข (2547) กระชายดำ *Kamepferia parviflora* Wall. Ex Baker. กรุงเทพฯ: โรงพิมพ์องค์การรับส่งสินค้าและพัสดุภัณฑ์ 16 หน้า.
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Output จากโครงการวิจัยที่ได้รับทุนจาก สกอ. และ สกว.

1. ผลงานตีพิมพ์ในวารสารวิชาการนานาชาติ

Chanchira Wasuntarawat, Sirinat Pengnet, Nutchanon Walaikavinan, Natakorn Kamkaew, Tippaporn Bualoang, Chaivat Toskulkao, and Glenn K. McConell.
No effect of acute ingestion of Thai ginseng (*Kaempferia parviflora)* on sprint and endurance exercise performance in humans. *Journal of Sports Sciences*, 2010, 28(11): 1243-1250.

Chanchira Wasuntarawat, Pattarabhorn Deema, Taksanee Mahasiripan, Wiraj Sirigulsatien, Chaivat Toskulkao and Glenn K McConell.
Lack of chronic effects of Thai ginseng on renal and hepatic toxicity, glucose tolerance and exercise performance in humans. (Manuscript in preparation)

Chanchira Wasuntarawat, Pattarabhorn Deema, Panchana Sanguansermsri, Kornkanok Ingkaninan, Weerapong Chidnok, Chaivat Toskulkao and Glenn. K. McConell.
Chronic effects of endurance training and *Kaemferria parviflora* ingestion on glucose tolerance and maximum exercise performance in humans: an improvement on lactate threshold. (Manuscript in preparation)

2. การนำผลงานวิจัยไปใช้ประโยชน์

2.1. เชิงวิชาการ

โครงการวิจัยนี้มีส่วนพัฒนาการเรียนการสอน ของภาควิชาสรีรวิทยา คณะวิทยาศาสตร์การแพทย์ มหาวิทยาลัยนเรศวร ด้านสรีรวิทยาการออกกำลังกายและการทดสอบสมรรถภาพทางกาย รวมทั้งได้สร้างนักวิจัยรุ่นใหม่ของคณะวิทยาศาสตร์การแพทย์

1. ระดับบัณฑิตศึกษา (ปริญญาโท) หลักสูตรวิทยาศาสตร์การแพทย์
   2550 การศึกษาผลของกระชายดำและการฝึกแบบทนทานต่อระดับการตอบสนองของแลกเตทในมนุษย์ โดย นางสาว ภัทราภรณ์ ดีมา
2. ระดับปริญญาตรี หลักสูตรวิทยาศาสตร์การแพทย์
   การวิจัยอิสระ นิสิตชั้นปีที่ 4
   2549 ผลของกระชายดำต่อสมรรถนะการออกกำลังกายแบบอากาศนิยมชนิดความเข้มสูง โดย นาย ณฐกร คำแก้ว

2548 ผลของกระชายดำต่อความเหนื่อยล้าและกำลังงานในมนุษย์
โดย นางสาวศิรินารถ เพ็งเนตร และ นายณัฐชนนท์ วลัยกวินันท์
(นายอนุสรณ์ ลัยนันท์)

2.2. เชิงสาธารณะ

1. โครงการนี้มีส่วนช่วยให้ภาควิชาสรีรวิทยา คณะวิทยาศาสตร์การแพทย์ พัฒนาหน่วยสรีรวิทยาการออกกำลังกาย สำหรับทดสอบสมรรถภาพทางกายให้กับบุคลากรของคณะ มหาวิทยาลัย และชุมชนใกล้เคียง
2. การดำเนินโครงการวิจัยนี้ได้สร้างเครือข่ายความร่วมมือด้านการเรียนการสอนและการวิจัยกับภาควิชากายภาพบำบัด คณะสหเวชศาสตร์ มหาวิทยาลัยนเรศวร

3. การนำเสนอผลงานในที่ประชุมวิชาการ

3.1. **Wasuntarawat C.**, Deema P., Mahasiripan T., Bualoang T., Chidnok W., Toskulkao C. and McConell G.K. (2009) Chronic effects of *Kaemferria parviflora* and endurance training on maximum exercise performance and glucose tolerance in humans. The 4th Asia Pacific Conference on Exercise and Sports Science (APCESS) and the 8th International Sports Science Conference (ISSC), Kota Bharu, Malaysia. 15th -17th July, 2009. p86.

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3.3. Kamkaew, N., Toskulkao, C., McConell, G.K. and **Wasuntarawat, C.** (2007) Effects of *Kaempferia parviflora* on human endurance capacity. The 2nd international conference on Forensic Science and Medical Science. Naresuan University, Thailand. 28th -29th July 2007. p81.

ผลงานนี้ได้รับรางวัลการนำเสนอผลงานวิจัยดีเด่น แบบโปสเตอร์

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ผลงานนี้ได้รับ Young Physiologist Grant from the FAOPS 2006, Seoul, Korea (The Federation of Asian and Oceanian Physiological Societies) ภายใต้การพิจารณาของสรีรวิทยาสมาคมแห่งประเทศไทย

ภาคผนวก

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No effect of acute ingestion of Thai ginseng (*Kaempferia parviflora*) on sprint and endurance exercise performance in humans

CHANCHIRA WASUNTARAWAT[1], SIRINAT PENGNET[1], NUTCHANON WALAIKAVINAN[1], NATAKORN KAMKAEW[1], TIPPAPORN BUALOANG[1], CHAIVAT TOSKULKAO[2], & GLENN McCONELL[3]

[1]*Department of Physiology, Faculty of Medical Science, Naresuan University, Muang, Thailand,* [2]*Office of the Permanent Secretary, Ministry of Science and Technology, Paya-tai, Thailand, and* [3]*Department of Physiology, The University of Melbourne, Parkville, Victoria, Australia*

(Accepted 1 July 2010)

Abstract

Thai ginseng, *Kaempferia parviflora*, is widely believed among the Mong hill tribe to reduce perceived effort and improve physical work capacity. *Kaempferia parviflora* is consumed before their daily work. Therefore, we conducted an acute study on the effects of *K. parviflora* on repeated bouts of sprint exercise and on endurance exercise time to exhaustion. Two studies were conducted in college males using a randomized, double-blind, crossover design. Ninety minutes after consumption of *K. parviflora* or a starch placebo, participants in study 1 ($n = 19$) completed three consecutive maximum 30-s sprint cycling Wingate tests, separated by 3 min recovery, while participants in study 2 ($n = 16$) performed submaximal cycling exercise to exhaustion. Peak and mean power output decreased with successive Wingate tests, while percent fatigue and blood lactate concentration increased after the third Wingate test ($P < 0.05$). There were no detectable differences in any measures with or without *K. parviflora*. There was also no effect of *K. parviflora* on time to exhaustion, rating of perceived exertion or heart rate during submaximal exercise. Our results indicate that acute ingestion of *K. parviflora* failed to improve exercise performance during repeated sprint exercise or submaximal exercise to exhaustion. However, chronic effects or actions in other populations cannot be excluded.

Keywords: *Repeated Wingate test, time to exhaustion, exercise fatigue, Thai ginseng, human*

Introduction

Kaempferia parviflora, also known as *krachai dum* in Thai, is a rhizomous plant of the Zingiberaceae family and has been used in Thai traditional medicine for many centuries for its purported broad effects (Institute of Thai Traditional Medicine, 2004; Wuttidharmmavej, 2002). *Kaempferia parviflora* is also specified as an essential herb of Mong hill tribe households (surveys conducted with the Mong hill tribe in 2005 and 2008). It is found in nearly every vegetable garden in Mong hill tribe villages and is incorporated into their regular meals or often used as a herbal tea.

Kaempferia parviflora is referred to as "ginseng of Thai" in the Thai traditional pharmacopeia (Wuttidharmmavej, 2002) and by traditional Thai practitioners (Pitiporn, 2001; Sroitongkham & Shiaplham, 1999). However, its main constituents differ from the bioactive ingredients of Asian and American ginseng or Siberian ginseng (Bucci, 2000) (Table I). The anecdotal effects of *K. parviflora* include those on the neurological, cardiovascular, gastrointestinal, and reproductive systems. It is believed that with *K. parviflora* there is improved functionality of the teeth, skin and visual perception, an improved sense of well-being, increased energy, increased male sexual performance, reduced flatulence, and reduced stomach aches (Institute of Thai Traditional Medicine, 2004). Surveyed Mong hill tribe villagers have also indicated their belief that *K. parviflora* improves their ability to undertake demanding physical agricultural work and prolonged hill trekking. For these tasks, they ingest *K. parviflora* in the morning before this arduous work. *Kaempferia parviflora* is eaten either as a fresh or dry rhizome, which is prepared in hot water or as an alcoholic solution. Its suggested dose in Thai traditional

Correspondence: C. Wasuntarawat, Department of Physiology, Faculty of Medical Science, Naresuan University, Muang 65000, Thailand. E-mail: chanchiraw@nu.ac.th

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Table I. The constituents of different ginsengs.

	Asian ginseng	American ginseng	Siberian ginseng	Thai ginseng
Species	*Panax ginseng*[a]	*Panax quinquefolium*[a]	*Eleutherococcus senticosus*[a]	*Kaempferria parviflora*[b]
Active components	ginsenoside[c] Rg1 Rg2, Rg3 Rb1, Rb2,Rb3 Rc, Rd, Re Rg1, Rg3 Rh1, Rh2		eleutheroside[d] C, D, E	5,7-dimethoxyflavone[e] 3,5,7,3′,4′-pentamethoxyflavone[e] 5-OH-7-methoxyflavone[f] 5-OH-3,7- dimethoxyflavone[f]

[a]Bucci (2000), [b]Smitinand (2001), [c]Chen, Chiou, and Zhang (2008), [d]Kimura and Sumiyoshi (2004), [e]Patanasethanont et al. (2007a), [f]Sookkongwaree et al. (2006).

medicine is 1.2 g of dried or 20 g of fresh rhizome per day (Institute of Thai Traditional Medicine, 2004).

Gas chromatographic analysis of *K. parviflora* reveals 11 flavonoid constituents with its two major constituents being 5,7-dimethoxyflavone and 5,7,4′-trimethoxyflavone (Sutthanut, Sripanidkulchai, Yenjai, & Jay, 2007). Some of the chemically identifiable constituents have potent molecular/pharmacological effects and include 5,7-dimethoxyflavone (Patanasethanont et al., 2007a, 2007b; Sookkongwaree, Geitmann, Roengsumran, Petsom, & Danielson, 2006), 5-OH-7-methoxyflavone, 5-OH-3,7-dimethoxyflavone (Sookkongwaree et al., 2006), and 3,5,7,3′,4′-pentamethoxyflavone (Patanasethanont et al., 2007a, 2007b).

Recent scientific research has begun to examine some of the purported benefits of *K. parviflora* and some recent observations show that it promotes vascular endothelial function by increasing nitrite and eNOS mRNA and protein expression in human umbilical vein endothelial cells (Wattanapitayakul et al., 2007), thus improving vasorelaxation (Wattanapitayakul, Chularojmontri, Herunsalee, Charuchongkolwongse, & Chansuvanich, 2008). This implies potential beneficial effects of *K. parviflora* on human exercise performance, which may be similar to vasodilator ginsenosides extracted from ginseng acting via the nitric oxide signalling pathway (Achike & Kwan, 2003). This may have an anti-fatigue effect (Morihara et al., 2006) by increasing the supply of oxygen or nutrients to skeletal muscles.

In addition, *K. parviflora* has potent anti-allergic activity against antigen-induced P-hexosaminidase release in the RBL-2H3 cell line (Tewtrakul & Subhadhirasakul, 2007) and appears to have gastroprotective effects (Rujjanawate, Kanjanapothi, Amornlerdpison, & Pojanagaroon, 2005). *Kaempferia parviflora* flavones also inhibit viral protease and P-glycoprotein, a multi-drug resistance mediator in a tumour cell line (LLC-GA5-COL150) (Patanasethanont et al., 2007b; Sookkongwaree et al., 2006). Thus the beneficial effects of *K. parviflora* appear not to be confined to vascular performance.

The anecdotal evidence and the clear vascular effects of *K. parviflora* suggest that this herb could well improve exercise performance and endurance. The Mong hill people usually consume *K. parviflora* prior to work and this suggests that its effects are acute (within a few hours). We therefore sought to test the efficacy of *K. parviflora* on anaerobic (exhaustive sprint) and aerobic (endurance) exercise performance after a single oral dose of the herb. We hypothesized that, compared with a placebo, acute *K. parviflora* administration would improve exhaustive sprint and endurance exercise performance and reduce ratings of perceived exertion during prolong submaximal endurance exercise to exhaustion.

Methods

General design and experimental treatments

To investigate the acute effect of *K. parviflora* on various aspects of sprint and endurance performance, two protocols were conducted, both of them approved by the Naresuan University Ethics Committee. Study 1 involved repeated Wingate 30-s extracted from sprint tests (Engels, Fahlman, & Wirth, 2003) while Study 2 involved a cycle ergometer endurance exercise test to exhaustion (Burgomaster, Hughes, Heigenhauser, Bradwell, & Gibala, 2005). The studies were conducted separately with more than 6 months between them, since some participants were involved in both studies. The participants reported to the laboratory on five or six occasions. During the first session, participants were given details about the protocol before signing the written informed consent. They then completed a medical questionnaire and their blood pressure was measured. Participants of Study 1 and Study 2 completed two and three familiarization trials, respectively, each trial separated by at least 3 days and then attended the laboratory for the first experimental exercise test. In both studies, the test

trials were performed in a randomized, double-blind, crossover study design, separated by 7 days. All participants reported to the laboratory in the morning between 06.00 and 09.00 h after refraining from alcohol and caffeine for 24 h and exhaustive exercise for 48 h. Either placebo or dried *K. parviflora* powder in capsules was consumed 90 min before beginning the trials.

The dose of *K. parviflora* was determined from:

1. The amount used by the hill tribe people as a herbal tea, approximately 0.5 – 1 teaspoon (an interview with the Mong families, Pethchaboon, Thailand, 2005). The dose of 1.35 g of dried *K. parviflora* in this study is approximately equal to half a teaspoon.
2. The suggested daily dose (1.2 g dried rhizome) from Thai traditional medicine (Institute of Thai Traditional Medicine, 2004).
3. One gram a day of dried *K. parviflora* as used by Bangkrathum Hospital, Phitsanulok, Thailand.
4. A comparison of positive effects of 1 g per day dried Asian ginseng root on exercise performance (Bucci, 2000).
5. Its toxicology (Institute of Thai Traditional Medicine, 2004). The safe dose for humans (1400 mg · day^{-1}) was estimated (Toskulkao, Glinsukon, & Temcharoen, 1992) by using a factor of 100 and the NOEL (no-observable effect level) in tests on rats (2000 mg · kg^{-1} · day^{-1} for 6 months).

There is a lack of direct data on *K. parviflora* absorption in humans. However, various studies in humans have shown positive effects with dried ginseng using absorption times of 60–130 min (Kennedy, Scholey, & Wesnes, 2001; Sievenpiper et al., 2006; Stavro, Woo, Heim, Leiter, & Vuksan, 2005), and also hill tribe people report that they feel relief from stomach ache 90–120 min following ingestion of *K. parviflora* (interviews of Mong families, 2005). We therefore chose 90 min as the absorption time. In both studies, each participant was asked to complete a food diary over the 24 h before the first test trial. This was then photocopied and returned to the participant who was requested to follow the same diet in the 24 h prior to the second experimental exercise trial. Heart rate was measured using a heart rate monitor (Polar, Kempele, Finland).

Capsule preparation

Kaempferia parviflora was grown in Nakorn Thai District, Phitsanulok and capsules of the dried *K. parviflora* were prepared by the Pharmaceutical section of the Bangkrathum Hospital, Phitsanulok, Thailand under standardized conditions. The *K. parviflora* used in this study was validated by quantifying its content of 5,7-dimethoxyflavone and 5,7,4′-trimethoxyflavone (Sutthanut et al., 2007) using high-performance liquid chromatography. The placebo capsules, which contained starch powder, had the same weight, size, shape, and colour as the *K. parviflora* capsules and were also prepared by the same hospital.

Study 1

Of the 21 participants initially enrolled in this investigation, two failed to complete one or more of the familiarization trials such that final data analysis was for the 19 participants who had completed the familiarization and test trials. The 19 untrained healthy males (mean age 19.0 years, $s = 1.0$; mass 56.0 kg, $s = 8.0$; body mass index 19.5 kg · m^{-2}, $s = 1.5$) performed repeated Wingate tests on a calibrated cycle ergometer (Monark 828E, Stockholm, Sweden).

Repeated Wingate test. The test began with a 3-min warm-up at 50 W followed by three consecutive 30-s Wingate tests each separated by a 3-min recovery period. During the warm-up, the participants were reminded that after the warm-up, they needed to sprint as hard and fast as possible while the resistance was increased to a predetermined workload (7.5% of body weight) within 3 s of each sprint. During the Wingate tests, participants were told to remain seated and to cycle as quickly and as forcefully as possible throughout the 30 s of exercise. Once full resistance was applied, the revolution rate was averaged every 5 s over the 30-s duration of the test via an electronic revolution sensor interfaced with a computer system (Thai Phan, Thailand). Verbal encouragement was provided throughout the cycling. The 3-min recovery period consisted of a 90-s active recovery with the participant cycling at the same power as the warm-up ride (50 W), which was followed by 90 s of passive recovery. To assess the peak post-exercise blood lactate concentration, the passive recovery duration was extended to 15 min after the third Wingate test.

Sprint performance variables. Peak power output was determined as the highest power output produced during a single 5-s period of each 30-s test using the following equation: (0.075 × body weight in kg) × (highest revolution × 6) × 5 s/60 s × 6.12. Mean power output was defined as the average power output (mean of six values) over each 5 s of the 30-s Wingate test. Percent fatigue was recorded as a percentage ratio of the difference between peak

and minimum power divided by peak power (McArdle, Katch, & Katch, 2001).

Blood collection and analysis. During the 90-min resting period before the test, a venous catheter was inserted into an antecubital vein. One milliltre of blood was drawn before exercise and at 0, 3, 5, 10, and 15 min after the third Wingate test and was immediately deproteinized in 2 ml of cold 0.7 M perchloric acid. These samples were centrifuged and the supernatant was subsequently assayed for lactate by an enzymatic method (Fink & Costill, 1990).

Study 2

Seventeen untrained healthy males (mean age 21 years, $s = 1.5$; mass 57.0 kg, $s = 6.3$; body mass index 19.8 kg · m^{-2}, $s = 1.9$) volunteered to take part in the cycling exercise test to exhaustion, including five participants who took part in Study 1. The participants undertook a maximum power output test (described below) in the first session and then cycled at 65% of this value to exhaustion during the familiarization and test trials.

Maximum power output test. Participants performed an incremental test to exhaustion on a cycle ergometer (Monark 828E, Stockholm, Sweden). The initial 3 min of the test was at 50 W before the workload was increased by 25 W each minute until volitional exhaustion, with verbal encouragement provided throughout the test. The test was terminated when the participants were unable to maintain the prescribed workload at a pedal cadence of 50 rev · min^{-1} despite exerting their maximal effort. Maximum power output was 179 W ($s = 27$). We then calculated 65% maximum power output, which is equivalent to 75% $\dot{V}O_{2max}$ (Jeukendrup, Saris, Brouns, & Kester, 1996).

Time-to-exhaustion test. The participants cycled to volitional exhaustion on the cycle ergometer at a workload calculated to be 65% of each individual's maximum power output. All trials were conducted in the absence of verbal encouragement and without physiological (heart rate) feedback. Heart rate and rating of perceived exertion were recorded every 5 min while pedal cadence was monitored closely and recorded every 30 s throughout the test. Time to exhaustion was defined as the instant at which the participant could no longer maintain a pedal cadence of 60 rev · min^{-1}.

Data analysis

All data are expressed as means and standard deviations (s). In Study 1, peak power output, mean power output, and percent fatigue were compared between placebo and *K. parviflora* using repeated-measures analysis of variance (ANOVA: 3 sprints × 2 treatments; SPSS version 11.5). If significance was obtained with ANOVA, specific differences were determined using the Fisher's least significant difference test. Blood lactate concentrations were compared using a 2 (treatments) × 6 (times) repeated-measures ANOVA. In Study 2, time to exhaustion, rating of perceived exertion, and heart rate were analysed using paired Student's t-tests. Statistical significance was set at $P < 0.05$.

Results

Study 1: Repeated Wingate test

Peak power output and mean power output declined ($P < 0.05$) across Wingate tests 1, 2, and 3 but there were no differences ($P > 0.05$) between *K. parviflora* and placebo (Figure 1). Sequential peak power output of Wingate tests 1, 2, and 3 was 554 W ($s = 114$), 495 W ($s = 109$), and 473 W ($s = 96$) respectively for placebo, and 545 W ($s = 95$), 499 W ($s = 99$), and 454 W ($s = 116$) respectively for *K. parviflora*. Mean power output across Wingate tests 1, 2, and 3 was 416 W ($s = 65$), 369 W ($s = 58$),

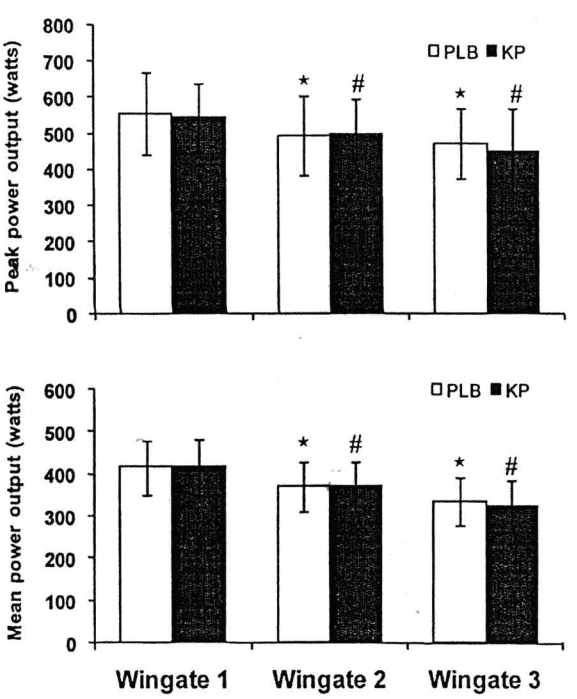

Figure 1. Peak and mean power output over three repeated cycling sprints with either placebo (PLB) or *Kaempferia parviflora* (KP) ingestion 90 min before the test (mean ± s; $n = 19$). $^{*}P < 0.05$ vs. Wingate test 1 of placebo treatment. $^{\#}P < 0.05$ vs. Wingate test 1 of *K. parviflora* treatment.

and 334 W ($s = 57$) respectively for placebo, and 417 W ($s = 65$), 369 W ($s = 59$), and 323 W ($s = 61$) respectively for *K. parviflora*. No differences in percent fatigue during each 30-s sprint were observed between placebo and *K. parviflora* (Wingate 1: 40%, $s = 15$ vs. 43%, $s = 13$; Wingate 2: 44%, $s = 15$ vs. 48%, $s = 12$; Wingate 3: 53%, $s = 10$ vs. 51%, $s = 13$; placebo vs. *K. parviflora*) (Figure 2). Percent fatigue during the third Wingate test was significantly ($P < 0.05$) greater than during the first Wingate test in both placebo and *K. parviflora* trials.

Repeated-measures ANOVA revealed that blood lactate concentrations were significantly ($P < 0.05$) increased above resting values in both treatments but there was no difference between the treatments (Figure 3).

Study 2: Time-to-exhaustion test

Acute ingestion of *K. parviflora* did not improve time to exhaustion (*K. parviflora*: 28.3 min, $s = 12.5$; placebo: 27.6 min, $s = 11.5$) during prolonged exercise to exhaustion at 65% of maximum power output. Ratings of perceived exertion and heart rate at 10 and 20 min and immediately after exhaustion were also not different between placebo and *K. parviflora* (Table II). Rating of perceived exertion at time to exhaustion was rated between 17 ("very hard") and 19 ("extremely hard").

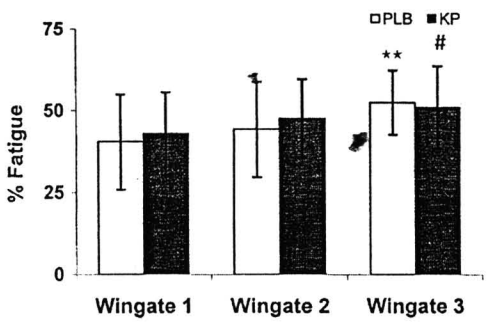

Figure 2. Percent fatigue during three repeated cycling sprints with either placebo (PLB) or *Kaempferia parviflora* (KP) ingestion 90 min before the test (mean ± *s*; $n = 19$). $^{**}P < 0.01$ vs. Wingate test 1 of placebo treatment. $^{\#}P < 0.05$ vs. Wingate test 1 of *K. parviflora* treatment.

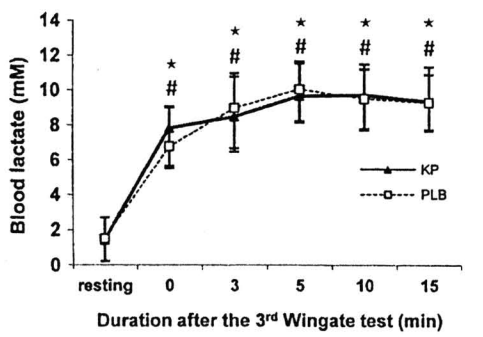

Figure 3. Blood lactate concentrations at rest and 0, 3, 5, 10, and 15 min after the third 30-s Wingate test with either placebo (PLB) or *Kaempferia parviflora* (KP) ingestion 90 min before the test (mean ± *s*; $n = 19$). $^{*}P < 0.05$ vs. rest in placebo treatment. $^{\#}P < 0.05$ vs. rest in *K. parviflora* treatment.

Discussion

The main finding of the present study was that *Kaempferia parviflora* (1.35 g) showed no acute improvement in either repeated sprint performance or endurance exercise performance using the repeated Wingate test and a time-to-exhaustion test, respectively. Furthermore, this was confirmed by the similar pattern of blood lactate concentrations following the repeated Wingate sprints. These novel findings using two established physical performance tests requiring extensive effort (Burgomaster et al., 2005; Engels et al., 2003), in fully familiarized participants, failed to support the anecdotal reports of benefits of acute *K. parviflora* ingestion on energy levels and protection against fatigue, as perceived by Thai hill tribe people.

Panax ginseng (Chinese or Korean ginseng) has a long history in Asian traditional medicine and there have been many claims of improved abilities to adapt to stresses including exercise (Bahrke & Morgan, 2000). However, there have been conflicting research results as to whether *P. ginseng* does indeed enhance aerobic exercise performance. Several studies have supported such an effect of *P. ginseng* on aerobic exercise performance (Hsu, Ho, Lin, Su, & Hsu, 2005; Kim, Park, Chang, & Sung, 2005; Liang, Podolka, & Chuang, 2005), whereas others have not (Allen, McLung, Nelson, & Welsch, 1998; Engels & Wirth, 1997; Morris et al., 1996). *Panax ginseng* does not improve predominantly anaerobic exercise performance involving either a single 30-s cycling sprint (Engels, Kolokouri, Cieslak, & Wirth, 2001) or three repeated 30-s sprints (Engels et al., 2003). Siberian ginseng also has shown mixed results in terms of

Table II. Rating of perceived exertion and heart rate at 10 min, 20 min, and immediately after (post) exercise to exhaustion at 65% maximum power output following placebo or *Kaempferia parviflora* ingestion 90 min before the test (mean ± *s*; $n = 17$).

	Rating of perceived exertion		Heart rate (beats · min^{-1})	
Time	Placebo	*K. parviflora*	Placebo	*K. parviflora*
10 min	14 ± 2	14 ± 2	164 ± 11	165 ± 13
20 min	17 ± 2	17 ± 2	172 ± 9	174 ± 10
Post[a]	18 ± 1	19 ± 1	174 ± 10	177 ± 8

[a]*Kaempferia parviflora* at 28.3 ± 12.5 min, placebo at 27.6 ± 11.5 min.

endurance performance (Asano et al., 1986; Dowling et al., 1996; Eschbach, Webster, Boyd, McArthur, & Evetovich, 2000; Goulet & Dionne, 2005). The inconsistency of ginseng ergogenic effects could be due to the different methods used in the studies, the amount of ginseng ingested or the duration of the test period. Indeed, the extensive review of Bucci (2000) revealed that improvements in exercise performance of Chinese and Korean ginseng are only found with standardized root extracts consumed on a daily basis for 8 weeks at higher doses than the 1 g dried root or equivalent and using a large number of participants. Thus, it is not surprising that acute ingestion of *K. parviflora* failed to augment exercise performance in the current study. Therefore, future studies should have a wider scope, where the variables should include chronic *K. parviflora* consumption, older participants, athletes or particular patient groups. Such an approach might also provide pointers to the mechanism(s) of action.

Previous studies examining the effect of various types of ginseng on exercise performance have examined either sprint type exercise or endurance exercise (Allen et al., 1998; Asano et al., 1986; Dowling et al., 1996; Engels et al., 2001, 2003; Engels & Wirth, 1997; Eschbach et al., 2000; Goulet & Dionne, 2005; Hsu et al., 2005; Kim et al., 2005; Liang et al., 2005). The current study was designed such that the effects of *K. parviflora* on both sprint and endurance exercise could be examined. This is important, since the intensity and duration are vastly different for the two types of exercise and thus the contributions of the anaerobic and aerobic energy systems will also differ. It is possible that *K. parviflora* may benefit only one type of exercise. The intensity and duration of the exercise stimuli are also important to determine any ergogenic effects of a tested substance. This was shown by using glycine-arginine-α-ketoisocaproic acid ingestions (Buford & Koch, 2004). Glycine-arginine-α-ketoisocaproic acid did not influence performance after a single 30-s Wingate test but it did maintain mean power output between the first few sprints of a repeated bout of 10-s cycle exercise. The present study employed the fatiguing sprint interval type exercise and also used prolonged submaximal endurance exercise protocols to test the effects of *K. parviflora* that may be more readily apparent when the body is fatigued. However, no ergogenic benefits of *K. parviflora* were found for sprint peak power, mean power, percent fatigue (Study 1) or for endurance time to exhaustion (Study 2) using these forms of exhaustive physical exertion.

The present data show that the treatment and placebo groups had very similar mean values. Thus it is highly unlikely that any significant differences would emerge by increasing the sample size beyond the 19 participants used here. Indeed, two *P. ginseng* studies detected improved exercise performance when using only 7 and 15 participants respectively (Bucci, 2000; Kim et al., 2005) Interestingly, older (>40 years) participants showed better responses to *P. ginseng* in terms of improved aerobic performance (reviewed by Bucci, 2000). Moreover, most studies using elite athletes have shown an enhancement of aerobic capacity after consuming *P. ginseng*. Thus the body processes that are limiting in athletes and the elderly may differ from those of the normally healthy, which would explain selective ergogenic effects of a medicinal plant.

The present study used a *K. parviflora* dose that was lower than those employed in animal studies that reported positive effects (Rujjanawate et al., 2005; Sudwan, Saenphet, Saenphet, & Suwansirikul, 2006; Trisomboon, Watanabe, Wetchasit, & Taya, 2007). The *K. parviflora* dose in this study was based on a wide safety margin using the rational described in the "Methods". However, there was no acute effect of *K. parviflora*, so it is possible that there may be a threshold dose required to reveal an ergogenic effect. This is an issue that requires further exploration.

Rating of perceived exertion can reflect a change in mental status but in the present study the rating of perceived exertion was unchanged. This suggests that there are no major effects on the brain, although the crudeness of the test cannot exclude more subtle cerebral actions.

Another possible reason to explain the ineffectiveness of *K. parviflora* was the interval between ingestion and testing. For *P. ginseng* studies, demonstrable effects were only observed if the participants were dosed daily for 4–6 weeks (Hsu et al., 2005; Kim et al., 2005; Liang et al., 2005; Pieralisi, Ripari, & Vecchiet, 1991). Nevertheless, a single dose of *P. ginseng* does improve human memory and attention tasks (Kennedy et al., 2001) and affects brain electrical activity (EEG) during a 60–120 min post-administration period (Kennedy et al., 2003). This indicates that at least some compounds of *P. ginseng* are absorbed and effective but the effects on exercise appear to be long-term via, for example, gene transcription. Thus the claims of the hill tribe people may be real through either enhanced cerebral function or through delayed actions. Notwithstanding this, a placebo action is a possibility.

In conclusion, this is the first study to examine the effect of "Thai ginseng", *K. parviflora*, on exercise performance in humans. It was found that acute *K. parviflora* ingestion, as undertaken by Thai hill tribes people prior to physical work, has no effect on repeated sprint performance or endurance time to exhaustion in a large cohort of young non-athletic Thai men. However, these findings are only representative of the genotype and phenotype of the

population tested and the results, therefore, cannot be attributed to other populations. Future studies should use chronic *K. parviflora* ingestion in a variety of participants (untrained, athletic, aged or patient groups) to determine if *K. parviflora* has any effect on human exercise performance.

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