The Effect of Ginseng Supplementation on Psychomotor Performance, Indices of Physical Capacity and Plasma Concentration of some Hormones in Young Well Fit Men.

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Abstract

Since immemorial time *Panax ginseng* has been known as therapeutic, tonic, prophylactic and restorative agent in ancient Korea, China and Tibet and at present time is also used as a food supplement by Western societies (6). Various ginseng preparations in a form of powders, teas, tinctures or extracts, very often mixed with other substances are recommended for attenuation of degenerative processes caused by aging or fatigue, as well as for treatment of various disorders and diseases in several organs (e.g. circulatory and nervous system, liver, kidney). One of the most commonly known properties of ginseng is its possibly positive influence on physical and mental performance and general well being. Because of these adaptogenic properties promoting vitality and resistance to stress ginseng is considered as an ergogenic aid. During almost 40 years in many laboratories attempts have been made to find out whether ginseng can be "a remedy for today's problems". The present work is focused on the results obtained in human studies and concerning an influence of ginseng root extracts on exercise and mental performance.

The effect of Ginseng on exercise performance.

In endurance exercise high level of physical performance is dictated mainly by the following factors:

* high maximal oxygen uptake (VO_2max), indicating aerobic capacity,
* low submaximal VO_2 value and heart rate (HR) values testifying high economy of effort.
* prolonged time to exhaustion,
* low blood or muscle lactate (LA) concentration, and muscle LA accumulation during maximal exercise,
* shifting of anaerobic threshold e.g. LA threshold to higher work loads

* quick post-exercise recovery,

* availability of energy substrates for working muscles (mediated by severeal hormones).

In Table 1. selected results of human studies on the effect ginseng on exercise performance with special attention to the above mentioned factors are summarized.

As it is shown in the Table 1 out of on the total number of 28 studies 16 failed to demonstrate beneficial effects of ginseng preparations on the indices of human exercise performance.

Table 1. Ginseng and exercise tolerance in human subjects (studies in chronological order). Adapted with modifications from Bahrke and Morgan (3, 4) and Bucci (5).

Authors	Subjects	Preparation	Results
Forgo and Kirchdorfer (18) NC	20 elite athletes (age 18-31 yrs)	Ginsana G115 (100 mg 2×day/9 wks)	↑aerobic capacity ↓ LA ↓ HR
Forgo and Kirchdorfer (19) NC	10 elite athletes (total 30 subjects, (18-31 yrs)	Ginsana G115 (extract 4% or 7% of ginsenoside (100 mg/2×day/9 wks)	↑aerobic capacity ↓ LA ↓ HR
Forgo (20) DB/PC	30 elite athletes (19-31 yrs)	Ginsana G115 S, Ginsana G115+tocopherol (100 g/2×day/9 wks)	↑aerobic capacity ↓ LA ↓ HR
Knapik *et al.* (25) DB/PC	11 well fit men	P. ginseng 2 g/day/4 wks	BG, FFA, glycerol, insulin, cortisol, hGH **NS**
Teves *et al.* (40) DB/PC.	12 marathon runners (22±1 yrs)	1.5% glycosides 2g/day/4 wks	time to exhaustion, aerobic capacity, HR **NS**
Murano *et al.* (33) NC	65 subjects (38-70 yrs)	ARM229 2 tablets/30 days 1 tablet/30 days	↑ performance in older group (Cooper test) performance (Cooper and Harvard Test) in younger group-**NS**
Forgo and Schimert (21) DB/PC	28 elite athletes (20-30 yrs)	Ginsana G115 100 mg/2×day/9 wks	↑ VO_2 ↓ HR, visual reaction times
Asano *et al.* (1) P/SB/CO	6 young males	E. senticosus 8 days	↑ total work ↑ time to exhaustion
Ng and Ng (34) ?	214 marathon runners	?	↑ endurance ? ↑ recovery speed
Macareg and Ramos (28) R/DB/PC/CO	12 marathon runnes	? /4 w	time to exhaustion, glucose and lactate **NS**

Table 1. Continued.

Authors	Subjects	Preparation	Results
Tesch *et al.* (39) PC	38 subjects (50-54 yrs)	80 mg/day/8 wks	↓ HR, LA - >180 W ↑ PE (60, 80, 120 W) LA up to 180 W-**NS**
McNaughton *et al.* (30) R/DB/PC/CO	15 F, 15 M marathon runners	Chinese/Russian ginseng 1 g/day/6 wks	↑ VO_2max ↑recovery HR ↑ strength
Gribaudo *et al.* (22) DB/CO	12 young M	Ginseng + fenu greek 0,5 g each/2×day/15 days	↑ total work output LA **NS**
Pieralisi *et al.* (35) R/DB/PC/CO	50 sport teachers (21-47 yrs)	Ginseng+DMAE +vitamins and minerals, 200 mg/day/6 wks	↑total work load ↑ VO_2max ↑ time to exhaustion ↓ submax. HR ↓ submax. LA
Gribaudo *et al.* (23) R/DB/CO	14 well trained amateur cyclists	Ginseng+fenu greek 0.5 g each 2×day/30 days	↑ maximal work ↑ VO_2max, ↑ AT, LA **NS**
Van Schepdael (42) R/DB/PC/CO	43 F triathletes (24-36 yrs)	Ginsana G115 2×100 mg/2×day/20 w.	during 1-10 wks-**NS** delayed loss of fitness after 11-20 wks
Engels *et al.* (12) DB	19 F (26±1 yrs)	P.ginseng C.A. Meyer 4% 200 mg/day/ 8 wks	VO_2, HR and LA in submax. and max work - **NS.**
Morris *et al.* (31, 32) R/DB/PC	7 M, 1 F well trained (27 ± 5 yrs)	Panax quinque folium 8 or 16 mg/kg/day/7days	time to exhaustion, VO_2, LA, BG, PE - **NS**
Dowling (9) R/DB/ PC	16 M, 4F distance runners (37±8yrs)	E. senticosus M 3.4 ml/day/6 wks	VO_2, HR, LA, BG, PE -**NS**
Engels *et al.* (13) R/DB/PC	19 F	P. ginseng C.A. Meyer 4% ginsenosides 200 mg/day/8wks	maximum work performance, resting, exercise and recovery O_2, HR, LA - **NS**
Engels and Wirth (14) R/DB/PC	31 adult subjects	P. ginseng C.A. Meyer 200 or 400 mg/day/ 8 wks	VO_2, HR, RER, LA and PE in submax. and max. Exercise loads **NS.**
Lifton *et al.* (27) DB/CO	7 M, 4 F well trained	ginseng 3 g/day/13 days	HR max, VO_2max, total workload **NS**

Table 1. Continued.

Authors	Subjects	Preparation	Results
Allen *et al.* (2) R/DB/PC/CO	8 F, 20 M, moderately fit (23 ± 3 yrs)	P. ginseng, 7% ginsenosides 200 mg/day/3 wks	exercise time, work load, VO_2, HR, LA, PE, NS
Engels *et al.* (15) R/DB/PC	12 M well fit young adults	P. ginseng C.A. Meyer 1000 mg/ 60 d	VO_2, HR, PE at maximal aerobic exercise **NS**
Kolokouri *et al.* (26) DB/PC	24 F adult	P. ginseg C.A. Meyer 400 mg/day/8 wks	peak anaerobic power output, fatigue rate-**NS**
Eschbach *et al.* (16) R/DB/CO	10 highly trained	E. senticosus 1200 mg/day/7days	VO_2, HR, LA, BG and PE **NS**
Ziemba *et al.* (44) DB/PC	15 M well fit (19.1±0.6 yrs)	Ginseng preparation 350 mg/day/6 wks	VO_2max, HRmax, LAT **NS**
Youl Kang *et al.* (45) R/PC	8 college students	Ginseng root extract 20 g single dose after exercise	cortisol, testosterone, hGH, insulin-like growth factor before, after and during 2h recovery period **NS**

Study design: CO: crossover, DB: double blind, PC: placebo-controlled, R: randomized, NC: not controlled. M: male, F: female, NS: statistically insignificant, HR: heart rate, AT: anaerobic threshold, BG: blood glucose, FFA: free fatty acids, hGH: human growths hormone, PE: ratings of perceived exertion. ? data not listed or unavailable. DMAE: dimethylaminoethanol.

Moreover, taking into account studies in which age of the subjects was considered in 16 investigations in young and young adult subjects (up to 47 years of age) only in a 7 positive effect on human exercise tolerance was reported.

According to Bahrke and Morgan (3) lack of absence of ginseng ergogenic effect may be caused by inadequate research design (measurements of inappropriate variables, absence of a control group or placebo) applied in some studies. The same authors in their next paper reviewing recent studies (4) emphasized, however, improved research protocols with increased number of those in which the placebo-controlled, cross-over, double- blind designs were applied. According to Bucci (5) Panax ginseng may improve exercise tolerance as well as mental performance if it is used in sufficient doses for a long enough period. It should be noted that acute administration of ginseng does not improve physical performance. It seems also likely that the effect of ginseng may be beneficial in untrained or/and older individuals.

The effect of Ginseng on mental performance

The pharmacological effects of ginseng manifest tlhemselves also at a level of the central nervous system. Several different psychological tests were applied for studying on mental efficiency (psychomotor, attention and concentration, learning and memory, abstraction trails). Besides, some observations of the subjects behavior were made. In Table 2 list of selected papers concerning an influence of ginseng on mental humans performance, and their behavior is given.

As it is shown in Table 2 improvements have been reported in a variety of mental functions, particularly psychophysical reactions, as well as subjective feeling of well being and vitality. However, again only few randomized, double-blind, placebo-controlled studies on

Table 2. Results of chosen human studies with Panax ginseng on various methods of mental performance evaluation. Adapted with modifications from Bahrke and Morgan (3, 4) and Bucci (5).

Authors	Subjects	Preparation	Results
Popov and Goldwag (36) DB/PC	32 men (21-23 yrs)	40% ethanol tincure, 2 ml extract acute dose.	↓ errors in radio transmission number of characters transmitted - **NS**
Dorling *et al.* (10) DB/PC	60 (22-80 yrs)	Standard extract 12 wks	↑ visual and auditory reaction time, hand coordination, alertness
Forgo *et al.* (17) DB.	120 (30-60 yrs)	Ginsana G115 2×100 mg/day/12 wks	↓ reaction time, ↑ subjective feeling of vitality, mood, sleep, concentration
Hallstrom *et al.* (24) DB/PC/CO	12 night shift nurses (21-27 yrs)	Korean ginseng 1200 mg/2 wks	↑ tapping rate test, mood **NS** ↓ sleep quality
DAngelo *et al.* (8) DB/PC	32 (20-24 yrs)	Ginsana G 115 2×100 mg/day/12 wks	↑ mental arithmetic tasks tapping test, visual, choice, auditory reaction time, recognition-**NS.**
Wiklund *et al.* (43) PC	390 middle-age	Ginsana 115 200 mg/day/12 wks	↑ alertness, relaxation, appetite, overall score and general well being
Smith *et al.* (37) DB	19 F (26±1 yrs)	Standardized extract 200 mg/day/8 wks	Psychological test, PE at rest and during exercise NS

Table 2. Continued.

Authors	Subjects	Preparation	Results
Marasco *et al.* (29) R/DB/PC	625 (18-65 yrs)	Ginsana G 115+vitamins and minerals 200 mg/day/12 wks	↑ quality of life
Sorensen and Sonne (38) R/DB/PC	112 (>40 yrs)	Ginsana G115 400 mg/day/8-9 wks	↓ reaction time ↑ abstract thinking - memory, concentration, well-being **NS**
Ziemba *et al.* (44) DB/PC	15 M well fit (19.1±0.6 yrs)	Ginseng preparation 350mg/day/6 wks	↓ RT during exercise ↑ psychomotor performance

Study design: CO: crossover, DB: double blind, PC: placebo-controlled, R: randomized, NC: not controlled. M: male, F: female, NS: statistically insignificant , ↓: shorter reaction time (improved psychomotor performance), ↑: improvement.

the effect of ginseng on the cognitive function have been performed. It should be also noted that mental perception depend largely on duration of treatment and a dose given.

Own investigations.

Ability to maintain psychomotor skill during fatiguing exercise is of importance for sports activities. Previous work from our laboratory demonstrated that during graded incremental exercise multiple choice reaction time (RT) decreases at low to moderate exercise intensity in comparison with the resting values, whereas at heavier work loads exceeding the lactate threshold by approx. 20% (approx. 60-70% VO_2max), RT increases and at the maximal load it often becomes much longer from the values measured at rest (7). Since multiple choice RT depends mainly of the rate of information processing within the central nervous system, thus it has been suggested that the exercise-induced activation of this system, due to central neuroendocrine changes, might facilitate the psychomotor performance (11,41). However, the arousal accompanying heavy work loads quite often exceeds the optimal level, which has a detrimental effect on the psychomotor function.

Among several factors, that can modify psychomotor skill during exercise, such as physical fitness, some nutrient intake, caffeine, ginseng seemed to be a good candidate for improving psychomotor skills because it stimulate the central nervous system. Besides ginseng root

contains proteins and carbohydrates, some vitamins (e.g., A, C, E and B) as well as calcium, iron, phosphorus and a series of teracyclic triterpoid saponins (ginsenosides) as active ingredients. It is still unclear, however whether ginsenoides or their metabolites penetrate the human blood-brain barrier and influence central nervous system Among numerous reported effects of ginseng on the basic human functions is its beneficial influence on psychological and mental state (see Table 2: 8,10,18,24,29,36,37,38,43). Thus, it has been assumed that prolonged treatment with ginseng preparation might enhance psychomotor performance during physical exercise, but apart from our own data no other reports could be found in the available literature to confirm this suggestion.

The aim of our investigation was therefore to determine whether previously described changes in the choice reaction time (RT) during graded incremental exercise till volitional exhaustion are affected by ginseng ingestion. Simultaneously work capacity and hormonal responses to the exercise test were determined.

Material and Methods

Subjects. The investigations were carried out with 15 male soccer players, (mean age 19.07± 0.62 years) who signed an informed consent to participate in this study. The research procedure was approved by the local Ethics Committee.

Experimental Procedure. The subjects were placed into two groups in a double blind manner: 1) Seven of them received for 6 weeks capsules containing Ginseng preparation (KRKA, Novo Mesto, Slovenia one capsule containing 1 g of concentrated ginseng root extract) in a dose of 200 mg daily 2) Eight subjects obtained placebo capsules for the same time period. Neither the staff directly involved in the study, nor the coach or athletes/subjects knew what kind of treatment was applied. The information pertatning to subject treatment was not uncoded until after study termination. Before the administration of ginseng or placebo, and then again after six weeks of the treatment, the subjects performed an incremental graded exercise test until volitional exhaustion. They were well acquainted with the experimental protocol and performed five to seven trials to become familiar with the procedure of determining the multiple choice reaction time (RT). Exercise tests were performed on an electrically braked bicycle cycloergometer. During the multistage incremental exercise, workload was increased by 50 Watts every three minutes, starting at 50W until volitional exhaustion occurred. Each exercise stage was separated

by 1 minute rest interval during which blood samples were taken.

The RT measurements were performed 2-3 times at rest prior to starting the exercise, and then within the last 2 minutes of each exercise load. Before exercise, at the end of each exercise load, and following termination of the exercise, blood samples were taken for determination of lactate (LA) concentration. Plasma growth hormone (hGH), testosterone and cortisol were estimated in blood samples obtained before and immediately after cessation of the exercise tests. Heart rate and oxygen uptake (VO_2) were recorded continuously throughout the whole exercise.

In order to determine the multiple RT during exercise the RT console was mounted on the wall in front of the ergometer at eye level, 1.5 m away from the subject. The RT test included 15 positive trials (red light or a sound) and 15 negative (green and yellow lights) stimuli applied in random order. The subjects were asked to press, and then to release, as quickly as possible, the button on the right handlebar of the cycle ergometer in response to the red light, the button on the left handlebar in response to the sound, and do not react to the negative stimuli. The total time for the 30 RT trials was 107 s. The stimuli and the subjects responses were recorded using the RT measuring device. Reaction time was determined to the nearest 0.01 second. The results are presented as the mean value of 15 responses to the positive stimuli.

The results of RT measurements in the ginseng - treated and placebo groups are presented in Fig. 1. In the group of subjects treated with placebo the pre-exercise RT and the RT changes during the exercise test were similar before and after 6-week program.

In this group reaction time decreased progressively until the workload of 175.0±16.4 and 175.0±21.1 W (pre and post 6 weeks of treatment respectively), and then it started to increase exceeding the resting value. In the ginseng group RT values at rest and during all exercise stages were significantly lowered after 6 weeks of treatment and the shortest RT was found at the work load of 150±15.4 W, whereas before ginseng administration the work load associated with the shortest RT was 200.0±15.4 W ($p<0.05$).

As it is shown in Table 3, the maximal oxygen uptake ($V0_2$ max) and HRmax did not differ statistically between the subjects assigned to the ginseng, or placebo groups either before or after 6 weeks of the investigation. The work loads (in Watts) corresponding to the lactate threshold (LAT) were not significantly affected by ginseng ingestion.

In both groups (ginseng and placebo) plasma cortisol concentration increased similarly during the control exercise and after 6 weeks of treatment. (Table 4). The exercise-induced increase in the plasma hGH concentration was statistically significant during the exercise tests ($p<0.01$),

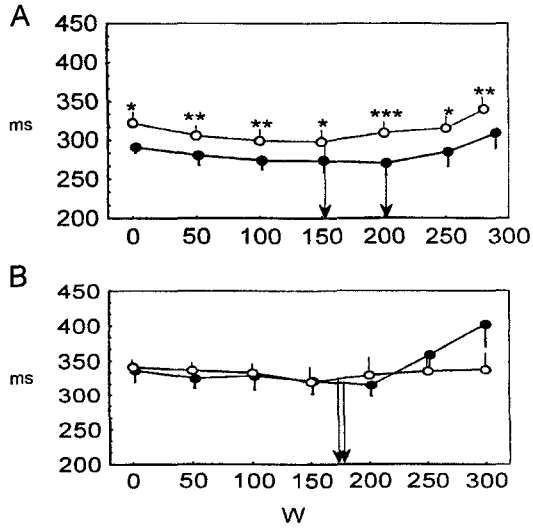

Fig. 1. Changes of choice reaction time (RT-ms) at rest (0-W) and during incremental exercise before and after 6 weeks of ginseng (A) or placebo (B) treatment. The data values are means (±SE). Asterisks denote significant differences between pre- and post- trial: *p<o.05, ** p<0.01, *** p<0.001. Open circles indicate control exercise, black circles exercise performed after 6 weeks of ginseng or placebo treatment.

except the control exercise performed by the subjects prior to ginseng treatment, when it showed only an increasing tendency. The differences between the two groups (ginseng vs placebo) were statistically insignificant. (Table 4). The plasma testosterone concentration increased during exercise tests (Table 4), except the first exercise performed by the subjects in the placebo group. There was no effect of ginseng ingestion on the plasma testosterone level.

The data presented above indicate that in young athletes 6-week supplementation with ginseng markedly improves their psychomotor skill both at rest and during incremental exercise. These

Table 3. Mean values (±SE) of maximal oxygen uptake ($V0_2$ max-l/min) maximal heart rate (HR-beats/min) and lactate threshold (LAT in Watts) during the graded exercise test before and after ginseng or placebo treatment.

	Ginseng (n=7)		Placebo (n=8)	
	Before treatment	After treatment	Before treatment	After treatment
$V0_2$ max (l/min)	3.9±0.09	3.8±0.14	3.8±0.15	3.8±0.15
HR max	186±2.4	186±3.4	182.±3.3	184±2.8
LAT	145.3±10.2	173±13.8	169.1±8.9	142.7±15.2

Table 4. The effect of six weeks of ginseng or placebo treatment on plasma cortisol, human growth hormone (hGH) and testosterone concentrations at rest and immediately after termination of graded exercise. The data are means (±SE). Asterisks denote significant differences between resting and post exercise values (*p<0.05, **p<0.01).

Group	Before treatment					
	Cortisol (nmol/l)		HGH (nmol/l)		Testosterone (nmol/l)	
	Rest	after exercise	rest	after exercise	Rest	after exercise
Ginseng	358.7±47.4	440.4± 61.2	30.6± 14.4	92.1± 26.9	20.1± 1.1	27.0± 1.6**
Placebo	302.9± 23.4	432.5± 53.4*	12.8± 5.2	71.4± 7.2**	25.9± 3.6	27.8± 3.3
	After 6weeks of treatment					
Ginseng	306.2± 33.1	377.0± 46.8	9.7± 7.4	102.8± 19.8**	22.1± 1.9	27.7± 2.1**
Placebo	353.0± 50.9	433.6± 59.1	27.5± 11.0	74.3± 19.2**	22.1± 2.3	33.5± 3.7**

findings partly support the results reported by Dorling et al. (10), and Forgo *et al.* (17) who found an advantageous action of ginseng on mental alertness and coordination of movements, however the above authors performed their study under resting conditions.

It should be emphasized that the beneficial effect of ginseng on psychomotor skill during physical exercise documented in this study was not accompanied by any significant alterations in work capacity expressed as $V0_2max$ or the lactate threshold. The above findings are in line with the results reported by Knapik *et al.* (25) who also failed to show any ginseng-induced enhancement of work tolerance, and alterations in exercise metabolism, endocrine profile or subjective perception of the effort, at least in young well fit men. Some other authors (1,27,31,42) also did not find any effects of ginseng treatment on physical fitness or physiological responses to exercise.

On the other hand, Forgo and Kirchdorfer (18), who investigated an influence of 9-week ginseng treatment on exercise performance in elite athletes reported a significant increase in their aerobic capacity, reduced blood lactate levels during recovery from exercise, and lower heart rates during and after exercise. Unfortunately, neither placebo nor control groups were included into this study. Results of the randomized, double-blind, cross over investigation by Pieralisi et al. (35) performed with 50 male sport teachers demonstrated that the subjects tolerated well greater total work loads and had enhanced VO_2 max after the ginseng treatment as compared with the placebo conditions. The effect of ginseng on exercise tolerance still requires further well designed studies; It seems likely that its effects of ginseng may depend not only on duration of

the treatment, but also on the physical state of subjects and the kind as well as intensity of exercise they perform.

It is of importance that ginseng treatment does not alter either the pre- or post-exercise levels of cortisol, growth hormone and testosterone, thus indicating that ginseng supplementation does not influence secretion of these hormones at least during the exercise applied in this study

It should be emphasized that high psychomotor performance and work capacity are both important for athletes who must respond quickly and efficiently to various tasks involved in sports events. Thus, ginseng in the dosage reported in this study can be recommended as an ergogenic agent which increases alertness, concentration and speed of movement in sports practice.

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