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The Effects of a Korean Ginseng, GINST15, on Hypo-Pituitary-Adrenal and Oxidative Activity Induced by Intense Work Stress

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Research article

The Effects of a Korean Ginseng, GINST15, on Perceptual Effort, Psychomotor Performance, and Physical Performance in Men and Women

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Abstract
The purpose of this double-blind, placebo-controlled investigation was to examine the effects of a Korean Ginseng (GINST15) on measures of perception and physical performance following an acute bout of resistance exercise. Ten women (age: 38.7 ± 7.8 years; height: 1.64 ± 0.05 m; body mass: 76.0 ± 11.6 kg) and nine men (age: 41.2. ± 9.7 years; height: 1.77 ± 0.05 m; body mass: 88.5 ± 5.0 kg) completed the investigation. Participants were randomized to a three-cycle testing scheme consisting of high dose ginseng (HIGH: 960 mg/day), low dose ginseng (LOW: 160 mg/day) and placebo (PBO: 0 mg/day). After 14 days of supplementation participants returned to the laboratory for an acute resistance exercise trial (5 sets of 12 repetitions of the leg press at 70% of one-repetition-maximum [1RM]). Ratings of perceived exertion (RPE) were assessed after each set. Muscle pain/soreness was assessed before exercise and 24 hours post exercise. Psychomotor performance and peak power were measured before exercise, immediately post exercise and 24 hours after exercise. Each treatment cycle was separated by a minimum one-week washout period. HIGH significantly reduced perceived exertion during exercise. HIGH and LOW significantly reduced change in muscle soreness at 24 hours post exercise. Analysis of peak power demonstrated the presence of responders (n = 13) and non-responders (n = 6). Responders showed a significant effect of HIGH GINST15 on maintenance of neuromuscular function. The appearance of responders and non-responders, could explain the mixed literature base on the ergogenic properties of ginseng.

Key words: Ginseng, anaerobic exercise, exertion, pain, peak power.

Introduction

The nutraceutical herbal supplement, Ginseng (Panax Ginseng C.A. Meyer; Araliaceae) has been used for thousands of years in Asian culture for its adaptogenic properties, including stress management and resistance to fatigue. It is no wonder then that many investigations have sought to examine its potential as an ergogenic aid. Interestingly, a meta-analysis and systematic review have found little evidence to support ginseng's role in combating fatigue or enhancing exercise performance (Bahrke and Morgan, 1994; 2000; Bach et al., 2016; Lee et al., 2016). However, the consensus remains, that further research is needed due to lack of quality-controlled investigations and the understanding of training specificity. Exercise response and adaption are tightly regulated by the mode, duration and frequency of training. While many investigations have focused on the role of ginsenosides in aerobic interventions (Kim et al., 2005; Liang et al., 2005; Pumpa et al., 2013; Morris et al., 1996; Bandyopadhyay et al., 2011; Dorling et al., 1980; Ziemba et al., 1999) there is a lack of research investigating the effect of ginseng on anaerobic performance and recovery.

Understanding the effects of ginseng must also be qualified by the type of herbal supplement and/or extract used in the investigation. As nicely overviewed in prior publications, various ginseng compositions have arisen including Asian ginseng, American ginseng, Siberian ginseng, and Thai ginseng, each with their own active components (Bach et al., 2016; Lee et al., 2016), the primary bioactive constituent being sapponins (ginsenosides) (Yang et al., 2015). Non-processed ginseng supplements have failed to demonstrate significant treatment effects in studies of aerobic exercise (Engels et al., 2001, Engels and Wirth, 1997, Gaffney et al., 2001, Biondo et al., 2008). This lack of effect may be attributed to low bioavailability of active components.

Our work has focused on a Korean ginseng, GINST15 (20-O-β-D-glucopyranosyl-20(S)-protopanaxadiol; or Compound K), which uses a modified process to increase bioavailability of ginsenoside metabolites through use of recombinant enzymes (Ko et al., 2007). GINST15 is readily absorbed into circulation (bioavailability ≅ 35% at 20mg/kg) due to its relative non-polarity (Kim, 2013; Wang et al., 2011). Evidence of decreased inflammation, oxidative stress and muscle damage (Joh et al., 2011; Qi et al., 2014; Yang et al., 2015) emphasizes the potential for GINST15 to mediate exercise-performance and fatigue.

Thus, the purpose of this study was to examine the effects of GINST15 on perception of exercise stress and measures of physical performance following an acute bout of intense resistance exercise.

Methods

Experimental approach

A double-blind, placebo-controlled, crossover study was utilized in this investigation. Participants were familiarized with all experimental procedures during an initial baseline visit. Next, participants were randomized to a three-cycle testing scheme in a counterbalanced order: high dose ginseng (HIGH: 960 mg/day), low dose ginseng (LOW: 160 mg/day) and placebo (PBO: 0 mg/day). For each cycle, participants supplemented for 14 days prior to returning to the laboratory for testing. Each testing cycle consisted of a performance and a +24 hour test visit. Measurements were taken before (PRE), immediately post (POST), and 24 hours post (+24 HR) intense resistance

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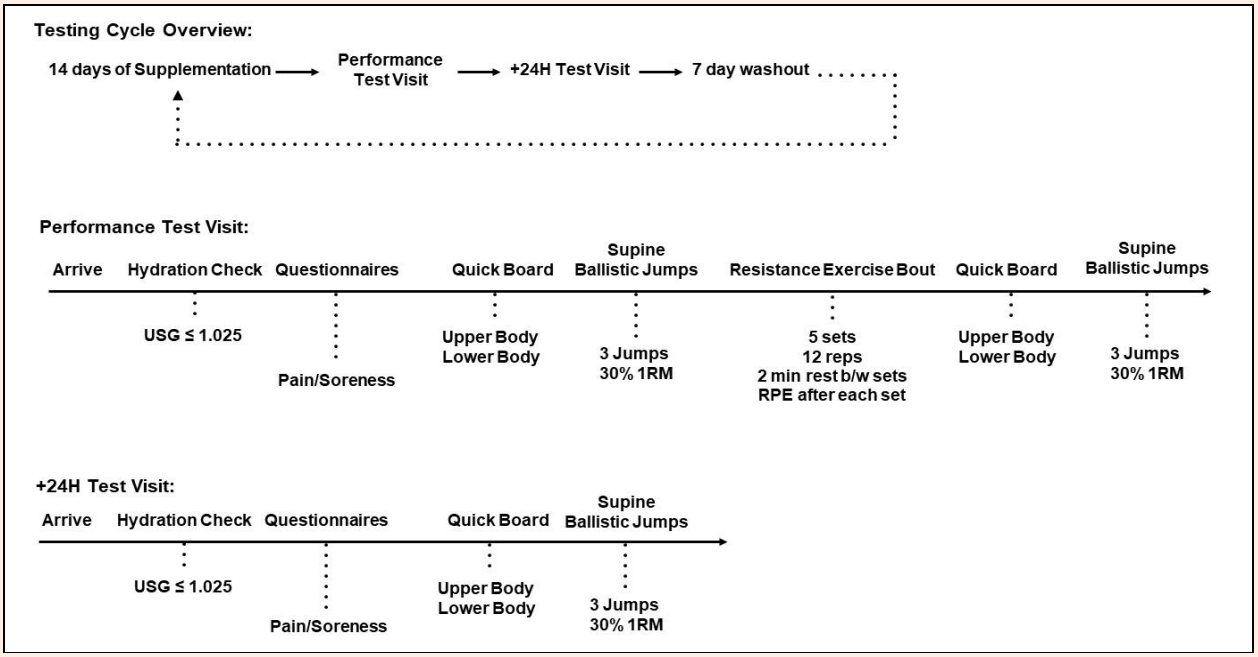

Figure 1. Experimental Approach and Design. Participants were tested on two consecutive days following 14 days of supplementation. Testing on the performance visit consisted of a pain/soreness questionnaire, Quick Board reaction tests, and supine ballistic jumps before an acute bout of resistance exercise and Quick Board and supine ballistic jumps after the bout of exercise. Testing on the +24H day consisted of the same pain/soreness questionnaires, Quick Board reaction tests, and supine ballistic jumps.

exercise. Each cycle was separated by a minimum one-week washout period (see Figure 1).

Participants

Ten healthy and active women (age: 38.7 ± 7.8 years; height: 1.64 ± 0.05 m; body mass: 76.0 ± 11.6 kg) and nine healthy and active men (age: 41.2. ± 9.7 years; height: 1.77 ± 0.05 m; body mass: 88.5 ± 5.0 kg) volunteered for participation. All volunteers were screened and medically cleared to engage in experimental procedures. In addition, individuals verified that they did not meet any of the following exclusion criteria: ongoing consumption of any ginseng-containing product; food or supplement allergies; hypersensitivity to caffeine; musculoskeletal injuries or physical limitations affecting the ability to exercise; current use of any hormonal substance including testosterone, anabolic steroids, or growth hormones; ongoing use of any anti-inflammatory medications; diagnosis of diabetes, hypertension, or cardiovascular disease; use of cholesterol or blood pressure-lowering medications; the use of tobacco products; alcohol consumption in excess of three drinks per day or 18 per week. Furthermore, individuals confirmed they engaged in recreational activities (e.g., walking, jogging) but were not currently enrolled in a structured and supervised exercise program. Previous experience with resistance training was not required, nor did it preclude participation. Prior to enrollment, interested volunteers provided written informed-consent in accordance with The Ohio State University's Institutional Review Board (2014H0404).

Ginseng supplementation

Supplementation was self-administered using identical liquid capsules (GINST 15®, ILHWA Co. LTD, South Korea). Daily doses consisted of 960 mg (HIGH), 160 mg (LOW), or 0 mg (PBO) of ginseng. Participants were provided pillboxes with compartments labeled AM and PM. Three capsules were placed in each compartment. PBO boxes contained 3 placebo capsules (0 mg) to be taken AM and PM. HIGH boxes contained three active capsules (160 mg) to be taken AM and PM. LOW boxes contained 1 active capsule and 2 placebo capsules in the AM with 3 placebo capsules in the PM. Treatment allocation was counterbalanced and double-blinded. For each cycle, participants supplemented for 14 days prior to testing. Participants were required to keep track of daily supplementation using a supplement log which was returned alongside the empty pillboxes on test days.

While an in-depth study of pharmacokinetics was beyond the scope of this investigation, previous work has demonstrated a similar dose of Compound K (10 mg/kg) to have a half-life of 4.4 hours and total plasma clearance of 1.4 L/h/kg (Yu, 2012). Based on this information, a minimum 7-day washout (38 times the length of the half-life) was selected to remove carryover effect.

Performance and +24H test visits

Following 14 days of supplementation, participants reported to the laboratory for the performance visit. Upon arrival, compliance with the study controls and minimal hydration (urine specific gravity ≤ 1.025) was confirmed. Participants then completed the pain/soreness questionnaire and pre-exercise physical performance tests consisting of the Quick Board and weighted ballistic jumps.

Following the acute bout of resistance exercise, the same Quick Board and ballistic jump tests were performed. Ratings of perceived exertion (RPE) were measured immediately after the last repetition of each set during the acute bout of resistance exercise.

Twenty-four hours after the completion of the acute bout of exercise, participants reported back to the laboratory, confirmed control compliance and minimal hydration status, completed the pain/soreness questionnaire and performed the same Quick Board and ballistic jump tests.

Acute bout of resistance exercise

Participants performed 5 sets of 12 repetitions at 70% of their pre-determined one-repetition maximum (1RM) using a leg press (Plyo Press, Athletic Republic, Park City, Utah) with two-minute rest periods between sets. The total work performed was kept the same for each testing cycle (Figure 2).

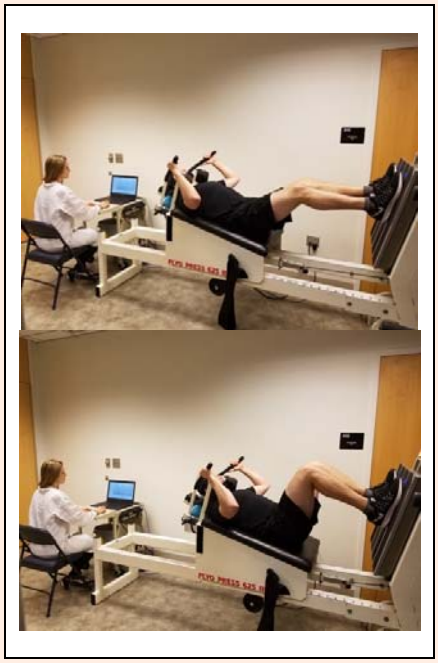

Figure 2. Acute resistance exercise. Participants completed 5 sets of 12 repetitions at 70% of 1 RM

Quick board reaction time tests

Upper body and lower body reaction time was measured using the Quick Board (The Quick Board, Memphis, TN). The Quick Board system is comprised of an iPad (Apple Inc., Cupertino, CA) Quick Board application and a footpad with 5 sensors placed equidistant from each other, with two at the front of the footpad, two at the back of the footpad, and one in the middle of the footpad. The iPad application presents the visual stimulus by replicating the footpad on its display and lighting up the sensors in a random order. Once the correct corresponding sensor is touched (by finger on the iPad for upper body tests, and by foot on the footpad for lower body tests) the next sensor is illuminated. The iPad is placed at eyelevel in front of the participant and connected to the footpad by a QBiAd interface cord.

For the upper body reaction test, participants stood on the footpad at a distance where the wrists were parallel to the sides of the iPad when arms were extended forward. Participants were instructed to use only the index fingers and to touch the sensors on the left side of the screen with their left finger and on the right of the screen with their right finger. The middle sensor could be touched with either index finger. The test consisted of 3 sets of 40 touches with a 0.05 second delay between correctly touching a lit sensor and subsequent stimulus. Total time to complete each set and mean reaction time for each touch was extracted for analysis.

For the lower body reaction test, participants began by standing on the footpad with feet carefully aligned on either side of the middle sensor (operationally defined as the base) and the head looking forward at the iPad. Participants were instructed to touch the corresponding sensor of the footpad that lit up on the iPad and then return to base before touching the next illuminated sensor. Sensors on the left side were touched with the left foot, sensors on the right side were touched with the right foot, and the sensor in the middle could be touched by either foot. Participants were instructed to keep the head up and eyes focused on the iPad, rather than looking up and down between the iPad and feet. The test consisted of 3 sets of 40 touches with a 0.05 second delay between correctly touching a lit sensor and subsequent stimulus. Total time to complete each set and mean reaction for each touch was extracted for analysis.

Ballistic jump power

Participants performed 3 maximal-effort ballistic jumps on the Plyo Press (Athletic Republic, Park City, Utah) in the supine position using 30% of 1RM. Participants were instructed to begin in the extended upright position with hands on the Plyo Press handles above their head, then perform a downward movement by flexing at the knees and hips (eccentric phase) until their knee angle was at or below 90°, and immediately extend their knees and hips to jump up in the air with maximal effort as high, hard and fast as they could. Upon landing participants were instructed to return to the starting position of full extension, briefly pause, then repeat the procedure for the second and third ballistic jump.

Jump power data were collected using an Advanced Mechanical Technology Inc. (AMTI) force plate (Watertown, MA) attached to the Plyo Press with a sample rate of 200 Hz. Peak jump power was selected and analyzed using Accupower 2.0 software (AMTI, Watertown, MA).

Questionnaires, perceptual measures

A pain and soreness questionnaire was administered at the beginning of each test visit. Pain/Soreness was measured using a visual analog scale. Participants indicated their pain/soreness by placing a mark on a 100mm line between two endpoints that read “no pain/soreness” and “pain/soreness as bad as it could be.” The mark was measured from the beginning endpoint and converted to a number between 0 and 100.

RPE was measured immediately after the last repetition of each set during the acute bout of exercise using the

Borg CR-10 scale with free magnitude estimation. Participants were instructed to use the scale presented in front of them to indicate their perceived exertion between 0 and 10 where 0 means "no exertion at all" and 10 means "maximal or very very strong exertion." In addition, participants were informed that the scale has no anchor, for instance if they gave a 10 on a previous rating and decided that the current exercise was more strenuous, they could give a higher number such as an 11.

Experimental controls

To reduce external confounders from effecting the results, participants were required to replicate their diet (food and drink) 48 hours before each test visit, refrain from any physical exercise and strenuous activity 72 hours before each test visit, fast 8 hours prior to each test visit, refrain from consuming any outside ginseng for the duration of the study, and refrain from using any outside recovery methods including baths, hot tubs, showers > 10 minutes, ice, compression, aspirin or any other medication, drugs or devices until after the completion of their +24 hour test visit of each testing cycle. Additionally, to control for hormonal status, premenopausal women were tested during the early follicular phase of the menstrual cycle, when progesterone and estrogen levels are lowest.

Statistical analyses

Data were analyzed using SPSS version 24 (IBM, Inc., Armonk, NY, USA). Means and standard deviations (SD) were calculated for each variable. A mixed-method ANOVA (Treatment x Time x Sex) was used to determine significant differences amongst means. Significant F tests were further investigated using pairwise post-hoc comparisons ($p \leq 0.05$). Cohen's d (mean difference/pooled SD) was calculated to evaluate magnitude of treatment effects.

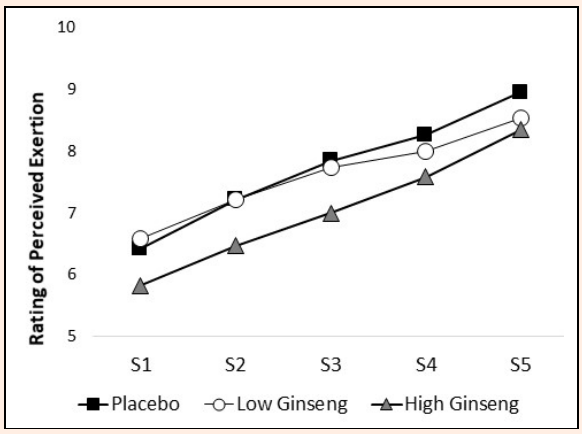

Figure 3. Mean perceived exertion (CR-10) during the 2-minute rest period following each set of the 5 x 12 leg press.

Results

No adverse events were reported by participants throughout the supplementation or testing period.

No significant sex-by-treatment interactions were observed for any of the variables of interest. Therefore, sex was dropped as a between-subjects factor and statistical analyses were rerun using a within-subjects (Treatment x Time), repeated measures ANOVA to elucidate the effects of GINST15 on measures of perception and performance.

RPE demonstrated a main effect for treatment ($F [2, 36] = 4.470$, $p < 0.018$) and time ($F [4,72] = 44.277$, $p < 0.001$) (Figure 3). Pairwise post hoc analysis revealed HIGH GINST15 significantly reduced perceived exertion during the resistance exercise protocol compared with LOW ($p = 0.004$, $d = 0.31$) and PBO ($p = 0.038$, $d = -0.39$). As expected, perceived exertion significantly increased across all sets of the 5x12 leg press.

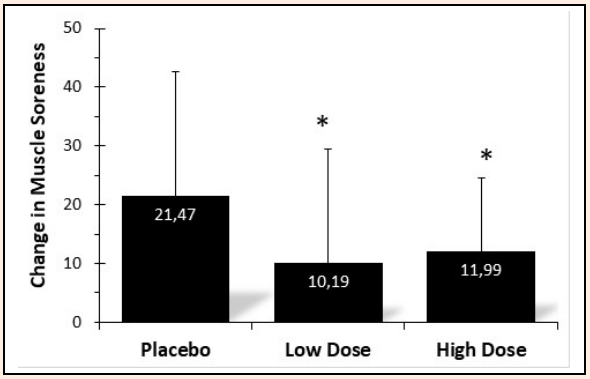

Figure 4. Change in muscle soreness (Mean ± SD). *significantly different from placebo ($p < .05$).

As presented in Flanagan et al. (2017) no significant treatment effect was demonstrated for raw perceived muscle soreness; however, secondary analysis using change in muscle soreness (+24 HR – PRE) revealed a significant treatment effect ($F [2,36] = 4.342$, $p = 0.020$) with HIGH ($p = 0.014$, $d = -0.59$) and LOW GINST15 ($p = 0.011$, $d = -0.59$) showing significantly lower muscle soreness than PBO (Figure 4).

Analysis of the Quick Board yielded no significant interaction or main effect for treatment, however, there was a main effect for time on both upper and lower body measures (Table 1). Upper body analysis demonstrated a main effect for time on both mean reaction time ($F [2, 36] = 7.311$, $p = 0.002$) and total time ($F [2, 36] = 10.872$, $p < 0.001$). Pairwise post hoc analysis revealed POST < +24HR < PRE. Likewise, lower body reaction time demonstrated a main effect for time on mean reaction time ($F [2, 36] = 3.33$, $p = 0.047$) and total time ($F [2, 36] = 7.437$, $p = 0.002$). Similar to the upper body trials, POST and +24HR were faster than PRE. However, for mean reaction time +24HR < POST < PRE, and for total time POST < +24HR < PRE.

As with reaction time, examination of peak power on the ballistic jump revealed a main effect for time ($F [2,36] = 20.694$, $p < 0.001$), but no significant treatment effect or interaction (Table 2). Peak power was significantly reduced POST, but showed full recovery at +24HR. Secondary analysis of individual performances revealed the lack of treatment effect may be attributed to evidence of responders and non-responders. A responder was categorically defined as an individual with highest peak power

Table 1. **Total time (sec) and mean reaction time (sec) per touch on upper and lower body Quick Board tests. Data are means (±SD).**

	UPPER BODY QUICKBOARD					
	TOTAL TIME (SEC)			MEAN REACTION TIME (SEC)		
	PLACEBO	LOW DOSE	HIGH DOSE	PLACEBO	LOW DOSE	HIGH DOSE
PRE	36.71 (1.43)	37.10 (1.81)	37.21 (1.48)	.44 (.03)	.45 (.05)	.45 (.05)
POST	36.44 (1.30)	36.54 (1.32)	36.47 (1.55)	.44 (.03)	.44 (.03)	.43 (.04)
+24 HR	36.67 (1.43)	36.71 (1.24)	36.67 (1.48)	.44 (.04)	.44 (.03)	.44 (.04)
	LOWER BODY QUICKBOARD					
	TOTAL TIME (SEC)			MEAN REACTION TIME (SEC)		
	PLACEBO	LOW DOSE	HIGH DOSE	PLACEBO	LOW DOSE	HIGH DOSE
PRE	51.69 (3.08)	51.98 (3.50)	51.47 (2.00)	.81 (.08)	.82 (.08)	.81 (.05)
POST	50.89 (2.82)	51.53 (3.52)	51.02 (2.45)	.79 (.06)	.81 (.08)	.79 (.06)
+24 HR	51.38 (3.21)	51.67 (3.54)	50.15 (1.97)	.81 (.08)	.81 (.08)	.77 (.05)

Table 2. **Peak power (W) on ballistic jumps before and after intense resistance exercise for all participants (n = 19). Data are means (±SD).**

	PLACEBO	LOW DOSE	HIGH DOSE
PRE	1587.34 (500.59)	1576.63 (431.85)	1587.74 (524.39)
POST	1518.18 (476.66)	1492.00 (419.27)	1536.11 (484.77)
+24 HR	1656.58 (494.00)	1674.95 (466.00)	1660.58 (543.25)

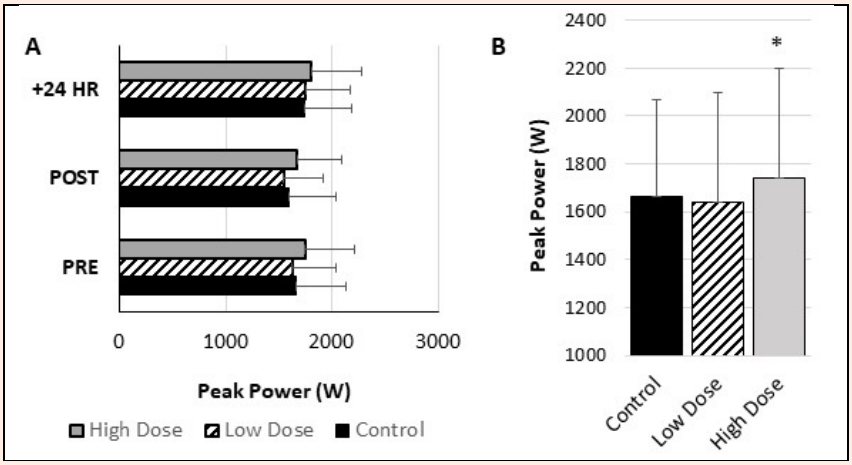

Figure 5. A) **Mean peak power (W) on ballistic jumps before and after intense resistance exercise B) Supplement effect for peak power (time-points collapsed). Data presented for Responders only (n = 13). * p < 0.05.**

using HIGH GINST15 or lowest peak power using PBO on at least 2 of the 3 time points (PRE, POST, +24 HR). Thirteen out of 19 participants were identified as responders. Statistical analysis of just the responders revealed a main treatment effect (F [2, 24] = 7.415, p = 0.003) with HIGH GINST15 supplementation resulting in greater peak power than LOW (p = 0.011, d = 0.31) and PBO (p = 0.001, d = 0.18) (Figure 5).

Discussion

This investigation yielded a number of original findings including the discovery that ginseng supplementation can effectively reduce exertion and pain following an acute bout of resistance exercise. Despite blood-based differences in HPA activation and muscle damage (Flanagan et al., 2017), males and females responded analogously to assessments of functional performance and perceived stress. Additionally, secondary analyses of the power data highlighted that ginsengs effectiveness may be masked by the appearance of responders and non-responders.

While the idea of differential response is hardly a novel concept in dietary supplementation research, to our knowledge, this is the first time responders and non-responders have been identified in the study of ginseng. Careful evaluation of individual responses suggested that the group mean may be disguising meaningful treatment effects. A common criticism of investigating individual trends is that responders and non-responders are a result of simple daily variation. This seems unlikely, however, for a number of reasons: (1) treatment allocation was randomized and counterbalanced (2) identification of responders and non-responders was based on evaluation at multiple time points, not just a single measurement and (3) the responders group comprised nearly 70% of the participant pool, refuting the criticism of hand selecting a marginal sample. This responder – non-responder phenomenon has been seen in other dietary supplement studies Beta-carotene (57% responders (Stahl et al., 1995), creatine supplementation (62% responders) (Greenhaff et al., 1994) and propionyl-L-carnitine supplementation (73% responders) (Bloomer et al., 2007). Review of the other experimental

variables in this study did not reveal the same pattern of response. This is not surprising given that the mediating mechanism for each variable may be different. This further highlights the importance of constructing a multifactorial investigation to reveal the full potential of an intervention.

GINST15 reduced perceived stress during anaerobic exercise. This is a novel finding, contradictory to several aerobic based investigations demonstrating no beneficial effect of ginseng supplementation on RPE (Bandyopadhyay et al., 2011; Engels and Wirth, 1997; Morris et al., 1996). Differential effects may be related to the mechanism of increase. RPE during aerobic exercise is highly correlated with heart rate, respiration, and ventilation; whereas, RPE during anaerobic exercise is largely related to the buffering capacity of skeletal muscle (Gamberale, 1972; Lagally et al., 2002; Noble and Robertson, 1996; Scherr et al., 2013). While aerobic investigations of ginseng and RPE have failed to demonstrate modifying effects on heart rate and ventilation (Bandyopadhyay et al., 2011; Engels and Wirth, 1997; Morris et al., 1996), previous work by our laboratory has demonstrated ginseng's capacity to buffer blood-based response to resistance exercise (Flanagan et al., 2017). GINST15 supplementation resulted in decreased cortisol and increased antioxidant activity immediately post-exercise with decreased creatine kinase (CK) concentrations at the 24-hour mark (Flanagan et al., 2017). The ability of GINST15 to positively modify both stress response and skeletal muscle integrity, during matched bouts of resistance exercise, likely contributed to the associated shift in perceived exertion. Owing to the fact that processing with ethanol may give estrogen-like properties this may well be part of the multivariate influence on muscle damage and soreness ratings but further study is needed to partial out this mechanism. GINST15 was not only effective in altering perception during exercise, but in recovery as well.

GINST15 significantly reduced perceived soreness at 24-hours post exercise as measured by 100-point VAS. The placebo treatment resulted in an increase of muscle soreness nearly twice the magnitude seen with ginseng supplementation. Both low and high dose treatments abated the characteristic response following intense resistance exercise. This finding is in contrast to the investigation by Pumpa et al. (2013) reporting no appreciable effect of ginseng on muscle damage or muscle soreness up to 48 hours post-exercise. The disparity in results may be attributed to dosage regimen. In addition to large differences in daily dose, the 2013 study examined the acute response to ginseng supplementation. Instead of employing a loading phase, the first ginseng treatment was provided just 1-hour prior to aerobic exercise, potentially limiting the capacity of ginseng to buffer exercise-induced muscle soreness. Perceived muscle soreness after intense-resistance exercise is attributed to sarcomere disruption and resulting inflammatory response (Proske and Morgan, 2001; Stauber et al., 1990). GINST15 has been shown to confer protective effects on oxidative damage with increases in anti-oxidant capacity and reduced CK concentrations (Flanagan et al., 2017). In addition to effects on oxidative stress (Yu et al., 2012), antioxidants have been shown to have beneficial effects on emotion, mental state, and other subjective measures (Gautam et al., 2012; Sadowska-Bartosz and Bartosz, 2014). The sources of any pain perception is related to a combination of factors from reductions in perceptual aspects in the brain to local aspects in the muscle but the occurrence is of interest to note and further studies need to drill down into the primary mechanisms. While ginseng supplementation appears to positively affect perception, performance benefits are less clear.

Upper and lower body reaction time, measured before and after resistance exercise, was not significantly altered by GINST15 supplementation. This is consistent with other investigations reporting no effect of ginseng on measures of psychomotor performance (D'Angelo et al., 1986; Ziemba et al., 1999). Ziemba et al. (1999) reported a significant treatment by time effect, with ginseng supplementation resulting in faster reaction times at rest and during aerobic exercise compared to pre-supplementation values; however, no significant differences existed between ginseng and control at any time point. These findings are similar to other ginseng investigations (Dorling et al., 1980; Forgo et al., 1981; Forgo and Schimert, 1985) in which benefits to psychomotor performance are tied to aerobic exercise. Several studies have found improvements in aerobic exercise parameters with supplementation of ginseng (Dorling et al., 1980; Forgo and Schimert, 1985; Forgo et al., 1981). The absence of significant effect in this study, may be explained by the lack of a mechanism to improve psychomotor performance following an acute bout of anaerobic activity such as heavy resistance exercise.

While multiple studies have investigated the effect of ginseng on aerobic (Bandyopadhyay et al., 2011; Chase, Kim et al., 2005; Dorling et al., 1980; Liang et al., 2005; Morris et al., 1996; Pumpa et al., 2013; Ziemba et al., 1999) and anaerobic performance (Engels et al., 2001; Cherdrungsi, 1995), there is a lack of research examining the role of ginseng on recovery from exercise stress. Jump performance is often used to assess recovery of neuromuscular function following fatiguing exercise (DuPont et al., 2017; Kraemer et al., 2001, Newham et al., 1988, Ronglan et al., 2006). While analysis of all participants together yielded no effect on peak power, secondary analysis of responders, revealed a significant effect of high dose GINST15 on maintenance of neuromuscular function. Post-exercise reduction in power is associated with a host of mediating mechanisms including CNS drive, neuromuscular propagation, excitation-contraction coupling, availability of metabolic substrates and integrity of contractile proteins (Enoka and Stuart, 1992). The means by which ginseng acts to combat muscle fatigue remains to be elucidated, however the literature points towards ginseng's adaptogenic properties including decreased susceptibility to oxidative stress as well as reduced lactate, cortisol and CK concentrations following exercise (Avakian et al., 1984; Flanagan et al., 2017; Kim et al., 1998; Ma et al., 2017; Nguyen et al., 2009; Saw et al., 2012; Seo et al., 2016).

Conclusions

In summary, this investigation revealed a two-week supplementation with GINST15 significantly improved

perceived exercise-exertion, muscular pain/soreness and neuromuscular fatigue following an acute bout of intense resistance exercise. The evolution of responders and non-responders draws into question the seemingly-mixed literature base on the ergogenic effects of ginseng, suggesting the potential of the supplement may be hidden in individual response (Bach et al., 2016, Bahrke and Morgan, 1994; 2000; Lee et al., 2016).

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Key points

- Perceived exertion during anaerobic exercise is reduced with 14-day supplementation of ginseng.
- Ginseng effectively reduces magnitude of pain/soreness increase 24 hours post resistance exercise.
- Evidence of responders and non-responders revealed ginseng may improve post-exercise muscle fatigue as evidenced by greater maintenance of neuromuscular function.

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