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Acute Effects of Wild Ginseng Extract on Exercise Performance, Cognitive Function, and Fatigue Recovery: A Randomized Cross-Over, Placebo-Controlled, and Double-Blind Study

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Abstract: Background: This study aimed to investigate the acute effects of wild ginseng extract (*Panax ginseng* C.A. Meyer) on exercise performance, cognitive function, and fatigue recovery. Methods: Twelve healthy male participants were randomly assigned to receive either wild ginseng extract (WG) or a placebo prior to exercise trials, utilizing a double-blind, placebo-controlled cross-over design. The exercise protocol included 30 min cycling exercises followed by a 10-mile time trial, during which muscular power, strength, endurance, cognitive function, and fatigue were assessed. Additionally, biomarkers such as glucose, interleukin-6 (IL-6), myoglobin, total antioxidant capacity (TAC), and cortisol were measured. Repeated measures ANOVAs were used to analyze the effects of acute WG intake on the dependent variables. Results: In the placebo condition, both peak and mean power levels significantly decreased over time ($p = 0.039$ and $p = 0.028$, respectively), whereas no such decline was observed in the WG condition ($p > 0.05$). Furthermore, average reaction time (ART) was significantly delayed over time in the placebo trial ($p = 0.005$), while ART remained stable in the WG trial ($p = 0.051$). A significant increase in TAC was observed across time in the WG trial ($p = 0.036$), but no change was found in the placebo trial ($p = 0.326$). Cortisol levels significantly decreased over time in the WG trial ($p = 0.001$), while no change was observed in the placebo trial ($p = 0.141$). No significant differences were found for other variables between the WG and placebo trials ($p > 0.05$). Conclusions: The acute supplementation with WG positively influenced exercise performance by maintaining muscular power, reducing reaction time delay, and enhancing antioxidant capacity and cortisol regulation. These findings suggest that WG may be a promising ergogenic aid for improving exercise performance and recovery. NCT06679725 (ClinicalTrials.gov).

Keywords: wild ginseng; cognitive function; exercise performance; anaerobic power

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1. Introduction

Dietary supplements are used by athletes worldwide. In the United States, the Dietary Supplement Health Education Act has defined dietary supplements as something added to the diet, mainly vitamins, minerals, amino acids, herbs or botanicals, metabolites/constituents/extracts, or a combination of any of these ingredients [1]. In the field of sports performance enhancement, the pursuit of safe and effective ergogenic aids is continually advancing. As the landscape of supplementation evolves, a notable segment of the American population tends to favor particular supplements.

Among the plethora of natural substances garnering attention, wild ginseng extract (WG) emerges as a compelling candidate. Ginseng is widely used for its promising healing and restorative properties, as well as for its possible tonic effect in traditional medicine and has recently become a popular supplement in Western Countries [2]. There are a multitude of variations among ginseng; among those, Korean ginseng is most notable for its efficacy [3,4]. To date, there have been numerous studies utilizing Korean ginseng (*P. ginseng* C.A. Meyer), attempting to establish an increase in sports performance, cognitive function, or fatigue recovery. The use of ginseng thus far has not proved much success in the realm of performance enhancement [5–12]. Conversely, notable achievements have been observed in the realms of cognitive enhancement and fatigue mitigation [13–15]. Korean WG has exhibited promising results in ameliorating psychomotor performance and mitigating the effects of chronic fatigue associated with various pathological conditions [16–18]. Korean ginseng (*P. ginseng*) is differentiated from other ginseng species, such as American ginseng (*Panax quinquefolius*) and other species, by its unique chemical composition and physiological effects [17]. It is especially recognized for its elevated levels of ginsenosides, the active compounds associated with its adaptogenic and ergogenic properties [19]. These characteristics may contribute to improved physical performance, decreased fatigue, and enhanced cognitive function more effectively than other ginseng varieties.

Some issues arise from previous studies of ginseng use as an ergonomic aid. First are the inadequate sample sizes that are utilized [9,11]. Secondly are the varying dosages that are used throughout the studies [5,10,12]. The limitations of previous investigations lie predominantly in their emphasis on chronic effects or their exclusive focus on specific domains such as endurance sports and cognitive function [8,9,13,14,20]. Consequently, there remains a notable scarcity of research delving into the acute impacts of wild ginseng extract on exercise performance, cognitive function, and fatigue recovery. Therefore, the primary objective of this study was to elucidate the acute effects of wild ginseng extract on exercise performance, cognitive function, and fatigue recovery.

2. Materials and Methods

2.1. Participants

This study was a double-blind, placebo-controlled cross-over experiment with two trials (WG and placebo). The participants were recruited from the general public at the local grocery stores (by flyer) and university students (by flyer and brief personal presentation). Twelve healthy adult males (age = 31 ± 6.86 years) were randomly assigned to either WG or placebo groups with a 2-week wash-out period. After a brief explanation of procedures, exercises, risks, and benefits associated with the study, each participant gave written consent before participation. The study was approved by the College's Institutional Review Board. It was also registered at ClinicalTrials.gov (NCT06679725). Participants completed a questionnaire before the initiation of the experiment. Any of the participants who had any health issues, injuries, metabolic, cardiovascular, pulmonary disease, or intake of medication and or herbal supplementation were excluded from the trials.

2.2. Testing Procedure

Before the test, we had a pre-familiarization that was conducted 3–5 days prior to the experiment. Participants were instructed to maintain their normal sleep, diet, and physical activity habits throughout the duration of the study. No changes to their routine were requested in order to minimize potential confounding effects on the study outcomes. During the pre-familiarization, we conducted a maximal volume of oxygen consumption

(VO_2 max) test, body composition measurements, and cognitive function tests. Body composition, body weight, height, percentage of body fat, blood pressure, and heart rate were assessed. Body weight and height were measured using a digital weight scale (HD-366, Tanita Corporation, Tokyo, Japan) and a wall stadiometer (PAT#290237, Novel Products, Madison, WI, USA), respectively. Body fat was measured by skin fold (PAT#3,008,239, Beta Technology, Santa Barbara, CA, USA). Blood pressure was measured using a blood pressure gauge (BP791IT, Omron Healthcare Co., Kyoto, Kyoto Prefectur, Japan). Heart rate was assessed by using a heart rate monitor (S120, Polar Electro Inc., Lake Success, NY, USA). After the pre-familiarization, the experiments began. A WG or placebo was given 90 min before the cycling exercise began. The 90 min window was determined based on the literature to ensure that the nutrients are sufficiently digested and available for metabolic processes during exercise [21]. The power and strength assessments were conducted at baseline (0 min), before the cycling exercise (120 min mark), immediately following the cycling exercise (150 min), and immediately after the completion of the 10-mile time trial (Figure 1). Cognitive function was evaluated before the cycling exercise (100 min mark), during the recovery phase after the cycling exercise (150–160 min mark), and during the recovery phase after the 10-mile time trial (260–280 min mark).

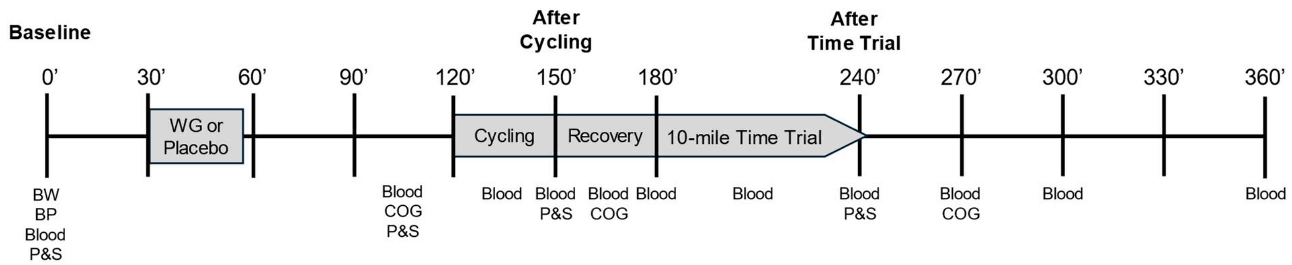

Figure 1. Testing procedure. BW: body weight, BP: blood pressure, Blood: blood collection, P&S: power and strength, COG: cognitive function test.

2.3. Supplementation

In this study, the WG and placebo were provided by the Korea Food Research Institute. The ginseng used in this study was a commercially manufactured standardized 140 mL liquid package and approved for safety. Korean WG drink contains 0.25% of Korean WG and other ingredients, while the placebo was manufactured to be identical in appearance (brown color, calorie (30.23 Kcal), taste, and content). To maintain a double-blind design, both participants and researchers involved in data collection were unaware of the treatment conditions. The supplements, which included wild ginseng extract and a placebo, were provided in identical packages, each marked with a unique identification number. The assignment of supplements was randomized by an independent researcher who had no role in the data collection process. The taste of the beverage was also very similar for both WG and placebo (based on the food survey). The placebo utilized in the study consisted of the same ingredients as the treatment drink, with the exception of 0.25% Korean WG. This was achieved by incorporating 0.25% scented ginseng and 0.06% caramel coloring (Table 1). The high-performance liquid chromatography (HPLC) analysis was conducted at SEMPIO Food and Research and Development Center, Korea (Table 2).

Table 1. Composition of test dietary supplement (WG) and placebo.

Ingredient	Ginseng Drink (%)	Placebo (%)
Korean Wild Ginseng Extract	0.25	0.00
Soy Powder	1.5	1.5
Almond Paste	1.5	1.5
Isomaltooligosaccharide	1.0	1.0
Fructooligosaccharide	0.75	0.75
Refined Salt	0.95	0.95
Scented Almond	0.05	0.05
Xanthan Gum	0.95	0.95
Sodium Bicarbonate	0.95	0.95
Soybean Extract	0.5	0.5
Water	93.15	93.15
Scented Ginseng	0.00	0.25
Caramel Coloring	0.00	0.06

Table 2. The result of high-performance liquid chromatography analysis.

Sample	Test Item/Unit		Standard Limit	Result	Method
Wild Ginseng Extract	Target ginsenoside (mg/kg)	PPT	Min. 3000	4100	HPLC (1 g per dry matter)
		PPD		4100	

PPT: protopanaxatriol type, PPD: protopanaxadiol.

2.4. Exercise Protocol

VO_2 max test: The participants were initially tested on a cycle ergometer to determine their maximal aerobic capacity (VO_2 max is an indicator) to accurately prescribe exercise intensities for endurance performance. During the VO_2 max test, the participant exercised on a cycle ergometer (894E, Monark Exercise AB, Varberg, Halland County, Sweden) with an initial work rate equal to 60 W and a pedaling rate of 60 revolutions per minute (rpm) for 2 min. Thereafter, the work rate increased by 30 W every 2 min until the participants reached exhaustion, which was determined when participants met at least 2 of the following conditions: (a) inability to keep up the pedaling rate of 60 rpm for more than 5 s with verbal encouragement, (b) respiratory exchange ratio (RER) 1.10, (c) rating of perceived exertion (RPE) $\geq$ 19 (Borg 6–20 scale), or (d) volitional fatigue. The oxygen consumption was measured using a metabolic cart (TrueOne 2400, Salt Lake City, UT, USA).

Cycling exercise: The participants performed the cycling exercise to assess endurance performance for 30 min at 70–75% of VO_2 max. The cycle ergometer utilized for the maximal aerobic test mentioned previously was employed to conduct the cycling exercise.

2.5. Exercise Performance Measurements

Power: Power was evaluated by peak (average) power test using automatic Power cycle (Powercycle, Austin, TX, USA). The participants performed a 2 min warm-up by cycling at 100 to 120 rpm with a power of 100 to 120 W. They performed four bouts of maximal acceleration for approximately 3 to 4 s on a verbal command with standardized encouragement. Data were recorded for 6.5 crank revolutions. The length of the seat height was selected by each participant.

Strength: Isometric knee extensor and flexor strength were measured by a muscle testing system (Lafayette Instrument Company, Lafayette, IN, USA). The participants sat on the table in a supine position, with the knee and hip positioned at 90 degrees. The participants were instructed to remain seated and place both hands on the table. The dynamometer force pad was placed proximal to the ankle joint, and the knee extensor strength was quantified in pound force. All participants performed two maximal trials for 3 to 5 s with a 30 s rest interval. The higher value of the two trials was normalized as a direct percentage of body weight (%BW).

Endurance performance: The participants performed the 10-mile time trial to assess endurance performance using a cycle ergometer. The cycle ergometer utilized for the maximal aerobic test mentioned previously was employed to perform the time trial cycling. The workload was standardized for each participant by setting the resistance to achieve 70% VO_2 max. Participants received standard encouragement to complete the time trial as quickly as possible, and the time to complete the 10-mile distance was recorded.

2.6. Blood Analysis

Glucose, IL-6, myoglobin, total antioxidant capacity (TAC), and cortisol were measured using about 2.5–3 mL of blood withdrawn from an antecubital vein at ten different time marks, including baseline, before and during the cycling exercise (90 and 110 min mark), right after the cycling exercise (150 min mark), during the recovery phase after the cycling exercise (150–160 min mark), and before (180 min), during (200 min) and the recovery phase after the 10-mile time trial (240–260, 300, and 360 min mark, respectively) (Figure 1). The total volume of blood withdrawn per test was less than 34 mL. Therefore, the total amount of blood withdrawn for all tests was less than 68 mL over the 60 days of the experimental period (34 mL × 2 trials = 68 mL). A trained phlebotomist used the same standardized procedure used in the doctors' offices and labs to collect blood. All blood samples were drawn into a tube containing ethylenediamine tetra-acetic acid (EDTA) to prevent coagulation. The blood was centrifuged, and the upper layer of plasma was transferred into a conical tube and stored at −20 °C. Serum was analyzed for glucose, IL-6, myoglobin, and TAC. Glucose level was analyzed using the oxidase/Trinder endpoint method (Fisher, Hampton, NH, USA). IL-6 was analyzed using the commercially available enzyme-linked immunosorbent assay (ELISA, EMD Millipore, Billerica, MA, USA). Myoglobin was analyzed by enzyme immunoassay (ELISA, Biocheck, Fremont, CA, USA). TAC was analyzed using an antioxidant assay kit (Cayman, Ann Arbor, MI, USA). Cortisol was analyzed by enzyme immunoassay (ELISA, DRG, Springfield, NJ, USA). All measurements were performed in duplicate.

2.7. Cognitive Performance

To assess cognitive function, psychomotor vigilance task (PVT) and delayed-match-to-sample task (DMS) were taken before and after each exercise. The PVT test was composed of 40 trials for 5 min to assess average reaction time. The DMS was taken over 20 min with 20 trials to assess memory. The PVT and DMS were implemented with a program called the Psychology Experiment Building Language (PEBL), an open-source programming language that can be run on any Windows computer [22].

2.8. Fatigue

Fatigue rates were measured utilizing a rate of perceived exertion (RPE), scale of muscle soreness, and a fatigue questionnaire that was provided.

2.9. Dietary Log

All Participants were asked to record their food intake on a dietary log to control the effects of dietary intake. Before the real trial, participants were asked to recall their last 3 days of food intake. Diet records were assessed using a nutritional analysis program (DietPower 3.0, Tucson, AZ, USA).

2.10. Statistical Analysis

Repeated measures ANOVAs were used to examine the effect of acute intake of ginseng-dependent variables by WG and placebo trials. The Greenhouse–Geisser (G-G) adjustment was applied to the F-statistic and degrees of freedom in the repeated measures ANOVA to correct for violations of the sphericity assumption, thereby providing more accurate and reliable statistical inferences. The alpha level was set at 0.05 [23].

3. Results

3.1. Participant Characteristics

Twelve healthy adult males (age, 31 ± 6.86 years; height, 164.9 ± 32.97 cm; weight, 92.48 ± 25.01 kg; systolic blood pressure, 128.67 ± 7.10 mmHg; diastolic blood pressure 76.92 ± 8.33 mmHg; heart rate, 69.92 ± 13.77 beats/min; body fat percentage, 13.10 ± 4.99%; and VO_2 max, 33.38 ± 6.54 mL/kg/minute) participated in this study (Table 3).

Table 3. Characteristics of the participants.

Variable	**Mean (SD)**
Age (years)	31 ± 6.6
Height (cm)	164.99 ± 32.97
Body Weight (kg)	92.48 ± 25.01
Body Mass Index (kg/m^2)	34.39 ± 6.12
Systolic Blood Pressure (mmHg)	128.67 ± 7.10
Diastolic Blood Pressure (mmHg)	76.92 ± 8.33
Heart Rate (beats/minute)	69.92 ± 13.77
Percentage Body Fat (%)	13.10 ± 4.99
VO_2 max (mL/kg/min)	33.38 ± 6.54

3.2. Power

In the placebo trial, peak power and mean power were significantly decreased across time, F (1.47, 13.24) = 4.63, G-G p = 0.039, and F (1.46, 13.13) = 5.31, G-G p = 0.028, while no differences were found in the WG trial (G-G p = 0.166 and 0.162, respectively).

The peak power level was significantly decreased across time ($p < 0.05$) at baseline, after cycling, and after the time trial (13.14 ± 1.83, 12.99 ± 2.30, 12.23 ± 2.13, respectively). The mean power level also showed a similar trend at three different time points (12.98 ± 1.88, 12.80 ± 2.35, 12.01 ± 2.15), while no differences were found in the WG trial (Figure 2).

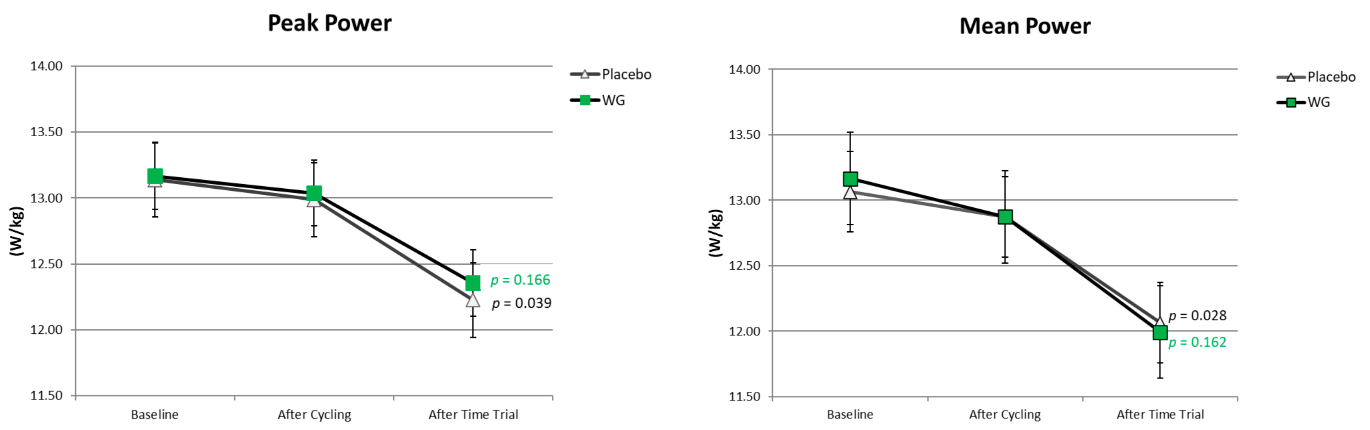

Figure 2. The results of the average peak power and mean power (watt/kg) at different time points. WG: wild ginseng extract. $p < 0.05$ is considered statistically significant.

3.3. Average Reaction Time

In the placebo trial, average reaction time (ART) was significantly delayed across time, F (1.29, 11.63) = 10.81, G-G $p = 0.005$, but in the WG trial, no difference in ART was found across time (G-G $p = 0.051$). In the placebo trial, reaction time measured by the PVT test was significantly increased across time ($p < 0.05$) at baseline, after cycling, and after the time trial (328.05 ± 24.63, 338.82 ± 29.51, 353.05 ± 29.66, respectively), but in the WG trial, no difference in average reaction time was found across time (Figure 3).

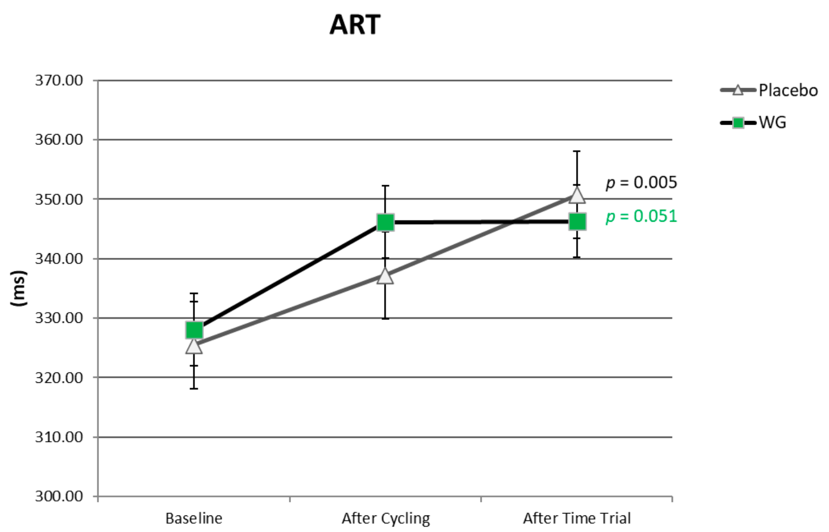

Figure 3. The results of the average reaction time at different time (ART) points. WG: wild ginseng extract. $p < 0.05$ is considered statistically significant.

3.4. TAC

There was a significant increase in TAC across time in the WG trial, F (1.42, 11.35) = 5.06, G-G $p = 0.036$, while no difference was found in the placebo trial (G-G $p = 0.326$). There was a significant increase in TAC across time in the WG trial ($p < 0.05$) at baseline, after cycling, and after the time trial (1.10 ± 0.50, 1.79 ± 0.85, 1.84 ± 0.75, respectively); no difference was found in the placebo trial (Figure 4).

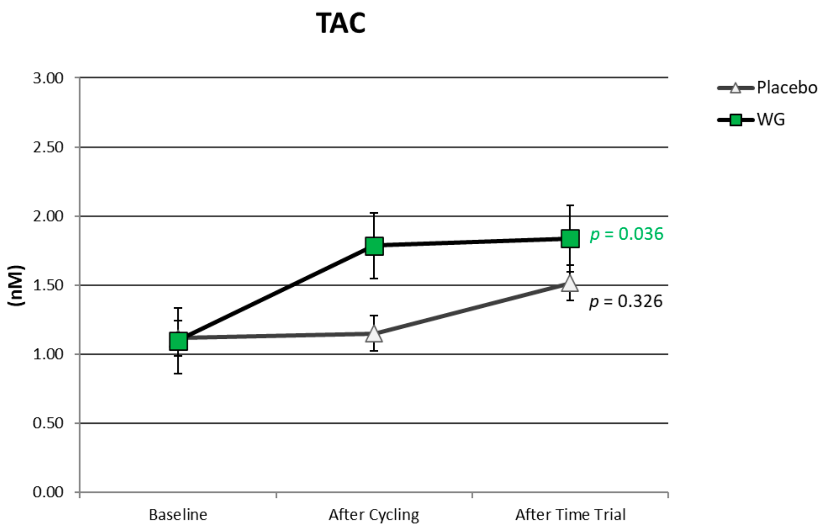

Figure 4. The results of the total antioxidant capacity (TAC) at different time points. WG: wild ginseng extract. $p < 0.05$ is considered statistically significant.

3.5. Cortisol

There was a significant decrease in cortisol level across time in the WG trial, F (1.83, 14.64) = 11.21, G-G $p = 0.001$, while no difference was found in the placebo trial (G-G $p = 0.141$). A significant decrease was observed across four time points in the WG trial: right after the time trial, after 30 min, 60 min, and 120 min (155.85 ± 78.54, 177.03 ± 72.80, 131.37 ± 58.96, and 89.71 ± 38.86, respectively), while no difference was found in the placebo trial (Figure 5).

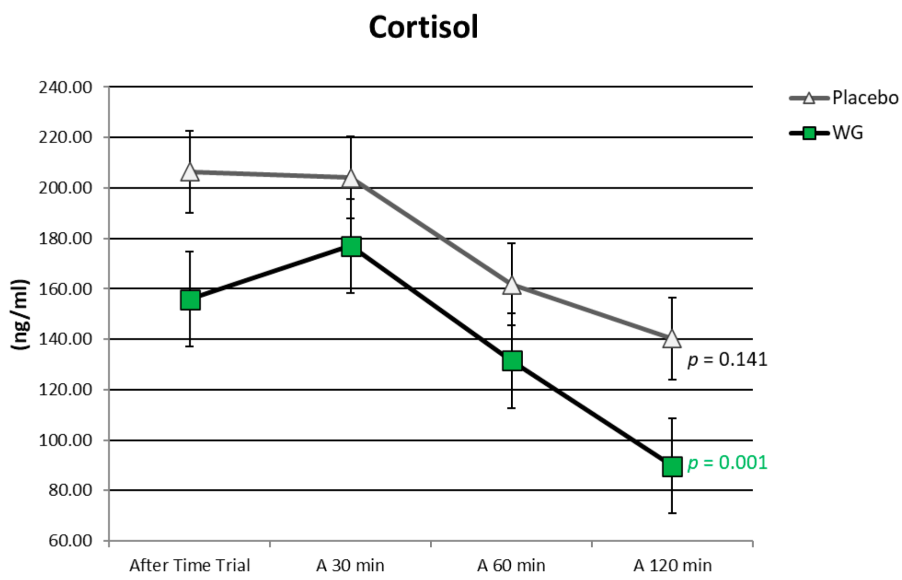

Figure 5. The results of cortisol levels at different time points. WG: wild ginseng extract. $p < 0.05$ is considered statistically significant. No significant differences were observed in all other variables from WG and placebo trials (G-G $ps > 0.05$).

4. Discussion

The present study aimed to elucidate the acute effects of wild ginseng extract (WG) on exercise performance, cognitive function, and fatigue recovery in healthy adult males. The findings indicate that WG had a positive impact on certain performance metrics, cognitive function, antioxidant capacity, and cortisol, suggesting its potential as an effective ergogenic aid.

The significant maintenance of peak and mean power levels in the WG trial compared to the placebo trial underscores the potential of WG in enhancing muscular power during acute physical exertion. This is particularly noteworthy given the decrease in these metrics observed in the placebo group [24–26]. Our results suggest that WG can acutely sustain performance levels, which may be beneficial for athletes requiring consistent power output during competitions or intensive training sessions.

The lack of significant delay in average reaction time (ART) across the WG trial contrasted with the significant delays observed in the placebo trial, highlighting the cognitive benefits of acute WG intake. Previous research has demonstrated the cognitive-enhancing effects of ginseng, particularly in terms of psychomotor performance and memory enhancement [13,14,20]. Our study extends these findings to an acute context, suggesting that even acute WG supplementation can mitigate cognitive fatigue and maintain reaction times during extended physical activities.

The significant increase in total antioxidant capacity (TAC) observed in the WG trial, but not in the placebo trial, supports the notion that ginseng possesses potent antioxidant properties. This is consistent with prior studies that have highlighted ginseng's role in reducing oxidative stress and improving antioxidant defenses [27]. Antioxidants play a crucial role in mitigating oxidative stress induced by exercise, which can enhance recovery and potentially improve overall sports performance [28,29]. Intense physical activity increases the production of reactive oxygen species (ROS), leading to oxidative damage to cells and tissues. The antioxidant capacity may help neutralize these ROS, reduce muscle fatigue, and prevent exercise-induced muscle damage, which can aid in maintaining performance over time [28,29]. Therefore, the acute rise in TAC observed in our study suggests that WG can promptly enhance the body's antioxidant capacity, which may help mitigate exercise-induced oxidative damage and improve recovery times.

The present study also observed a significant decrease in cortisol levels following wild ginseng extract (WG) compared to the placebo. This reduction in cortisol is noteworthy, given cortisol's role as a biomarker for stress and its catabolic effects on muscle tissue [30]. Lower cortisol levels suggest that WG may mitigate the physiological stress response associated with intense exercise, thereby enhancing recovery and preserving muscle mass. This finding is particularly important as it indicates that WG not only supports physical and cognitive performance but also promotes a more favorable hormonal environment during and after exercise. Such an effect could contribute to reduced muscle breakdown, faster recovery times, and improved overall athletic performance. Cortisol, a key stress hormone, plays a complex role in modulating cognitive function. Acute increases in cortisol during stress or exercise can temporarily enhance certain cognitive processes by facilitating arousal and alertness. However, chronic or prolonged elevation of cortisol can impair cognitive function [30]. The present study suggests a potential interaction whereby the acute decrease in cortisol levels induced by wild ginseng (WG) supplementation may help mitigate cognitive fatigue and maintain reaction times during prolonged physical activity. By reducing the impact of elevated cortisol, which is typically associated with cognitive fatigue, WG supplementation could support sustained cognitive performance. Future research should further explore the mechanisms by which WG influences cortisol levels and the long-term implications of this hormonal modulation on athletic health and performance.

Ginsenosides, the active compounds in *P. ginseng*, are believed to exert their effects through multiple mechanisms, including modulation of the central nervous system, anti-inflammatory properties, and antioxidant actions, which may enhance cognitive function, mood, and fatigue resistance [31]. Additionally, ginsenosides are known to reduce oxidative stress and inflammation, which can help mitigate exercise-induced muscle damage and support recovery [32]. These combined effects suggest that ginsenosides may improve physical and cognitive performance, particularly in stressful or prolonged conditions.

The findings of this study have several practical implications for athletes and individuals seeking to improve exercise performance and cognitive function. The ability of WG to maintain power output and cognitive performance during acute physical exertion suggests that it could be strategically used before competitions or demanding training sessions to enhance performance and delay fatigue. Additionally, the antioxidant benefits of WG could aid in faster recovery post-exercise, potentially reducing the risk of injury and improving overall training outcomes.

Despite the promising findings, this study has several limitations that warrant consideration. One limitation of the present study was the relatively small sample size (n = 12). This is primarily due to the highly invasive nature of the study design, which involved repeated measurements over an extended testing period (over 6 h). Given the complexity and demands of the protocol, including the participant burden and the necessity for precise data collection, it was challenging to recruit a larger sample while maintaining the integrity of the study design. Also, the study focused exclusively on healthy adult males, which may limit the generalizability of the results to other populations, such as females, older adults, or individuals with health conditions. Future research should aim to include larger and more diverse sample populations to validate and extend these findings.

Additionally, while this study focused on the acute effects of WG, further research is needed to investigate the long-term effects of regular wild ginseng extract on exercise performance, cognitive function, and recovery. Understanding the optimal dosing regimens and the potential interactions with other supplements or medications would also be valuable for developing comprehensive supplementation strategies.

5. Conclusions

WG exhibited positive effects on muscular power, reaction time, antioxidant capacity, and cortisol, suggesting its potential as an ergogenic aid. This study contributes to filling the gap in research on the acute effects of WG on exercise performance, highlighting its promising prospects in sports science.

Author Contributions: Conceptualization, S.L.; methodology, S.L.; investigation, S.L. and H.C.J.; data curation, M.K.; writing—original draft preparation, S.L. and M.S.; writing—review and editing, S.L., M.K. and H.C.J.; supervision, S.L.; funding acquisition, S.L. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of Texas A&M University-San Antonio (2025-50, 20 March 2015).

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The data are available for non-commercial research purposes after this publication upon reasonable request. A request to share data can be addressed to the principal investigator.

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Conflicts of Interest: The authors declare no conflict of interest.

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