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Article

A Study on the Effectiveness of Glycerophosphocholine (α-GPC) as an e-Sports Supplement

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Abstract
This study examined the effects of oral intake of Glycerophosphocholine (α-GPC) on stress response and cognitive function in e-sports. α-GPC is a precursor of acetylcholine and is sometimes used to treat Alzheimer's disease and other dementias, but its potential effects in e-sports have not been investigated. In this study, 21 participants from university e-sports clubs and other groups were given α-GPC for 2 weeks. We measured their stress responses induced by e-sports and their performance in cognitive tasks. The results showed that the placebo increased the rate of increase in salivary amylase after e-sports, but α-GPC significantly decreased this increase. It also suppressed the increase in heart rate after e-sports. Furthermore, 1g of α-GPC significantly increased the rate of correct responses in a 3-back task, a cognitive task involving working memory, after ingestion. These results suggest that 2-week intake of α-GPC may enhance cognitive function and contribute to stress reduction and suppression of autonomic nervous system disturbances caused by e-sports. Further study is needed to determine the minimum effective intake period of the supplement.

Keywords: Glycerophosphocholine; Stress response; e-sports play; Working memory

1. Introduction

Glycerophosphocholine (α-GPC) is a deacylated water-soluble compound of phosphatidylcholine, a precursor of acetylcholine. In clinical trials, it improved cognitive function in patients with Alzheimer's disease (De Jesus Moreno Moreno, 2003; Parnetti et al., 1993) and vascular dementia (Parnetti et al., 2001). In healthy adults, effects on growth hormone secretion (Kawamura et al., 2012), motivation (Tamura et al., 2021), and exercise performance (Marcus et al., 2017) have been reported, but the effects on cognitive function and concentration in healthy adults remain unclear.

In recent years, e-sports has attracted attention around the world, and with the remarkable growth of the e-sports market, the population of e-sports players and fans has also increased. E-sports has been adopted as an official event for the 2022 Asian Games, and the International Olympic Committee (IOC) has decided to establish a new e-sports competition in 2025.

The mental component is critical for good sports performance (Himmelstein et al., 2017). E-sports athletes must cope with competition-specific mental stress, and there is concern that the potential mental stress experienced during prolonged and repetitive gameplay may increase the risk of chronic stress (Ballesteros et al., 2017). These considerations suggest that e-sports athletes must cope appropriately with stress. Thus, the demand for performance improvement and mental care for e-sports players is increasing, and there have been numerous reports of the effects of supplement intake on e-sports play.

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The effects of caffeine and glucose on the performance of e-sports players have been investigated primarily. According to those reports, caffeine improved shooting game performance in e-sports players and elite e-sports players (Sainz et al., 2020; Wu et al., 2024), and glucose increased SMR wave power percentage during racing games in people who do not normally play games (Furukado et al., 2022). Glucose also significantly shortened the completion time of a cognitive task, the Trail Making Test A (TMT-A) (Furukado et al., 2022). This suggests that glucose improves attention, which is one of the cognitive skills. On the other hand, whether α-GPC is useful as an e-sports supplement and the effects of α-GPC on e-sports play and cognitive tasks have not been reported.

Therefore, the purpose of this study is to investigate how the effects of e-sports gameplay on the stress response and cognitive performance change when α-GPC is ingested for two weeks.

2. Methods

2.1 Participants

Participants were 20 male and 1 female students (mean age = 20.0 years; SD = 1.2 years) who played e-sports on a daily basis, such as belonging to a university e-sports club or e-sports college. The study was approved by the Kyushu Institute of Technology Human Experimentation Committee (Approval #21-12). Participants were informed about the content of the experiment and, if they agreed, were asked to submit a participant consent form before participating in the experiment.

The study was conducted as a placebo-controlled, double-blind, parallel-comparison study using three supplements, two with different α-GPC content and a placebo. Twenty-one participants were randomly assigned to two different e-sports games (League of Legends and Valorant), as described below. Seven of the twenty-one participants were assigned to the supplement 1 group (containing 1g α-GPC), seven to the supplement 2 group (containing 0.600 g α-GPC), and seven to the supplement 3 group (placebo). However, one of the participants in the supplement 3 group was absent from the post-experiment and was excluded from the data.

The League of Legends and Valorant e-sports games were assigned to the participants.

League of Legends

Eleven of the participants played League of Legends, the most typical Multiplayer Online Battle Arena game in e-sports, where each match usually lasted approximately 30 minutes and was played with five players.

Valorant

Ten participants played Valorant, the most typical competitive first-person shooter game in e-sports. Each match usually lasted 40-50 minutes and was played in the common bomb mode (blasting mode). The game is played in a 5-player format, with the players divided into attackers and defenders. The attackers aim to blow up one of the 2-3 targets on the map, while the defenders attempt to stop them.

2.2 Test procedure

Salivary amylase measurements, heart rate measurements, and cognitive tasks were performed before (pre) and after (post) consumption of the supplement for 2 weeks. During the pre- and post-measures, participants were asked to play the e-sports game they played during the supplement intake, and salivary amylase measurements and cognitive tasks were performed before and after the play. To ensure that the pre/post e-sports playing conditions were the same among the participants, they were asked to play their assigned e-sports game every day for 2 weeks after consumption of the supplement. The e-sports game played pre/post was the same title as the assigned e-sports game. The supplement was ingested once a day, approximately 1 hour before playing the e-sports game. The supplements were either swallowed directly or consumed with a glass of water. The participants were also asked to report daily online whether or not they had consumed the supplement. Other than the supplement, participants were prohibited from drinking alcohol on the day before the measurement day and from consuming caffeine on the day of the measurement. The rest of the supplements were optional.

2.3 About Supplements 1-3

The ingredients of the three 2g supplements are shown in Table 1. The three supplement powders were all sweetened and dissolved in the mouth so that they could not be distinguished just by eating them. Supplements 1 and 2 contained 1g and 0.6g of α-GPC, respectively. α-GPC was made from NICHIYU® GPC85R powder. NICHIYU® GPC85R powder contains 85% α-GPC.

Table 1. Ingredients of supplements

Test Supplements	Powder including 85% α-GPC (g)	Erythritol (g)	Processed oils and fats (g)	SiO_2 (g)
Supplement1 incl. 1 g α-GPC	1.177	0.819	0	0.004
Supplement2 incl. 0.6 g α-GPC	0.706	1.29	0.071	0.004
Supplement3 Placebo	0	1.996	0.176	0.004

2.4 Physiological indicator

2.4.1 Salivary amylase measurement

Salivary amylase was measured as a stress marker. A saliva amylase monitor (NIPRO, Japan, model number: 23-2826-02) was used for the measurement. The participants were asked to gargle before the measurement to ensure that the oral environment was the same, and then they were asked to hold the sensor tip under their tongue for 30 seconds to collect saliva. The tip was then placed in the monitor to measure the amylase values. The measurement was taken a total of four times, before and after e-sports play at pre/post periods.

2.4.2 Heart rate measurement

Heart rate was measured using an accelerometer pulse wave measurement device (YKC Co., Ltd., model number: TAS9VIEW). The measurement was taken a total of four times, before and after e-sports play at pre/post period.

2.5 *Participantive evaluation of stress*

Before and after e-sports play at pre/post periods, participants were asked to rate how stressed they felt on a 5-point Likert scale.

2.6 Cognitive task

We conducted the N (N = 1, 2, 3) back task as a measure of working memory in the brain. The task was conducted using a tablet (NEC Corporation, Japan, model number: LAVIE Tab E 10FHD1, OS: Android 9, CPU: Qualcomm Snapdragon 450) with a touch panel. The task program was developed using Unity var2019.3.13f1. The measurement was conducted four times in total, before and after gameplay at the pre/post periods.

In the N-back task, two symbol pairs were displayed on the screen for 5 seconds one screen at a time, and the participants were asked to remember the symbols and compare them with the symbol pairs displayed on the Nth previous screen. They tapped the symbol if a different symbol appeared in one of the symbol pairs on the screen. If the two symbols were the same, they tapped the “same” button at the bottom. This was repeated 20 times, and the correct response rate and reaction time were measured. This task requires working memory because participants have to remember the pair of symbols for the continuous N screens.

2.7 Experimental protocol

The experiment took around 3 hours per person in total. For the pre/post measurement, salivary amylase was measured for two minutes, followed by heart rate measurement using TAS9VIEW for 3 minutes, and finally, the 1, 2, and 3-back tasks were performed in a pseudo-random order. Each N-back task was practiced once before the measurement. After that, participants played e-sports for about two hours. Participants played their assigned game of League of Legends or Valorant on net-connected PCs provided on the spot; the five teammates were decided on the spot or on the Internet and played the game. Approximately 20 min before the end of the session, they were asked not to begin the next game and to play the last game at that time. If a play ended at that time, no further games were allowed. After playing e-sports, salivary amylase, heart rate, and N-back tasks were again measured. In other words, measurements were taken a total of four times, before and after playing e-sports at pre/post periods.

2.8 Statistical analysis

In order to eliminate individual differences, the rate of increase in the measured values before and after e-sports play was defined as follows for each pre/post period: (Rate of increase in measured values) = ((the value after e-sports play) - (the value before e-sports play)) / (the value before e-sports play)) Unless otherwise specified, the pre-data mean and variance were used to perform z-transformation, and the normalized rate of increase before and after e-sports was calculated for each supplement. The pre- and post-data were compared and evaluated. JASP (https://jasp-stats.org/) was used for statistical analysis, and a paired t-test was performed. The significance level was set at $p<0.05$, and the marginal significance level was set at $p<0.1$.

3. Results

All participants in the experiment consumed the supplement every day.

3.1 Effect of supplement on increased salivary amylase

At the pre- and post-periods, amylase levels increased after e-sports play. The rate of increase after e-sports play was compared for the three supplements (Figure 1). The rate was normalized by the before-e-sports value. The rates increased for supplements 1 and 2 but decreased for supplement 3. However, there was no significant difference between them ($p = 0.24$; one-way ANOVA). The rate of increase in salivary amylase was calculated for the pre- and post-periods, and the results after normalization with z-transformation are shown in Figure 2. In supplement 3 (placebo), the rate of increase in amylase after e-sports play increased at the post period, but in supplements 1 and 2, this increase was suppressed. In supplement 1, there was a slight decrease at the post period. Notably, there was a significant difference between the amylase increase rates of supplements 1 and 3 at the post period (supplement 1: post 0.51 ± 0.16 (mean ± standard mean error (s.e.m.)), supplement 3: post 1.85 ± 1.50, $p = 0.005$; two-way ANOVA followed by Tukey test as a post-hoc test). The same results were obtained between the two e-sports games, with no significant difference between them. From the above, it is clear that stress increases due to e-sports play, but this effect can be significantly suppressed by consuming supplements 1 and 2 for two weeks, especially supplement 1.

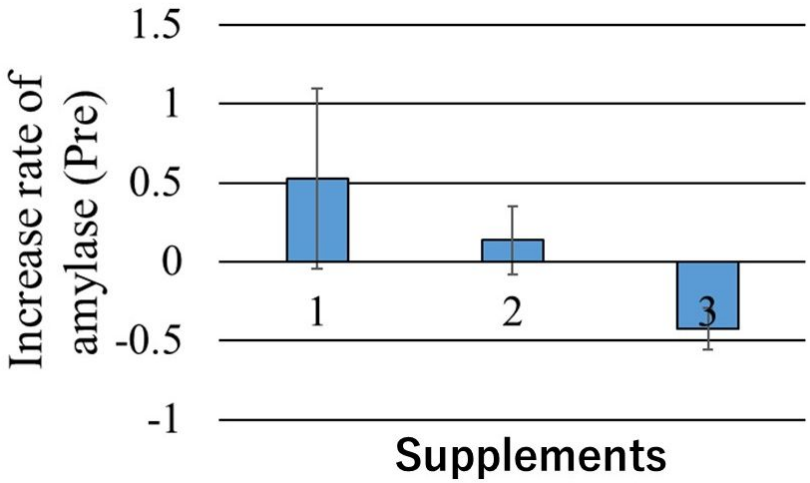

Figure 1. Rate of increase in amylase before and after playing e-sports at the pre period. A positive value indicates that amylase increases after e-sports play.

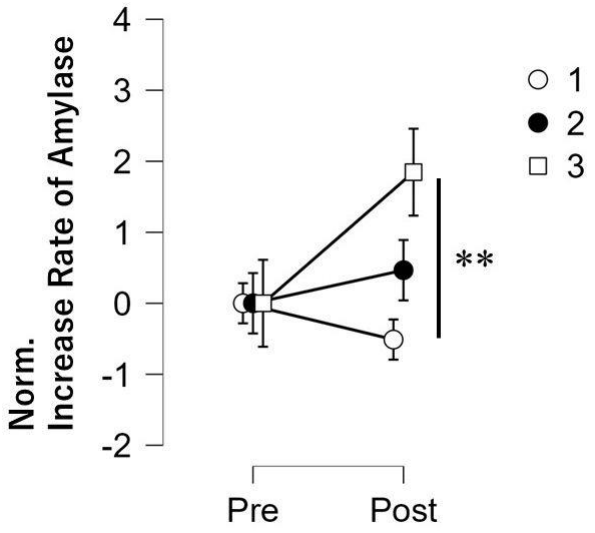

Figure 2. Increase rate of amylase after e-sports play at the pre/post period with the intake of three types of supplement.

3.2 Effect of supplement on heart rate increase

Heart rate increased after e-sports play. When the rate of increase in heart rate after the play was measured, it was found that it increased with supplements 2 and 3 but decreased with supplement 1 (Figure 3). Although this result was not significant, since heart rate increases due to the stress response (Jouven et al., 2009), it is consistent with the result of Figure 2, which shows that supplement 1 suppresses the stress response.

3.3 *Effect of supplements on participantive stress scale*

The participantive stress scale was 1.71 ± 0.36, 2.00 ± 1.16, and 2.33 ± 0.52 for supplements 1, 2, and 3, respectively, in the pre period, and there was no significant difference among them. In the post period, only supplement 3 increased the stress scale (Figure 4). There was a significant interaction for this change (*p = 0.046).

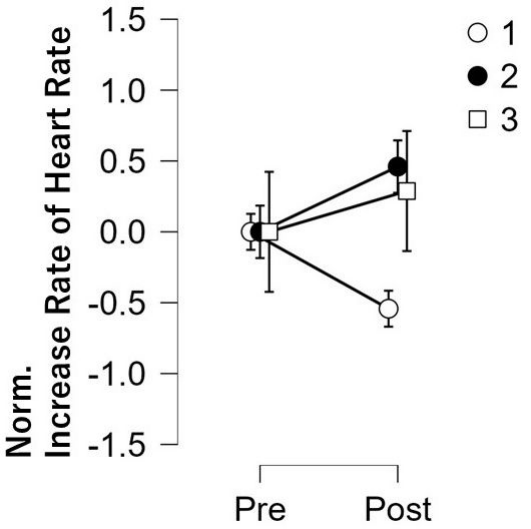

Figure 3. Heart rate (HR) increase for three types of supplement after e-sports play at the pre/post period.

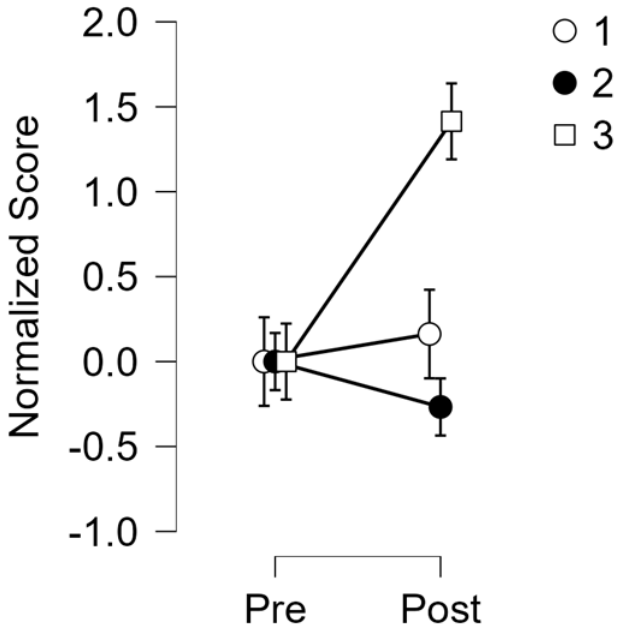

Figure 4. Participantive stress scale after playing e-sports with three types of supplement

3.4 Effect of supplement on cognitive task performance

There were no significant changes in the correct response rate or reaction time for all N (N = 1, 2, 3) back tasks before and after e-sports play at the pre- and post-periods. There was no significant difference in the correct response rate

for the one- and two-back tasks or in the reaction time for all tasks. The results of the correct response rate for the three-back task by intake of the three supplements are shown in Figure 5.

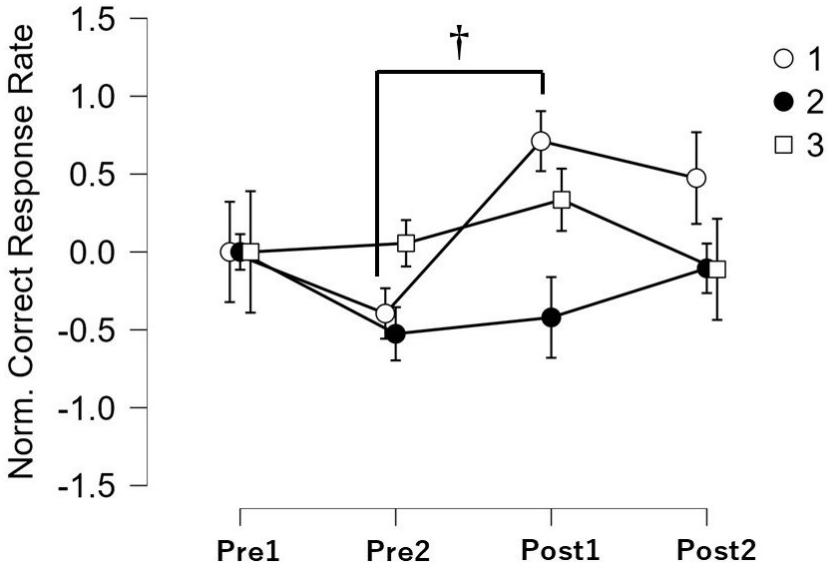

Figure 5. Effects on the correct response rate in the three-back task for the three types of supplements.

"Pre1," "Pre2," "Post1," and "Post2" indicate the time points before and after e-sports play in the pre-period and post-period, respectively. There was a marginally significant increase in the correct response rate in the three-back task at Post1 compared to Pre2 with the intake of supplement 1 (†p = 0.073; post-hoc Bonferroni test).

The results were normalized using the Pre1 values, i.e. the correct response rate before e-sports play in the pre-period. There was no significant difference in the rates between Pre1 and Pre2 and between Post1 and Post2 for any supplement. There was only a marginally significant increase in the correct response rate at Post1 compared with that at Pre2 with the intake of supplement 1, as shown in Figure 5 (†p = 0.073; the post-hoc Bonferroni test). The rate of supplement 1 intake in Post1 was not significantly different from that in Pre1. The rates for supplements 2 and 3 at Post1 did not differ significantly from those at Pre1 either.

4. Discussion

The results of a 2-week intake of α-GPC, an e-sports supplement, showed that the intake suppressed the stress response as measured by salivary amylase and heart rate, and significantly increased the percentage of correct responses in a 3-back task. The results also showed that 1g of α-GPC was particularly effective.

In both pre/post periods, amylase elevation occurred after e-sports play (Figure 2). In supplements 1 and 2, the rate of post-amylase elevation was reduced compared to supplement 3 (Figure 2). In particular, it was significantly smaller in supplement 1 (Figure 2). These results suggest that supplements 1 and 2 suppress the e-sports stress response after two weeks of consumption. Notably, the suppression was significant in the case of supplement 1.

Heart rate increased before and after e-sports play. However, when the rate of increase was measured pre/post, it increased at the post period for supplement 3 but decreased at the post period compared to the pre period for supplement 1 (Figure 3). Although this result was not significant, as with the aforementioned amylase results, supplement 1 may have an inhibitory effect on the stress response. Since stress can cause disturbances in the autonomic nervous system, supplement 1 may also reduce autonomic disturbances. The results of the pre/post comparison of the participantive stress scale also support the aforementioned findings, as it increased in supplement 3 but did not change in supplements 1 and 2 (Figure 4).

The correct response rates in the three-back task, a cognitive task involving working memory, showed no significant differences between Pre1 and Pre2 or between Post1 and Post2 for all supplements (Figure 5). At these intervals between Pre1 and Pre2 or between Post1 and Post2, they played e-sports for 2 hours. Thus, playing e-sports for 2 hours may not affect the correct response rate in the three-back task. If some supplement has an enhancing effect on the rate and e-sports for 2 hours has no effect on the rate, there should be a significant difference in the rate between Pre1 and Post1, as well as between Pre2 and Post1. Figure 5 shows that the consumption of supplement 1 for two

weeks significantly increased the correct response rate in the three-back task at Post1 compared with that at Pre2, but that of supplements 2 and 3 did not (Figure 5). However, there was no significant increase in the rate between Pre1 and Post1 for supplement 1. Thus, these results suggest that consuming supplement 1 for two weeks may improve the working memory capacity. Working memory has been shown to be associated with e-sports play (Blacker et al., 2014; Toril et al., 2014; Waris et al., 2019). Two weeks of α-GPC consumption improved working memory capacity, resulting in e-sports play at the post period may have been successful and attenuate the induction of the stress response. These findings suggest that two weeks of e-sports supplementation (α-GPC) may reduce stress induced by e-sports by improving brain working memory.

Caffeine improves shooting performance in e-sports players and elite e-sports players (Sainz et al., 2020; Wu et al., 2024). It has also been shown that performance on cognitive tasks improves when participants consume supplements high in glucose (Gold et al., 1986; Kennedy & Scholey, 2000; Sunram-Lea et al., 2001). In particular, consumption of glucose ramune significantly shortened the completion time of the TMT-A test (Furukado et al., 2022); since the TMT-A test requires sustained attention, the effect of glucose ramune on the brain is believed to have improved sustained attention function. Caffeine and glucose are absorbed directly into the bloodstream and are thought to reach and act on the brain via the bloodstream. The α-GPC used in this study is a precursor of acetylcholine. In the brain, acetylcholine is released from cholinergic nerves in the basal forebrain and acts in the frontal area. Acetylcholine regulates working memory and attention functions in the frontal lobes (Eckart et al., 2016). Since the frontal lobes are involved in working memory function (Cristofori et al., 2019), two weeks of 1g α-GPC intake may have caused the supplement substance itself, its metabolite acetylcholine, or other metabolites to act on the frontal lobe nerves and affect working memory function.

In the future, we aim to clarify more detailed information on the effectiveness of α-GPC at different levels of players and whether it is effective after a single intake.

5. Conclusions

The results suggest that a 2-week intake of a supplement containing α-GPC suppressed the stress response to e-sports. In particular, the intake of 1g α-GPC may improve the working memory function of the brain. In the future, it is necessary to examine the minimum duration of α-GPC intake and whether a single intake of α-GPC is effective in suppressing stress response and improving working memory.

Author Contributions

Conceptualization, Y.K. and H.I.; methodology, Y.S. and K.N.; software, K.N.; validation, Y.S. and K.N.; formal analysis, Y.S. and K.N.; investigation, Y.S. and K.N.; resources, Y.K.; data curation, Y.S.; writing—original draft preparation, H.I. and K.N.; writing—review and editing, Y.K., Y.S., H.I., and K.N.; supervision, H.I.; project administration, Y.K. and H.I.; funding acquisition, Y.K. 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 according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Kyushu Institute of Technology (protocol code #21-12).

Informed Consent Statement

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

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Conflicts of Interest

The authors declare no conflict of interest.

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