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Article

The Effects of Positive and Negative Ions on esports Performance and Arousal Levels Part 2 -Testing Higher Ion Density-

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Abstract
The purpose of this study was to investigate the psychological effects of higher positive and negative ion conditions on the arousal levels of esports players during a racing game. Participants (10 males) from a collegiate esports team were the participants in the study. The effects of higher concentrations of positive and negative ions were evaluated in a randomized crossover. Each participant performed two experiments four weeks apart; two experimental environments were used: positive and negative ions filling the atmosphere (PNI) condition and a control (CON) condition. A car racing game was employed as the performance task. Arousal was measured by the two-dimensional mood scale (TDMS) and electroencephalogram (EEG). EEG was used to measure arousal. The results showed that the level of arousal in the subjective assessment and the level of arousal in the EEG were significantly higher in the CON condition for PNI. In addition, PNI performed significantly better on the game task than in the CON condition.
The present study demonstrated in positive and negative ion environments with higher concentrations than in the previous study, and the results showed higher arousal levels in subjective assessments, indicating that higher concentrations of ionic environments are beneficial for esports players.

Keywords: esports, training environment, performance, athletes, ions

1. Introduction

Successful esports athletes require psychological or cognitive skills rather than the physical skills on which athletes in traditional sports depend (Himmelstein et al., 2017) Therefore, it is important for esports athletes to train in cognitive skills and psychological skills and cognitive function. Research on training methods and environments for this purpose is also considered necessary in esports competitions. However, currently there are no established esports training methods in the field of sports science, and further research is needed. In addition to the establishment of training methods, the training environment is also important in the field of sports science. Therefore, it is necessary to study the training environment related to esports in the field of sports science.

Incidentally, an air ion is a naturally existing tiny particle, a positively or negatively charged molecule or atom in the air (Jiang & Ma, 2018). Positively charged ions are positive ions, and negatively charged ions are defined as negative ions (Yamamoto et al., 2015). Air ions, including positive and negative ions, also have certain functions such as purifying the atmosphere and deodorizing the air (Nishikawa, 2013). Some research has also been conducted on the relationship between air ions and emotions (Flory et al., 2010; Perez et al.) For example, a high-density negative ion environment was found to reduce depression. In addition, several studies have examined the relationship between

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negative ions and depression (Goel & Etwaroo, 2006; Terman & Terman, 2006; Terman et al., 1998), lower stress (Malik et al., 2010), and increased happiness (Lips et al., 1987). There are also several studies suggested that a relationship exists between positive ions environments and human emotions (Perez et al., 2013). For example, Gianinni et al. (1986) investigated the correlation between positive air ions and emotions. The results indicated that anxiety and excitement were significantly increased under these conditions. They also examined the relationship between positive ions and discomfort, irritation, and anxiety (Giannini et al., 1986; Charry & Hawkinshire, 1981). Thus, although the results of the studies are variable, there is a relationship between the environment and emotions that trigger ions.

Furthermore, negative and positive ions exist simultaneously in the natural air (Terasawa, 2002), and the effect on human biological functions when positive and negative ions are generated at the same time has also been investigated. Hagiwara et al (2021) examined the relationship between gameplay and air ions by examining the relationship between game performance and subjective and objective arousal levels in positive and negative ion environments and in controlled environments in 10 university students, The results indicated that game performance levels were higher in the positive and negative environments, as were levels of subjective and objective arousal, compared to the control environment. However, it is difficult to suggest an association with air ions based on their study alone, and as mentioned earlier, air ion research is highly skeptical and difficult to prove. Therefore, the purpose of this study was to examine arousal levels and performance in gameplay in an environment with increased concentrations of positive and negative ions, replicating the protocol employed by Hagiwara et al. (2021).

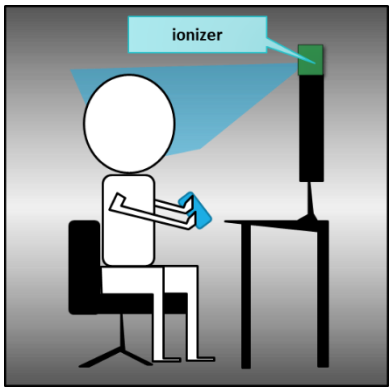

Fig.1 Position of ion exposure

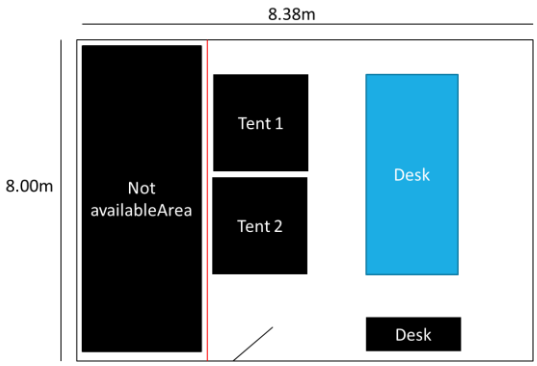

Fig.2 Laboratory Layout

2. Methods

Participants and Procedures

Participants were ten male members of a collegiate esports team. Participants were informed of the purpose of the study and completed an informed consent form prior to participation. Approval was obtained from the Institutional Review Board of the research institution. The effects of the ions environment were evaluated in a randomized, crossover, placebo-controlled, double-blind study. Each participant participated in two experiments, four weeks apart; two experimental conditions were provided: a positive and a negative ionic environment (PNI) and control conditions (CON) with the same wind speed and without ionization. In the PNI condition, a Plasmacluster® TM ionizer (Sharp Corporation) was used, and positive and negative ions (approximately 250,000 ions/cm3) were irradiated; under the CON condition, wind from the ionizer without ions was adapted at the same wind speed (wind speed: 0.43 m/sec) (Fig. 1, 2). In addition, positive and negative ions were generated by applying positive and negative high voltages to each discharge brush electrode of the ionizer to break up molecules in the air (Nishikawa & Nojima, 2001). The details of the experimental procedure are as follows (Fig.3).

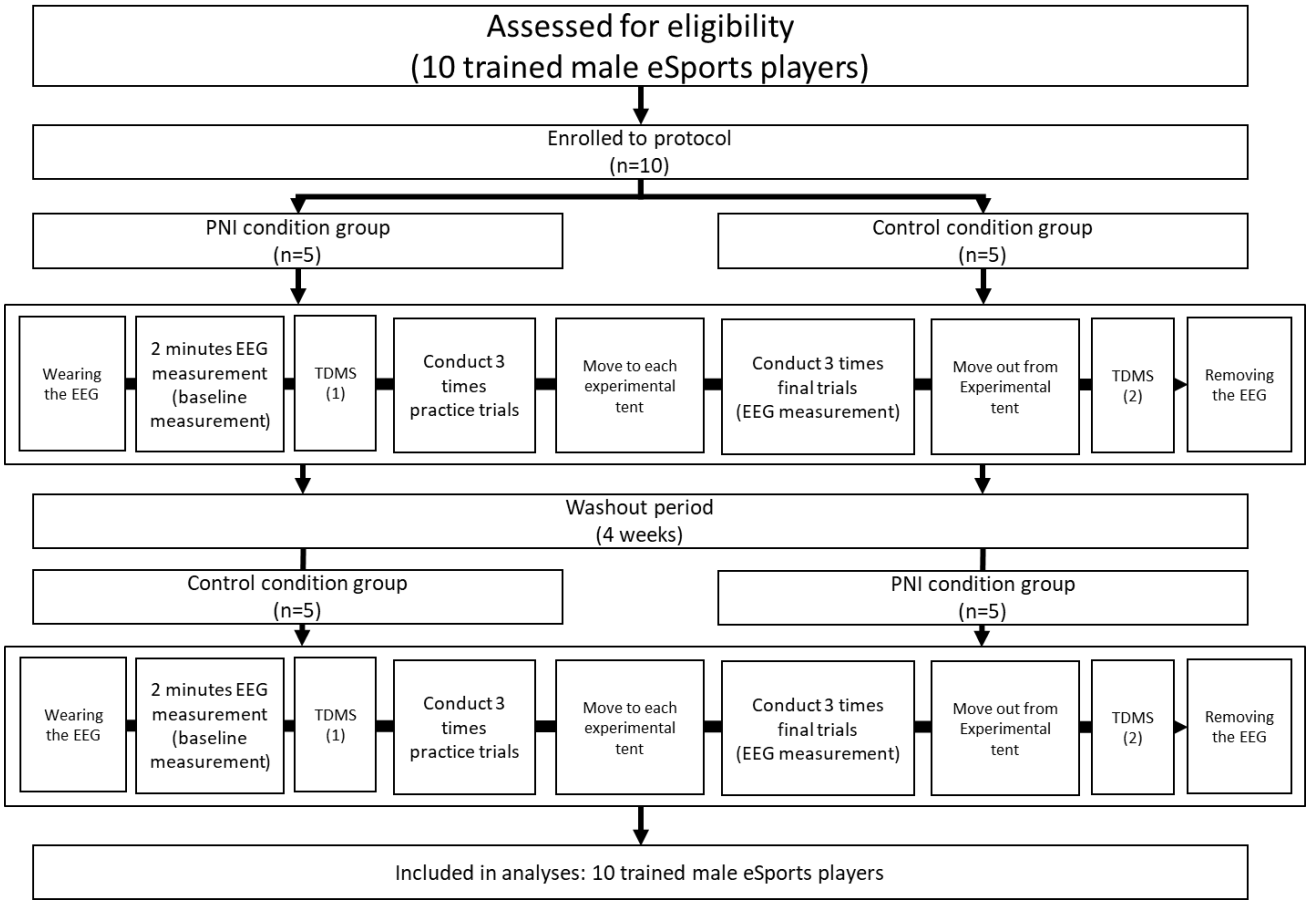

Fig.3 Flow diagram of the study design

First, participants were required to wear an electroencephalograph (EEG) for two minutes to conduct a baseline assessment of their arousal level. Then, participants completed a questionnaire to assess their arousal level before playing a racing game. Participants completed three trials as practice trials prior to the experiment in the tent. In addition, three trials were conducted as the final trial. For the performance task, participants played MARIOKART Deluxe 8. In the race mode, the setting was time attack, with three laps of the same course. The vehicle class was set to 150 cc, and participants selected a driver character. EEG was measured upon completing the task, and arousal level was measured. After the task, participants completed the questionnaire again.

Arousal level was assessed by questionnaire and EEG. The two-dimensional mood scale (TDMS) (Sakairi et al., 2013) was used to assess arousal; the TDMS consists of eight items and four factors: activity, stability, comfort, and arousal. For EEG, we employed a simple band electroencephalograph (Neurosky Corporation, Tokyo) that measures only the frontal pole 1 lobe (Fp1) as defined by the International 10-20 System, and EEG obtained from Fp1 has been found to be suitable for obtaining psychological state data (Mitsukura, 2016), Fp1 was used to estimate arousal level. The estimation method is the same as in previous studies (Hagiwara et al., 2021). The TDMS scores before and after completing the task and EEG during the task were averaged. A t-test was used to examine the difference between the PNI and CON conditions on the TDMS and EEG. For the task performance, the 3 trials prior between the PNI and CON conditions were averaged. A t-test was also performed to examine the difference between the two conditions. The IBM SPSS Statistics 25.0 software was used for the analysis, and p value was set at 0.05.

3. Results

3.1. TDMS

For TDMS, there was a significant tendency ($p > 0.1$) between the PNI condition ($M = 8.1$, $SD = 4.3$) and the CON condition ($M = 6.6$, $SD = 3.2$) (Fig.4).

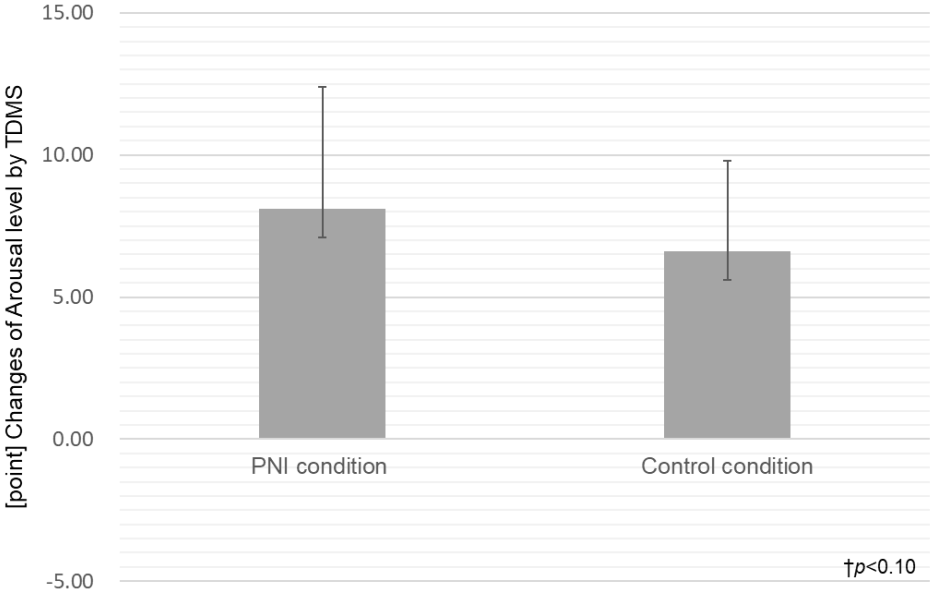

Fig.4 Arousal level by TDMS

3.2. EEG

The PNI condition (M=31.0, SD=7.3) had a significantly higher (p<0.05) change in beta band power ratio indicating arousal than the CON condition (M=10.5, SD=8.2)（Fig.5）.

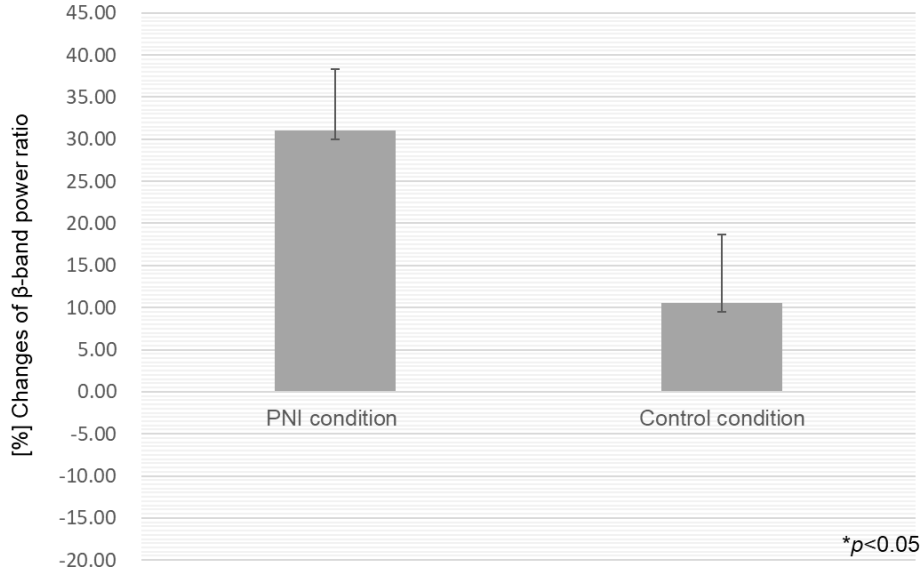

Fig.5 β -band power ratio

3.3. Racing performance

Race performance indicated that the PNI condition (M = -4.9, SD = 3.1) tended to have significantly faster time changes than the CON condition (M = -3.1, SD = 2.3) ($p < 0.1$) (Fig.6).

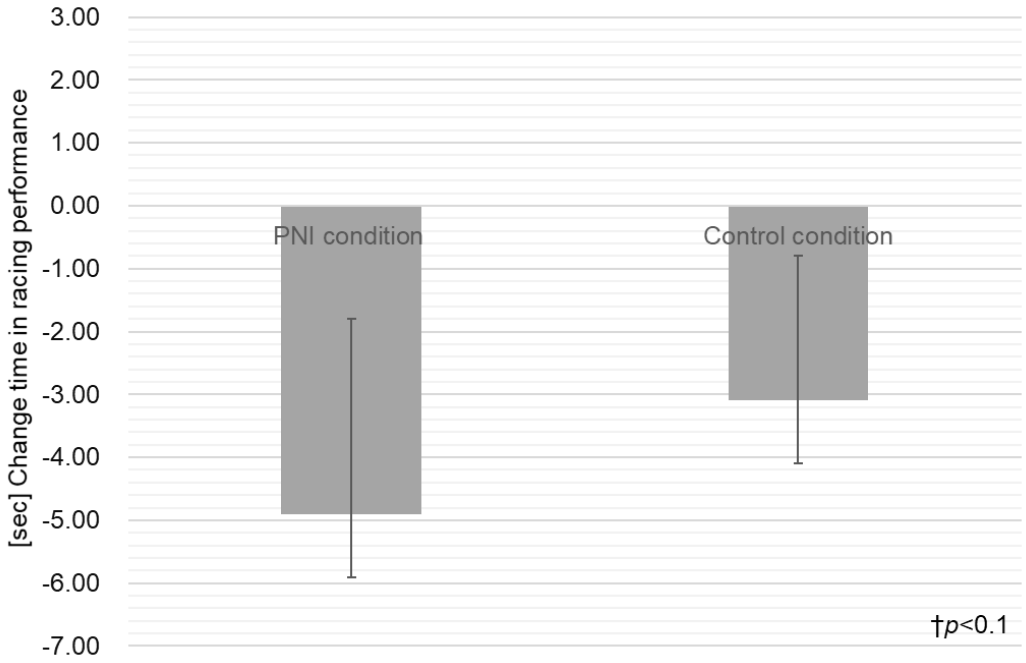

Fig.6 Racing performance

4. Discussion

The purpose of this study was to investigate the psychophysiological effects of arousal in racing game-type esports under positive and negative ionic conditions. In addition, the study was conducted in a similar experiment conducted by Hagiwara et al (2021) with an even higher ion concentration. In the present study, arousal tended to be higher in the PNI condition than in the CON condition, even in TDMS. EEG also showed that the PNI condition was higher than the CON condition in arousal. Furthermore, performance was also better in the PNI condition. how esports performance improves is of interest to researchers and esports players, and our study found that altering the environment with positive and negative ions can increase brain activation as well as improving esports performance. Furthermore, the results were even more interesting in that the effects were observed with higher ion concentrations than in the previous experiment.

Previous study examined whether the use of higher concentrations of ions differed from lower concentrations in terms of cognitive performance and physiological measurements (Wallner et al., 2015). The results showed that, although there was no difference in lung function and well-being, the higher concentrations outperformed the lower concentrations in cognitive performance. Specifically, cognitive performance was assessed by measuring reasoning ability and perceptual speed. Namely, exposure to higher concentrations of ions was shown to increase the speed of cognitive processing. In the present study, increased ion concentrations also increased subjective and biological arousal, as well as esports performance, suggesting that increased ion concentrations might be more effective.

esports is one of the fastest growing sports in the world today, and how performance could be enhanced is fascinating from many aspects. Interestingly, a recent review article focuses on the application of coaching to what practice conditions can be provided by coaches to their athletes in order to improve esports performance from a coach's perspective (Iwatsuki et al., 2021). Over the past five years, a variety of research lines in esports have emerged as researchers, coaches, and athletes search for ways to improve esports performance as in traditional sports, and environmental factors such as the use of positive and negative ions have been used in esports performance. More research will be conducted on how environmental factors, such as the use of positive and negative ions, affect esports performance.

In summary, the purpose of this study was to reexamine the effects of positive and negative ion environments on game performance and arousal levels, which had been indicated in previous studies, and the results of the present study also demonstrated that the PNI condition resulted in higher race game performance and arousal levels. It is interesting to note that the results also demonstrated a greater amount of change in subjective arousal of changing ion density.

However, to further scientifically prove the results of this study, it is also necessary to examine that what has changed in brain function. For example, additional studies of changes in cerebral blood flow in ionic environments would probably come closer to resolving the question of why game performance is better in ionic environments. Ion research is skeptical, and further experiments are needed.

5. Conclusions

The study demonstrated that esports performance and subjective and biological arousal levels were higher in the PNI condition. In addition, higher ionic concentrations were indicated to be more effective. Using the protocol implemented in a previous study (Hagiwara et al., 2021), similar findings were obtained, and given that esports performance was enhanced by increasing ion concentrations, it can be argued that positive and negative ion environments are important for the esports training environment. However, to further scientifically confirm the results of this study, it is necessary to examine what changes in brain function were observed. For example, further study of changes in cerebral blood flow in ionic environments would likely help answer the question of why game performance improves in ionic environments. Ion studies are skeptical and further experimentation is needed.

Author Contributions

Conceptualization, G.H.; methodology, G.H., H.F., M.M., S.T., H.O., and D.A.; software, G.H.; validation, G.H., and M.M.; formal analysis, G.H.; investigation, G.H., H.F, M.M., S.T., H.O. and D.A.; writing—original draft preparation, G.H.; project administration, G.H.; funding acquisition, H.F., M.M., S.T., H.O.; 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 Declaration of Helsinki, and approved by the Institutional Review Board of the National Institute of Fitness and Sports in Kanoya (No.5-1, 22 April 2020).

Informed Consent Statement

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

Data Availability Statement

Not applicable

Conflicts of Interest

This study was funded by Sharp Corporation. M.M., H.F. Y.K., S.T., and H.O. are employees of Sharp Corporation.

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