



Effects of Moderate-Intensity Cycling on Reaction Time and Point-and-Click Accuracy in Collegiate Esports Athletes: A Brief Report

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Abstract

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Collegiate electronic sport (esport) athletes spend extended periods seated, a pattern associated with reduced cerebral blood flow and potential decrements in executive function and performance. Aerobic exercise acutely improves cognitive function and reaction time (RT) in healthy populations; however, its effects on esport-specific performance metrics have not been established. The purpose of this brief report was to estimate the feasibility of a 15-minute moderate-intensity cycling (MIC) bout and to generate preliminary effect-size data for its influence on RT, point-and-click (PC) accuracy in collegiate esport athletes. Twelve male collegiate esport athletes (age: 20.3 ± 1.5 years) completed two counterbalanced sessions. Three familiarization trials preceded either a 15-minute MIC protocol at 45–55% heart rate reserve or a 15-minute seated rest control (CON). Immediately following each condition, participants completed three RT assessments using a simple RT tool and three PC performance trials using AimHero software. No significant differences were observed between MIC and CON for RT (221.4 ± 49.8 vs. 211.2 ± 29.0 ms; $p = 0.38$, $d = 0.36$), PC accuracy (86.6 ± 10.3 vs. $83.0 \pm 11.7\%$; $p = 0.24$, $d = 0.38$), or PC time (0.99 ± 0.15 vs. 0.96 ± 0.16 s; $p = 0.21$, $d = 0.26$). Individual response data suggest responders, non-responders, and negative responders to MIC may occur. These pilot data indicate that a single 15-minute MIC bout does not significantly alter esport performance metrics at the group level; however, small-to-moderate effect sizes and inter-individual variability suggest adequately powered future investigations are warranted.

Keywords: Electronic sports, reaction time, aerobic exercise, cognitive performance, moderate-intensity cycling, brief report, point-and-click accuracy

Introduction

Electronic sports (esports) are an expanding collection of competitive online games in which individuals and teams compete globally. The esport industry experienced substantial growth in the early 2020s, with an estimated 465 million viewers and \$1.08 billion in global revenue reported in 2021.²⁴ Competitors across game genres including first-person shooters, third-person shooters, and real-time strategy game; perform rapid and accurate mouse movements and key inputs while seated for extended durations. Reaction time (RT), movement speed, and accuracy are important components of performance in these environments, as successful gameplay requires players to rapidly perceive visual information, select an appropriate response, and execute precise motor actions.^{6,7,12} Consequently, research examining physical, perceptual, and cognitive characteristics associated with esports performance has identified reaction time and

accuracy as important performance-related variables, particularly because differences in these abilities may influence the speed and precision of performance.

The esports experience is characterized by extended periods of sedentary behavior¹² and dynamic physiological responses to cognitive and psychological stressors.^{2,6} Prolonged sitting, an inherent feature of esports competition, is associated with cardiometabolic risk^{15,20} and may contribute to progressive performance decrements through diminished executive function mediated by acute reductions in cerebral blood flow.⁹ In contrast, structured aerobic exercise has well-documented protective effects on cardiometabolic health,²⁶ reduces all-cause mortality risk,³⁰ and acutely enhances cerebral blood flow and executive function,¹² suggesting that aerobic exercise may positively influence esports performance variables. These effects provide a potential rationale for incorporating brief aerobic exercise into pre-competition routines. However, whether such exercise produces meaningful improvements in esports specific performances is unclear.

The effects of acute aerobic exercise on cognitive and motor performance appear to be influenced by the characteristics of the exercise stimulus. Previous research has demonstrated improvements in reaction time and information-processing performance following acute aerobic exercise. Garg et al.¹⁶ reported improvements in auditory and visual reaction time following aerobic exercise, while Audiffren et al.⁴ found that acute aerobic exercise enhanced information processing during a choice reaction-time task. Similarly, Nanda et al.²² reported improvements in cognitive performance following a single bout of moderate-intensity aerobic exercise in healthy adult males. Collectively, these findings suggest that moderate-intensity aerobic exercise may acutely influence processes relevant to rapid perceptual and motor responses. Proposed mechanisms include increased physiological arousal and enhanced allocation of attentional resources, which may facilitate perceptual processing and motor execution.^{8,14,17,21,29} However, evidence from general cognitive and motor-performance research cannot necessarily be assumed to translate directly to esports performance. Electronic sports tasks require rapid visuomotor responses under conditions that differ substantially from traditional laboratory reaction-time paradigms, including continuous visual monitoring, precise mouse movements, and speed-accuracy demands. The limited esports-specific literature has primarily examined exercise protocols that differ in intensity or performance assessment from the present investigation. For example, De Las Heras et al.¹¹ reported improved video game performance following a 15-minute high-intensity interval training protocol in participants completing a multiplayer online battle arena task. Although these findings provide evidence that acute exercise may influence video game performance, the substantially higher exercise intensity and game-based outcome measures used in that study leave unanswered whether a brief bout of moderate-intensity aerobic exercise is sufficient to alter esports-related performance measures. Beyond aerobic exercise, other modifiable training approaches have also been explored as potential enhancers of esports-relevant cognitive performance. For example, immersive virtual reality (VR) training programs in amateur e-athletes have been associated with improvements in concentration performance, alternating attention, and visuospatial memory.^{18,19}

An important gap remains regarding the acute effects of brief moderate-intensity exercise on esports-specific performance outcomes. It is unclear whether a 15-minute bout of moderate-intensity cycling, performed at 45–55% heart rate reserve, is sufficient to alter reaction time and point-and-click performance in collegiate esports athletes. As a brief report, the present pilot investigation was designed primarily to estimate the feasibility of this protocol and to generate preliminary effect-size data, rather than to test its efficacy, for the acute effects of a standardized 15-minute moderate-intensity cycling bout on RT, point-and-click (PC) accuracy, and PC time in collegiate

esports athletes, using a counterbalanced within-subject design. These effect-size estimates are intended to inform sample-size planning for future, adequately powered investigations. Based on prior work examining acute exercise and motor-cognitive performance,^{11,28} we descriptively hypothesized that moderate-intensity cycling would be associated with decreased RT and PC time and increased PC accuracy.

METHODS

Participants

Thirty-five University esports athletes were recruited to participate in this study, with 12 male athletes (mean age: 20.3 ± 1.5 years) volunteering to participate. Inclusion criteria required a minimum of five years of computer-based gaming experience and self-reported absence of any neurological, psychiatric, or medical conditions known to affect central nervous system function.²⁷ Participants self-reporting use of medications or recreational substances with known central nervous system effects were excluded. All participants completed preparticipation health screening per ACSM guidelines³ and were free from cardiovascular, metabolic, or pulmonary disease. Written informed consent was obtained from each participant prior to enrollment following a thorough explanation of study procedures and associated risks. All testing were conducted in accordance with the ethical principles of the Helsinki Declaration and the protocol was approved by the University IRB. This investigation was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science.²³

Protocol

Participants reported to the laboratory on two separate occasions separated by 24–48 hours and were instructed to abstain from caffeine consumption for 24 hours prior to each visit. During the initial session, demographic and health characteristics were recorded, including age, academic year, years of esports experience, dominant hand, habitual pre-competition warm-up practices, physical activity level, and daily gaming practice time. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ).⁵ Anthropometric data (height and weight) were obtained using a digital scale and standard stadiometer (Detecto™, Webb City, MO).

Following 10 minutes of seated rest in a quiet room, resting heart rate was recorded using a Polar H10 heart rate monitor (Polar Electro, Kempele, Finland) and used to calculate the target heart rate range corresponding to 45–55% heart rate reserve (HRR) via the Karvonen formula: $[(220 - \text{age}) - \text{resting HR}] \times \text{intensity\%} + \text{resting HR}$. This method standardized exercise intensity across participants.

Each experimental session began with three standardized familiarization trials of the AimHero point-and-click assessment (ProGame Studios, 2016)¹ to minimize the influence of learning effects on experimental outcomes. Following familiarization, participants performed either a 15-minute MIC protocol or a 15-minute quiet seated rest period (CON) in counterbalanced order where the initial participant assignment was random and subsequent assignments were alternating. This counterbalancing assignment resulted in 6 participants completing MIC first, and 6 completing CON first. During MIC, participants cycled on a mechanically braked cycle ergometer (828El, Monark, Sweden) with seat height adjusted to achieve approximately 15 degrees of knee flexion at bottom center of the pedal stroke. Cadence was maintained at 50 rpm, and ergometer resistance was adjusted continuously to maintain heart rate within the 45–55% HRR target zone.

All participants achieved and maintained an exercising heart rate within the target HRR zone for the full 15 min MIC trials. Average heart rate across the MIC trials was not recorded.

Immediately following MIC or CON, participants completed three RT assessments using an online simple RT tool (Reaction Time Test, humanbenchmark.com²⁵) with 10-second inter-trial rest intervals. This assessment required a mouse click when the screen color changed without requiring cursor movement. RT was recorded to the nearest millisecond per trial.

PC performance was subsequently assessed using AimHero software¹ administered offline to eliminate network latency as a potential confounding variable. Testing was conducted on a custom-built PC (Intel Core i5-6500 CPU; AMD Radeon RX 5700 XT GPU) connected to a 144 Hz MSI G271 monitor. Participants used a HyperX Pulsefire Saga pro mouse (polling rate up to 8000hz) and were permitted to adjust mouse sensitivity (DPI), graphics settings, and seat height to individual preferences at the beginning of the first session. These settings remained fixed for all subsequent trials. The AimHero assessment presented stationary and random targets one at a time, and participants were instructed to click as many targets as possible with maximum speed and minimum misses. Three trials were completed with 15-second intertrial rest intervals. PC accuracy (hits/total clicks $\times$ 100) and mean time between successful target hits (PC time, seconds) were extracted from each trial. For all computer-based assessments, peripherals consisted of a blank grey wall in a quiet and private windowless room and were consistent between all trials and participants.

Statistical Analysis

All data are reported as means $\pm$ standard deviations. Two-tailed dependent samples *t*-tests were used to compare RT, PC accuracy, and PC time between MIC and CON conditions. Cohen's *d* effect sizes were calculated as the mean paired difference divided by the standard deviation of the paired differences. Cohen's *d* effect sizes were considered small, medium, and large at $d = .20$, $d = 0.5$, and $d = 0.8$, respectively. Statistical significance was set at $p \leq 0.0167$ to adjust for the use of three separate comparisons. All analyses were performed using IBM SPSS Statistics (IBM Corp., Armonk, NY). As this was a pilot test, an a priori power analysis was not conducted.

Results

Participant descriptive characteristics are presented in Table 1. Participants reported 16.6 ± 20.7 months of collegiate esports experience and 2.8 ± 1.8 hours of daily practice. IPAQ data indicated that one participant had low physical activity score, six were moderately active, and 5 were highly active. Pre-competition warm-up strategies included repetitive in-game trials, point-and-click training software, and casual online matches.

Means, standard deviations, *p*-values, and effect sizes for all outcome variables are presented in Table 2. No statistically significant differences were observed between MIC and CON conditions for RT, PC accuracy, or PC time. However, PC accuracy was 3.6 percentage points higher following MIC compared to CON and a moderate effect of .38 was observed. Conversely, mean RT and PC time were slower after MIC compared to CON also with moderate effect sizes (.36 and .26, respectively).

Individual response analysis of RT data revealed substantial heterogeneity. Four participants demonstrated improved RT (range: 6.7–52.7 ms faster) following MIC; three participants showed

worsened RT (range: 27.7–32.7 ms slower); and four participants showed minimal difference between conditions. This pattern indicates the presence of responders, non-responders, and negative responders to MIC within this pilot sample, and likely contributed to the large standard deviation observed in the MIC condition (± 49.8 ms).

Because this study was a brief report, a formal *a priori* power analysis was not conducted due to the absence of published effect size data for esports-specific RT and PC performance outcomes in response to acute aerobic exercise at the time of study inception. The observed effect sizes ($d = 0.26$ – 0.38) indicate that a future two-tailed paired-samples *t*-test designed to detect a small-to-moderate effect ($d = 0.35$) with 80% power at $\alpha = 0.05$ would require approximately 67 participants; if multiplicity correction ($\alpha = .0167$) is retained in a future confirmatory design, approximately 89 participants would be required.

Table 1. Descriptive characteristics of participants ($n = 12$).

Characteristic	Mean $\pm$ SD
Age (years)	20.3 $\pm$ 1.5
Height (cm)	178.99 $\pm$ 8.03
Weight (kg)	81.78 $\pm$ 21.05
Resting HR (bpm)	71 $\pm$ 5
APHRM (bpm)	199 $\pm$ 3
45% HRR (bpm)	135 $\pm$ 3
55% HRR (bpm)	152 $\pm$ 5
Walking MET-minutes/week	1567.5 $\pm$ 1152.2
Moderate MET-minutes/week	490.0 $\pm$ 675.8
Vigorous MET-minutes/week	913.3 $\pm$ 1656.9
Total MET-minutes/week	2970.8 $\pm$ 2267.9
Sitting minutes per day ($n = 10$)	393.0 $\pm$ 179.1
Daily esports practice time (hours)	2.8 $\pm$ 1.8
Collegiate esports experience (months)	16.6 $\pm$ 20.7

Note. Data are presented as mean $\pm$ SD. HR = heart rate; APHRM = age predicted heart rate max; HRR = heart rate reserve; MET = metabolic equivalent of task.

Table 2. Comparison of Outcome Variables Between MIC and CON Conditions.

Variable	MIC	CON	<i>p</i>	<i>d</i> [95% CI]	95% CI
Reaction Time (ms)	221.4 $\pm$ 49.8	211.2 $\pm$ 29.0	0.38	.36 [-0.22, 0.94]	-14.55, 34.94
PC Accuracy (%)	86.6 $\pm$ 10.3	83.0 $\pm$ 11.7	0.24	.38 [-0.21, 0.97]	-2.82, 10.04
PC Time (s)	0.99 $\pm$ 0.15	0.96 $\pm$ 0.16	0.21	.26 [-0.32, 0.84]	-0.02, 0.09

Note. Data are presented as mean $\pm$ SD. MIC, moderate-intensity cycling; CON, control; PC, point-and-click; *p*, significance value; *d* [95% CI], Cohen's effect size with 95% confidence intervals; 95% CI = 95% confidence intervals for the MIC-CON mean paired difference.

Discussion

The primary finding of this investigation was that 15 minutes of MIC did not statistically improve RT, PC accuracy, or PC time in collegiate male esports athletes. These results are inconsistent with the majority of prior literature examining acute exercise effects on RT and cognitive performance,^{11,31} though notable methodological differences exist between the current investigation and previous studies.

De Las Heras et al.¹¹ demonstrated improved accuracy and performance in a multiplayer online battle arena (MOBA) game following a 15-minute high-intensity interval training (HIIT) bout.

However, the exercise protocol employed by De Las Heras et al.¹¹ was of substantially greater intensity than the MIC protocol used here. It is plausible that 45–55% HRR was insufficient to drive the arousal-mediated improvements in cognitive and motor function described by Brisswalter et al.⁸ and McMorris and Graydon.²¹ Future research should consider dose-responses when attempting to identify the intensity threshold that may improve esports performance outcomes.

Recent findings provide additional mechanistic context. Dykstra and colleagues¹³ reported a significant inverse relationship between estimated aerobic capacity ($\text{VO}_2\text{max} = 45.7 \pm 11.8 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) and RT ($r = -0.338$) during a Stroop Color Word Task in moderately active esports gamers. Those investigators further observed that participants with higher aerobic capacity committed fewer errors during different trials. These findings suggest that cardiorespiratory fitness may moderate the relationship between aerobic exercise and cognitive performance. It is possible that the fitness levels of the current sample were insufficient to confer exercise-induced cognitive benefit, an important variable that should be considered in future studies.

Bickmann and colleagues⁷ examined the influence of competitive status (amateur vs. professional) and game genre on RT in esports athletes and compared these measures to traditional sport athletes using the Vienna Test System. Their findings highlight the importance of participant stratification in esports research, as baseline RT and motor performance vary substantially across competitive levels and game genres. The homogeneous sample in the present report (collegiate-level athletes from a single institution) limits generalizability across the broader esports population.

Although no statistically significant group-level differences were detected, mean PC accuracy following MIC was 3.6 percentage points higher than CON, with a corresponding small-to-moderate effect size ($d = 0.38$). In the context of competitive esports where individual actions can determine match outcomes, a 3.6 percentage points improvement in targeting accuracy may carry meaningful practical significance. This observation of a non-significant p -value alongside a small-to-moderate effect size is characteristic of this underpowered pilot studies and reinforces the need for a larger, confirmatory investigation. The heterogeneous individual response pattern suggests that responders ($n = 4$), non-responders ($n = 4$), and negative responders ($n = 3$) may be present in MIC investigations. This possibility is supported by the inter-individual variability and large RT standard deviation observed in the MIC condition ($\pm 49.8 \text{ ms}$). Future investigations should explore potential moderating variables (e.g., aerobic fitness, game genre, competitive experience, and baseline RT) that may identify subgroups most likely to benefit from pre-competition aerobic exercise. Future studies should also consider the limitations of this brief report. First, the sample ($n = 12$) was insufficient to detect small to moderate effects with adequate statistical power. Based on a two-tailed paired-samples t -test designed to detect a small-to-moderate effect ($d = 0.35$) with 80% power at $\alpha = .05$, we estimate that future studies should enroll approximately 67 participants; if multiplicity correction ($\alpha = .0167$) is retained in a future confirmatory design, approximately 89 participants would be required. Second, the absence of a maximal aerobic capacity assessment (e.g., VO_2max) did not allow for the inclusion of fitness as a moderating variable. Given the small sample size, formally testing for order effects was not possible. Additionally, our computer-based assessments were general and not specific to any particular esports game/competition.

This report provides preliminary evidence and foundational effect size data to guide the design of future investigations. Adequately powered studies should employ a range of exercise intensities and durations, include aerobic fitness assessments, incorporate ecologically valid esports performance measures within participants' primary game genres, and recruit diverse samples

across sex, competitive level, and game genre. Understanding the optimal exercise prescription for acute esports performance enhancement would have direct implications for pre-competition routines at collegiate and professional levels.

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