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William J. Kraemer
The Ohio State University

Lydia K. Caldwell
University of North Texas

Emily M. Post
Otterbein University

Matthew K. Beeler
Hastings College

Angela Emerson
The Ohio State University

See next page for additional authors

Authors

William J. Kraemer, Lydia K. Caldwell, Emily M. Post, Matthew K. Beeler, Angela Emerson, Jeff S. Volek, Carl M. Maresh, Jennifer S. Fogt, Nick Fogt, Keijo Häkkinen, Robert U. Newton, Pedro Lopez, Barbara N. Sanchez, and James A. Onate

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William J. Kraemer,[1,2,3,4] Lydia K. Caldwell,[5] Emily M. Post,[6] Matthew K. Beeler,[7] Angela Emerson,[2] Jeff S. Volek,[1] Carl M. Maresh,[1] Jennifer S. Fogt,[2,8] Nick Fogt,[2,8] Keijo Häkkinen,[9] Robert U. Newton,[3,4] Pedro Lopez,[3,4] Barbara N. Sanchez,[1] and James A. Onate[2,10,11]

[1]Department of Human Sciences, The Ohio State University, Columbus, Ohio; [2]Human Performance Collaborative, Office of Research, The Ohio State University, Columbus, Ohio; [3]Exercise Medicine Research Institute; [4]School of Medical and Health Sciences, Edith Cowan University, Joondalup, WA, Australia; [5]Applied Physiology Laboratory, University of North Texas, Denton, Texas; [6]Exercise Science Department, Ohio Dominican, Columbus, Ohio; [7]Department of Exercise Science, Hastings College, Hastings, Nebraska; [8]The College of Optometry, The Ohio State University, Columbus, Ohio; [9]Neuromuscular Research Center, Biology of Physical Activity, Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland; [10]School of Health and Rehabilitation Sciences, The Ohio State University, Columbus, Ohio; and [11]Jameson Crane Sports Medicine Research Institute, The Ohio State University Wexner Medical Center, Columbus, Ohio

Abstract

Kraemer, WJ, Caldwell, LK, Post, EM, Beeler, MK, Emerson, A, Volek, JS, Maresh, CM, Fogt, JS, Fogt, N, Häkkinen, K, Newton, RU, Lopez, P, Sanchez, BN, and Onate, JA. Arousal/stress effects of "Overwatch" eSports game competition in collegiate gamers. *J Strength Cond Res* 36(10): 2671–2675, 2022—To date, no physical response data are available for one of the most popular eSport games, *Overwatch*. The purpose of this investigation was to describe the stress signaling associated with competitive *Overwatch* play and to understand how acute hormonal responses may affect performance. Thirty-two male college-aged gamers (age: 21.3 ± 2.7 years; estimated time played per week: 18 ± 15 hours) completed the study. Subjects were randomly assigned to a 6-player team to compete in a tournament-style match. Salivary measures of cortisol and testosterone were collected immediately before (PRE) and after (POST) the first-round game, with the heart rate recorded continuously during the match. The mean characteristics were calculated for each variable and comparisons made by the skill level. Significance was defined as $p \leq 0.05$. There were no differences in measures of salivary cortisol. A differential response pattern was observed by the skill level for testosterone. The low skill group displayed a significant increase in testosterone with game play (mean ± *SD*, testosterone PRE: 418.3 ± 89.5 pmol·L^{-1}, POST: 527.6 ± 132.4 pmol·L^{-1}, $p < 0.001$), whereas no change was observed in the high skill group. There were no differences in heart rate characteristics between skill groups. Overall, the average heart rate was 107.2 ± 17.8 bpm with an average max heart rate of 133.3 ± 19.1 bpm. This study provides unique physiological evidence that a sedentary *Overwatch* match modulates endocrine and cardiovascular responses, with the skill level emerging as a potential modulator.

Key Words: video games, heart rate, endocrine, cortisol, testosterone

Introduction

Globally, competitive electronic gaming (eSports) is gaining traction as a recognized sport. Market research indicates that the eSport industry will be worth more than 3.5 billion dollars by 2025—representing a growth of 70% over the next 4 years (7). The drastic increase is attributed to the emergence of streaming platforms and associated advertisement and high-value sponsorship deals. In 2021, the Olympic Council of Asia announced that 8 eSport games (*League of Legends*, *Hearthstone*, *Dota 2*, *Street Fighter V*, *Arena of Valor*, *Dream Three Kingdoms 2*, *FIFA*, and *PUBG Mobile*) will be official events at the 2022 Asian Games in Hangzhou—awarding medals alongside more traditional sporting events such as archery, baseball, cycling, track, and martial arts (25). Whether the sport will be included as an official event at the 2028 Olympic Games in Los Angeles continues to draw speculation. However, inclusion seems plausible given that the International Olympic Committee launched the first ever Olympic-licensed virtual sporting event—The Virtual Series—ahead of the 2020 Summer Games in Tokyo (2).

The growth of the industry is not limited to the professional arena. One of the most rapidly evolving areas of eSport has been the rise of collegiate gaming. In 2016, The National Association of Collegiate Esports (NACE) was formed in the United States. At the time of its formation, there were just 7 colleges and universities offering varsity eSport programs (https://nacesports.org/May 6, 2022). As of 2022, there are more than 170 officially recognized varsity eSport programs in the United States. According to the NACE directory, the 3 most popular games at the collegiate level are *League of Legends*, *Overwatch*, and *Rocket League*, with more than 115 programs listing each game as part of their member profile (https://members.nacesports.org/AF_MemberDirectory.asp, May 6, 2022).

Mirroring this increasing popularity, scientists have become interested in studying eSport athletes to understand the stress of the competitive and noncompetitive environments (13). Many have had serious concerns regarding a variety of health issues resulting from the long sedentary demands and psychological stress of intense gaming practice and participation (27). To date, the study of eSport has primarily focused on *League of Legends*

Address correspondence to William J. Kraemer, kraemer.44@osu.edu.

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because of its popularity in the gaming community (8). However, a recent study by Sousa et al. (23), highlights the need for studying a variety of gaming contexts given that first-person shooter (FPS) games, such as *Overwatch*, appear to elicit a greater sympathetic nervous system response than multiplayer online battle area (MOBA) games such as *League of Legends* (23). This may partially explain the varied findings observed for stress responses during competitive eSport play with some displaying increases (17,19), decreases (1), or no changes (8,17) in measures of salivary cortisol. Interestingly, expert gamers appear to respond differently than novice players, yet the influence of game skill ranking on hormonal response patterns has yet to be evaluated. Given the lack of data on this emerging sport, there is a need to explore the physiological demands of eSport competition and to understand how acute hormonal responses may impact performance. The purpose of this study was to examine the physiological stress responses of college-aged gamers during a laboratory-controlled *Overwatch* competition. We hypothesized that the player skill level would influence biomarkers of stress (cortisol, testosterone, and heart rate) because of the anxiety and arousal associated with competitive performance (17,19).

Methods

Experimental Approach to the Problem

Biomarkers were assessed surrounding the first round of a tournament-style *Overwatch* (Blizzard Entertainment, Irvine, CA) match. Subjects were randomly assigned to a 6-player team to compete in the multiplayer first-person shooter game. We examined the acute physiological responses to a single game of Overwatch in a team competition set up in a laboratory setting. Salivary measures, for the assessment of cortisol and testosterone, were collected immediately before (PRE) and after (POST) the first-round game. The heart rate was recorded continuously to assess cardiovascular arousal during game play.

Subjects

Thirty-two male gamers (mean ± *SD*, age: 21.3 ± 2.3 years; range 18–32 years; estimated time played per week: 18 ± 15 hours) participated in this study. The study was approved by the institutional review board for use of human subjects at Ohio State University. Each subject gave written informed consent after having the risks and benefits of the study explained. Subjects were recruited from the collegiate population of students and the surrounding community. All subjects had some experience playing *Overwatch* whether recreationally or competitively. All subjects were asked to self-report their rank in Overwatch. High rank players were defined as those self-ranked diamond and above (skill ranking ≥3,000; top ~20% of Overwatch players), whereas low rank players were defined as those self-ranked platinum and below (skill ranking <3,000; bottom ~80% of Overwatch players).

Procedures

All subjects were tested during the initial game of the tournament competition. Each subject was tested pre to post first game (i.e., 16–25 minutes) within the afternoon competition structure (1300–1530). The Overwatch game was played with Alienware computers (Aurora R5 D23M; Dell Inc., Round Rock, TX), mouse (AW558; Dell Inc.), keyboard (AW768; Dell Inc.), and monitor (AW2518H; Dell Inc.). The monitor, desk, and chair heights were standardized (0.16, 0.74, and 0.44 m, respectively), and the monitor was 0.35 m from the front edge of the desk. All subjects fit into the chairs for optimal comfort and movement distances for game play. The mouse and keyboard positions were adjusted to each subject's preferred location. Multiple large screens were set up in the room for audiences to view the various games being played on the monitors of the teams (Figure 1).

Subjects wore a Polar H10 chest strap (Polar Electro Inc., Lake Success, NY) to monitor the heart rate throughout the game. The heart rate monitor was paired with the *Polar Beat* app on a tablet computer to record the continuous heart rate throughout the game. The recording was started manually on the tablet computer when the game began and stopped as soon as the game ended, providing an accurate game play window for analysis. Again, the game play duration ranged from 16 to 25 minutes.

Salivary samples for assessment of cortisol and testosterone were obtained before and after the game using procedures outlined by Salimetrics LLC (State College, PA). It is well known that samples that are collected from the salivary biocompartment measure only concentrations of the "free" or unbound cortisol or testosterone hormone. In brief, saliva was collected using unstimulated passive drool. Subjects tilted the head forward, allowing the saliva to pool on the floor of the mouth, and then passed the saliva into a polypropylene vial. Saliva samples were stored at −80° C until assayed. Samples were assayed in duplicate using ELISA immunoassays (Salimetrics LLC, State College, PA). The intra-assay variances for cortisol were 6.2 ± 1.2% and 5.1 ± 1.7% for testosterone with the sensitivities for cortisol and testosterone 0.018 $\mu g \cdot dl^{-1}$ and 1.0 $pg \cdot ml^{-1}$, respectively.

Statistical Analyses

Data were analyzed using SPSS v.27 (IBM Corp., NY). Normality of distribution was assessed using the Shapiro-Wilk test. Comparisons for hormonal variables were evaluated for the whole group of subjects and then classified as low and high skill players. Differences between groups (based on skill levels before the game play) were assessed using independent *t* test and independent samples Mann-Whitney U tests when necessary. Dependent variables between PRE and POST were assessed for change using 2-way (skill levels × time) repeated measures analysis of variance, with time effects testing the

Figure 1. Overwatch game play was performed in teams of 6 players in the same large room with audiences watching on the competition screens.

Table 1
Salivary cortisol and testosterone measures before and after the game play.*

				F and *p*	
Variables	**n**	**PRE**	**POST**	**Skill level × time**	**Time**
Salivary cortisol, $nmol \cdot L^{-1}$†					
All subjects	32	15.9 ± 11.4	14.1 ± 8.1	$F = 1.7$, $p = 0.199$	$F = 0.1$, $p = 0.789$
Low skill	22	15.0 ± 11.4	14.4 ± 8.9		
High skill	10	18.0 ± 11.7	13.4 ± 6.6		
Salivary testosterone, $pmol \cdot L^{-1}$					
All subjects	32	472.8 ± 191.3	554.0 ± 167.8‡	$F = 6.2$, $p = 0.019$	$F = 12.6$, $p < 0.001$
Low skill	22	418.3 ± 89.5	527.6 ± 132.4‡		
High skill	10	592.8 ± 290.1	612.1 ± 225.1		

*Values are presented as mean ± *SD.*
†Statistical analysis based on log transformed data.
‡Within-group significant difference between pre and post values.

response in these outcomes following the first-round game, and interactions assessed to determine if these responses are moderated by the skill level in highly involved recreational gamers. To analyze a between-group difference in heart rate variables, independent *t* tests were used. Data not normally distributed were log transformed for analysis. In the event of a significant F test, pairwise comparisons were further evaluated using the Bonferroni post hoc procedure for multiple comparisons. Using the nQuery Advisor software (Statistical Solutions, Saugus, MA), it was determined that the n size was adequate to defend the 0.05 alpha level of significance with a Cohen probability level of at least 0.80 for each dependent variable. The statistical significance for all analyses was set a priori at $p \leq 0.05$.

Results

Changes in salivary measures of unbound cortisol and testosterone from PRE to POST initial game of the competition are presented in Table 1. Overall, subjects ($n = 32$) exhibited an 11.3% decrease in salivary cortisol and a 17.2% increase in salivary testosterone following the game play. Salivary cortisol was not statistically different between skill level groups before the game play ($p = 0.489$). A time × group interaction ($p = 0.199$) or time effect ($p = 0.789$) were not observed in salivary cortisol, with both high and low skill groups presenting no significant changes after the game play. Overall and individual responses of cortisol to the competitive Overwatch game are shown in Figure 2.

Overall and individual responses in the salivary testosterone to the competitive *Overwatch* game are shown in Figure 3. There were no differences between the high and low skills groups in salivary testosterone before the game play ($p = 0.093$). A significant time × group interaction was observed ($p = 0.019$). Low skill players showed a significant mean increase following the game play ($p < 0.001$), whereas high skill players showed no significant change over time ($p = 0.634$). Almost all low skill gamers exhibited an increase in testosterone over time, whereas there was more variability in response patterns among the high skill group of individuals (Figure 3).

Heart rate characteristics during the game play are presented in Table 2. The *p* value noted is related to the lack of significant differences between skill groups; therefore, results are presented as the entire cohort. The average heart rate and maximum heart rate were significantly higher than the pregame minimum heart rate in the group with game play.

Discussion

Our understanding of the physiological responses to *Overwatch* game play including in collegiate recreational yet competitive gamers is nonexistent. Is the arousal/stress response similar to what has been observed in the literature for elite and novice gamers playing other eSport games? Furthermore, is there a difference due to skill levels which are more highly variable in this group of collegiate players? These are some of the first questions we endeavored to address for the first time in this study.

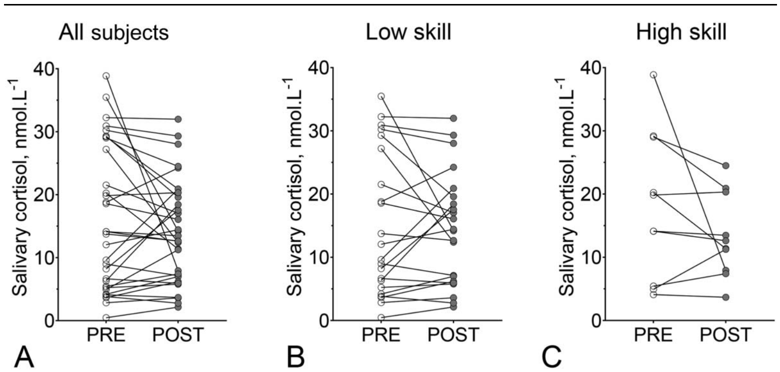

Figure 2. A) Individual responses in salivary cortisol for all players to pre to post game play. B) Individual responses of each player in the low skill group. C) Individual responses for each player in the high skill group.

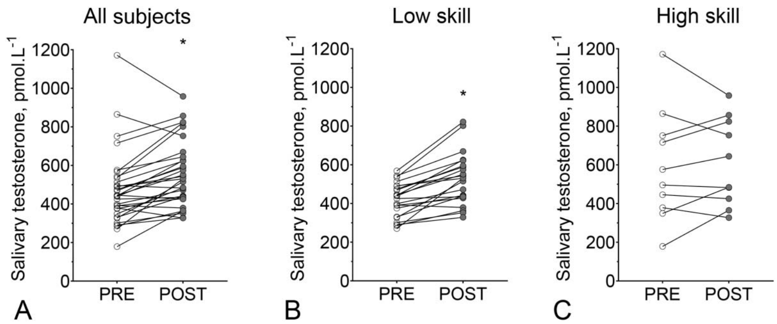

Figure 3. A) Individual responses in salivary testosterone for all players to pre to post game play. B) Individual responses of each player in the low skill group. C) Individual responses for each player in the high skill group. * = ($p \leq 0.05$) for significant increases observed for the postgame with mean data shown in Table 1.

In this study, no significant changes were observed in salivary cortisol despite an 11% decrease with game play. This decrease in cortisol seems to be reflected in the significant statistical impact on a time effect for salivary cortisol. Yet no changes were observed between skill groups. This variable response pattern is reflected in the prior work on other eSport games for salivary cortisol (8,17,19). Again, to the best of our knowledge, no other study has examined arousal/stress responses to the eSport game *Overwatch* albeit other eSport Games have similar combative/strategy dynamics. As a group, there was no significant decline. The overall group findings are in agreement with a study by Gray et al. (8) in which no changes in salivary hormone levels in collegiate recreational eSport gamers were found during *League of Legends* game play. Once game play proceeds it is apparent that optimal brain activity supported by arousal and anxiety levels pregame may play important roles. The frontal lobe of the brain is highly involved with the processing of attention and executive functions, and arousal levels appear to facilitate such functions to a certain extent (1). Mendoza et al. (17) examined a group of expert eSport gamers who participated in tournaments and a recreational control group of gamers who never played eSport games with real strategy demands. It might be suggested that higher skilled players partitioned in this study and in the study by Mendoza et al. (17) would have greater perception of the oncoming game demands. This would lead to greater arousal and anxiety preparing players for more rapid neurophysiological adjustments before game play. Interestingly, Schmidt et al. (19) found increases in salivary cortisol for all players with winners having greater anxiety levels, leading to the concept that higher levels of anxiety may also be favorable for optimizing game performance. Thus, the skill levels of our subjects may not have been high enough in either group to produce any anxiety leading to an adapted pregame arousal preparation for the competition.

Cortisol responds to stress and alters functional circuits to limit dysregulation. Expert or more highly skilled players may have both peripheral and central brain neural pathways which allow for facilitation of cognitive and stress modulation compared with lower skilled or novice gamers who have not experienced eSport game demands (10–12,15,20). Collegiate gamers may require much more practice and competitive play to mimic cortisol responses similar to highly skilled elite gamers. Thus, salivary cortisol responses to eSport games may be related to the level of game play, experience, and skill levels with competition.

In this study as a group, we observed a significant increase in salivary testosterone pregame to postgame play. Yet interestingly, the high skill group showed significantly higher salivary testosterone concentrations before game play with no changes over time. Lower skilled gamers showed significant increases in salivary concentration of testosterone with game play with no changes in higher skilled players who may have already increased to a pregame arousal state. However, variability was observed in the high skill group. We know that testosterone plays vital physiological roles in men including competitive venues for winning and losing (5,12). Testosterone's role in physiological arousal may be related to success in sports because of the need for psychological aggression and physiological adjustments for the so called fight part of the "fight-flight" phenomenon (3–5,16,28). The duration of game play was also brought into question for such hormonal responses when a meta-analysis of eSport game competitions suggested that the lack of changes in salivary testosterone may in fact be due to the length of game play with longer game play needed to see increases compared with shorter game play (6). In the study by Gray et al. (8), an acute short gameplay of *League of Legends* (i.e., 15–27 minutes) did not find any changes in salivary testosterone or cortisol, and thus, game length was used to explain the lack of responses. Our study provides somewhat novel data on this question that shorter duration game play does impact hormonal responses. However, the finding that high-skilled players may upregulate testosterone concentrations before game play resulting in no changes with the game play itself may explain the lack of pre to post game significant effects. Owing to the game context of audience presence, it may be that the lower skilled players were more affected, as observed audience effects have been shown to affect testosterone's responses (14). Thus,

Table 2
Heart rate characteristics during the game play.

Variables	n	Mean ± *SD*	*p*
Minimum heart rate, bpm			
All subjects	32	81.2 ± 13.5	
Low skill	22	82.7 ± 13.5	0.357
High skill	10	87.5 ± 13.6	
Maximum heart rate, bpm			
All subjects	32	133.3 ± 19.1*	
Low skill	22	131.7 ± 21.3*	0.491
High skill	10	136.8 ± 13.3*	
Average heart rate, bpm			
All subjects	32	107.2 ± 17.8*	
Low skill	22	105.8 ± 18.8*	0.534
High skill	10	110.1 ± 15.7*	

*Indicates $p < 0.05$ compared with the minimum heart rate. p-value listed is for statistical comparison of the heart rate change between skill groups.

acute short-term eSport *Overwatch* game play may in fact lead to greater arousal levels of testosterone in more highly skilled gamers before game play but with game play increases are stimulated in less skilled players.

It has been known for some time that video game play will elevate cardiovascular demands during a game (9). Arousal, visual stimuli, emotional responses, and game play naturally produce a sympathetic drive for elevation in the heart rate above resting levels (18). In this study, we found highly variable heart rate responses in gamers of all skill levels. We report that the heart rate was maintained throughout the game at about 54% of the age-predicted maximal heart rate, and it was variable throughout the game with most heart rates during the game ranging from about 40 to 70% of age-predicted maximal heart rate range. Yeo et al. (26) also demonstrated moderate increases in the heart rate with game play. With sympathetic drive related to game play or anticipatory stress, the elevated heart rate with eSport games is typical for games of all durations (24). Sousa et al. (23) also showed peak heart rate changes; however, first-person shooter games elicited a larger change than did multiplayer online battle arena games. This may explain our general findings for acute cardiovascular stress because of *Overwatch* multiplayer team game play regardless of the skill level.

Practical Applications

At first glance, the passive nature of eSport gaming may indicate little or no physiological stress. However, it is clear from this study that even collegiate gamers experience elevation in heart rate and changes in hypo-pituitary-gonadal functions when playing *Overwatch* in a competitive format. The highly variable response patterns observed for cortisol suggest that changes in sympathetic response may continue as experience with competitive game play increases. Furthermore, the skill level may impact the arousal levels of testosterone including adjustments with game play in lower skilled players. Understanding the physiological responses to competitive gaming is the first step in understanding how best to prepare the eSport athlete for competition. The importance of physical conditioning for eSport performance has yet to be determined, but it is possible that strength and conditioning programs may help counter the negative health effects of sedentary behavior and enhance the glandular adaptations needed to respond to the physiological stress of eSport competition (21,22,27).

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