Exploratory Study of Psychophysiological Stress in Esports: Training and Competition in Professional League of Legends

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One goal of sport psychology research is to assist athletes in adapting their training and competitive behavior to maintain or enhance high-level performance under stressful and competitive conditions. To extend this research into esports, a comprehensive understanding of the stress-performance relationship in esports is essential. This knowledge can subsequently guide future intervention studies focused on enhancing players' performance. This study aimed to explore the relationship between playing esports in competitive settings and psychological and physiological stress among professional League of Legends players. Unlike previous research focusing on non-competitive gameplay, we examined seven male professionals during training and competition, measuring perceived motivation and match importance, as well as perceived stress, affect, emotion, heart rate, heart rate variability, and respiratory rate. Data were collected before, during, and after gameplay, evaluating in-game performance (i.e., kill-death-assist ratio, gold, and self-rated performance). Significant differences were observed, with motivation and perceived match importance being greater during competition compared to training. Our findings substantiate that both psychological and physiological stress responses intensify during competitive gameplay in contrast to training. This supports existing theoretical and empirical research, emphasizing the intricate nature of the stress-performance relationship. Practical and theoretical applications are discussed.

Keywords: emotion; cortisol; heart rate; motivation; psychophysiology; competitive gaming

Sport psychology research, among other goals, aims to assist athletes in optimizing training and competitive behavior to sustain or enhance high-performance levels in stressful and competitive situations (see review by Brown & Fletcher, 2017). Applying a similar approach to esports players could therefore be advantageous (e.g., Cottrell et al., 2019; Leis et al., 2021). A better understanding of stress in esports could support researchers and applied sport psychologists to help players achieve high cognitive (e.g., strategical thinking) as well as motor performance (e.g., fine motor control) in competitive settings (e.g., Leis & Lautenbach, 2020; Nicholson et al., 2020). While existing research has offered insights on psychological aspects (see Bányai et al., 2019; Pedraza-Ramirez et al., 2020 for review) and stress and coping in esports (see Leis et al., 2024 for review), additional investigations into psychophysiological stress in esports are warranted (see Leis & Lautenbach, 2020 for review). Leis and Lautenbach's (2020) review reported mixed results regarding stress in esports competition. In summary, two of the five studies indicated an activation of the sympathetic nervous system (Behnke et al., 2020b; Chaput et al., 2011), whereas three studies showed no hormonal response (Chaput et al., 2011; Gray et al., 2018; Oxford et al., 2010). One study, however, reported an increase in anxiety in winners and an increase in cortisol levels from baseline to postgame conditions (Schmidt et al., 2020). Similarly, research found higher cortisol levels and cognitive anxiety before competition in expert players than non-expert players (Mendoza et al., 2021) and increased heart rate (HR) during competition compared to pre-game play (Andre et al., 2020; Koshy et al., 2020). From a different perspective, research highlighted a number of stressors (e.g., performance pressure) that players associated with stress responses as well as positive and negative performance output (e.g., Behnke et al., 2021; Leis et al., 2022; Poulus et al., 2022a, 2022b; Sharpe et al., 2024ab). However, research on esports competition and whether stress can predict in-game performance is limited (e.g., Behnke et al., 2020a). Thus, the purpose of this study is to (i) investigate whether playing esports in competitive settings is related to psychological and/or physiological stress and (ii) if so, whether stress responses before game play can predict in-game performance.

Model of Neuroendocrine and Mood Responses to a Competitive Situation

According to the Model of Neuroendocrine and Mood Responses to a Competitive Situation (Salvador & Costa, 2009), competition is related to psychophysiological stress responses. This model is divided into pre-competition, competition, and post-competition/recovery. Pre-competition is characterized by the cognitive appraisal of a competitive situation, which is affected by aspects such as previous experience, personality, and generic ability. Appraisal of a competitive situation as challenging (i.e., important, controllable, and dependent on effort) is suggested to relate to active/proactive coping, an increase in testosterone, a decrease in cortisol from baseline, activation of the sympathetic nervous system, and positive mood changes. Active/proactive coping is also associated with a higher probability of victory (transition from competition to post-competition) than passive/reactive coping. The latter coping pattern is adopted more frequently when individuals appraise a situation as threatening or uncontrollable, which is related to an insufficient activation of testosterone and the sympathetic nervous system, negative mood changes, and increases in cortisol compared to resting conditions (Salvador, 2005). After competition (i.e., post-competition/recovery), the appraisal of the outcome (i.e., victory or defeat) affects mood and satisfaction, while hormonal responses are related to victory (i.e., increase in testosterone and decrease in cortisol) and defeat (i.e., decreases in testosterone and increase in cortisol; Salvador, 2005; Salvador & Costa, 2009).

Empirical Evidence

Research has highlighted the relevance of psychological factors to the psychological and physiological stress response before competition (see review by Casto & Edwards, 2016; see meta-analysis by Van Paridon et al., 2017). While Abad-Tortosa et al. (2017) reported an increase in systolic blood pressure from baseline to pre-task, Van Paridon et al. (2017) showed a moderate increase in anticipatory cortisol before competition compared to baseline cortisol levels. Although this anticipatory cortisol response was absent in athletes competing at the international level, evidence suggests that this might be due to other psychological factors such as previous experience (e.g., Kivlighan et al., 2005; Van Paridon et al., 2017). In other words, experienced performers have greater exposure to similar competitive situations, which in turn, has influenced their appraisal and associated stress response. For example, esports players reported more stressors around competitive matches and perceived competitive stressors as more intense than training stressors (Poulus et al., 2022a). In addition, the perceived importance of a competition has been shown to positively impact the psychophysiological stress response, prior to competition (in sports: Lobinger et al., 2018; Passelergue et al., 1995; in esports: Mendoza et al., 2021). When a competition is appraised as challenging, it is associated with more active coping and an increased likelihood of winning (e.g., Filaire et al., 2009; Oliveira & Oliveira, 2014; Wang & Perry, 2006) and lower physiological stress responses (e.g., Gaab et al., 2005; Lautenbach et al., 2015; Tomaka et al., 1997). The opposite has been reported for competitions appraised as threatening. For example, threat appraisal has been associated with an increased and longer cortisol response (e.g., in cyclists Thompson et al., 2020). The stress response of the autonomic nervous system is suggested to relate to state coping-related variables such as task-oriented coping (e.g., Laborde et al., 2015). Increased cortisol levels and negative affect are negatively associated with performance during competition (e.g., putting performance in Doan et al., 2007; unforced errors in tennis in Lautenbach et al., 2014). In a similar vein, research indicates that anticipatory stress regulation can enhance the regulation of physiological stress (e.g., cortisol; Pulopulos et al., 2020). Furthermore, greater activation of the sympathetic nervous system has been found in competitive situations compared to non-competitive situations (e.g., in traditional sports: García-León et al., 2003; in esports: Watanabe et al., 2021). In contrast, studies have demonstrated mixed results regarding post-competition hormonal responses (e.g., cortisol; see Archer, 2006; Geniole et al., 2017; Oliveira & Oliveira, 2014; Salvador, 2005 for reviews). Moreover, studies have emphasized the importance of personal (e.g., age, experience) and situational (laboratory settings) factors (e.g., Casto & Edwards, 2016). Overall, the Model of Neuroendocrine and Mood Responses to a Competitive Situation (Salvador & Costa, 2009) is an appropriate framework for investigating psychological and physiological stress during competitive situations..

Psychophysiological Stress and Performance

Psychological and physiological stress responses have been associated with performance (e.g., Hardy, 1999; Jones & Hardy, 1990; Salvador & Costa, 2009). This relationship is moderated by the performer, the situation, and the task at hand (e.g., Jones & Hardy, 2007). In line with the model of Salvador and Costa (2009), challenge states were primarily reported to benefit performance, whereas threat states were associated with lower performance (see review by Hase et al., 2019). While Behnke et al. (2020b) indicated a relationship between challenge appraisal in players, higher HR and higher in-game scores, authors also demonstrated a relation between higher in-game scores and increased levels of cognitive (challenge evaluation) and cardiovascular response (e.g., higher HR). Similarly, research suggested that pleasant emotions are associated with better sport performance (e.g., Rathschlag & Memmert, 2015; Uphill & Jones, 2007; Vast et al., 2010). Conversely, unpleasant emotions more often relate to lower levels of performance (e.g., Campo et al., 2019; Martinent & Ferrand, 2015; Rathschlag & Memmert, 2015; Uphill & Jones, 2007; Vast et al., 2010). For instance, anxiety has been associated with impaired attentional control and decreased performance (see review by Payne et al., 2019). In addition, happiness has been associated with higher performance (e.g., Rathschlag & Memmert, 2013, 2015; Uphill et al., 2014). Behnke et al. (2020a) found that unpleasant emotions did not impact esports performance. Enthusiasm led to better performance compared to amusement (Behnke et al., 2020a). In contrast, Sharpe et al. (2024a) indicated that elevated anxiety, threat appraisals, and disrupted gaze behavior can negatively affect esports performance. While studies suggest that moderate controllable stress positively impacts high-level cognitive abilities (e.g., undergraduate students performing the Stroop task: Henderson et al., 2012), higher stress levels are associated with decreased global cognition skills and executive functioning (see review by D'Amico et al., 2020).

Mixed results have been shown with regard to the relationship between cortisol and performance (e.g., Doan et al., 2007; Lautenbach & Lobinger, 2018). For example, cortisol has been demonstrated to negatively correlate with performance parameters (Doan et al., 2007; Lautenbach et al., 2014) and negatively predict performance during the competition phase in sport (e.g., Campbell et al., 2020; Cintineo & Arent, 2019). On the other hand, Lautenbach and Lobinger (2018) observed a positive correlation between cortisol level during competition and performance (e.g., Lautenbach & Lobinger, 2018; Rano et al., 2018). However, studies also report no correlation between cortisol and cognitive performance (e.g., Casanova et al., 2020; Oumohand et al., 2020).

HR and HR variability (HRV) have been linked to performance outcomes in various contexts (Etxegarai et al., 2018; Ortega & Wang, 2018; Urzeală et al., 2020). HRV, referred to as the variation in time intervals between successive heart beats (Camm et al.,1996), reflects the dynamic interplay between sympathetic and parasympathetic branches of the autonomic nervous system (e.g., Mosley & Laborde, 2022). While not a direct stress indicator, HRV is lined to self-regulation and health (e.g., Thayer et al., 2009). An important aspect of HRV is its interaction with respiratory rate (RR), which also influences autonomic balance (e.g., Thayer et al., 2011). When vagally mediated HRV (vmHRV) is diminished, it indicates that the parasympathetic response is weaker, allowing the sympathetic nervous system to become more dominant, relating to increased RR and HR. For instance, athletes who experience anxiety before a competition may exhibit reduced vmHRV, indicating that those with higher anxiety levels may struggle to regulate themselves effectively in challenging environments (e.g., Mosley & Laborde, 2022). This suggests that stressors encountered by performers often lead to decreased vmHRV. Increased sympathetic activity can negatively affect precision activities like shooting and archery, which require fine motor control similar to esports (Armuand et al., 2019; Ortega & Wang, 2018; Pedraza-Ramirez et al., 2020). For instance, Ortega and Wang (2018) found higher vmHRV correlated with better self-efficacy and shooting performance. Research further indicates that athletes who perceive events as challenging tend to have higher root mean square of successive differences (RMSSD) in HRV compared to those who view events as threatening (Mosley & Laborde, 2022). In the context of esports, research indicates that semi-professional and professional players demonstrate greater HRV during stressful periods of gameplay, suggesting that expertise may enable players to manage in-game stressors more effectively (Ding et al., 2018; Hong et al., 2018). This enhanced HRV, likely associated with more controlled breathing and better autonomic balance, can be an indicator of improved self-regulation and performance in esports (Welsh et al., 2023).

Study Purpose

Applying the Model of Neuroendocrine and Mood Responses to a Competitive Situation (Salvador & Costa, 2009) could provide a better understanding of the effects of psychophysiological stress in esports. In turn, this research could inform future intervention strategies aiming to positively impact players' cognitive and motor performance (e.g., Leis & Lautenbach, 2020). In contrast to previous studies that primarily focused on physiological stress in non-competitive game play in amateur players (see review by Leis & Lautenbach, 2020), this study aims to assess both psychological and physiological stress responses. While previous studies primarily investigated non-competitive game play (e.g., Ferguson et al., 2016) and amateur players (e.g., Schmidt et al., 2020), this study assesses stress responses during training and actual competition in professional esports players. In addition, this study addresses limitations of previous studies (see review by Leis & Lautenbach, 2020) such as prior assessment of motivation and perceived match importance. Furthermore, the present study assesses performance data and investigates whether pre-competition stress responses can predict in-game performance.

Based on previous research (e.g., Mendoza et al., 2021) and theoretical frameworks on competition, we assume that (H1) perceived motivation and match importance is higher in competitive than training matches. We further hypothesize that (H2) psychological and physiological stress responses (i.e., perceived stress, anxiety, affect, HR, RR) are higher before and during competitive game play than responses in relation to game play during training (e.g., Leis & Lautenbach, 2020; Oliveira & Oliveira, 2014; Salvador & Costa, 2009; Van Paridon et al., 2017). Additionally, we hypothesize that HRV (RMSSD) is lower before and during competitive game play compared to training settings. Given that the relationship between stress and performance varies with individual stress levels and that research in esports contexts is limited, our study aims to explore how psychological and physiological stress responses relate to performance outcomes. We hypothesize (H3) that psychological and physiological stress responses (i.e., perceived stress, anxiety, affect, HR, RR) will be associated with performance metrics, such as game outcomes, kill-death-assist ratio, gold income, and self-rated performance, though the direction of these associations remains to be determined..

Method

Participants

To determine the sample size of the present study, effect sizes of previous research on psychophysiological stress in esports were analyzed (see review by Leis & Lautenbach, 2020). Opting for a medium effect size of f = .25, we conducted a priori power analysis using G*Power 3.1 (Faul et al., 2009). This resulted in a required sample size of N = 24 participants for a repeated-measures MANOVA (within-interaction) with a statistical power of .80 and an α level of .05. Anticipating potential missing or incomplete data, we aimed to recruit 27 participants (+10 %).

Despite initial interest from multiple esports teams, only three teams participated, representing 15% of the overall population in the League of Legends (LoL) European Championship and La Ligue Française (defined as elite; as per Poulus et al., 2024). Challenges in recruiting more professional players and teams included, but were not limited to, recurring delays in discussing potential measurements, staff and player turnover within teams, and the perceived limited value of our time-intensive study (Mmin = 111.07; *SD* = 23.88). Additionally, not all players involved in training sessions participated in stress response measurements during competitive match due to recent defeats impacting their willingness to participate in the study (n = 2), prioritizing full focus (n = 2), and study design conflicts with competitive regulations prohibiting Bluetooth device use on stage (n = 5). While 14 professional LoL players were measured during training sessions, only seven players were measured during competition. To counterbalance between training and competition measurements for methodological consistency and allow for a within-subject design, the seven players exclusively involved in training measurements were excluded from the study's analysis.

The remaining seven players were male, aged average 21.14 years (*SD* = 1.77), spent 55 h per week playing LoL (*SD* = 10.41), had 8.29 years of experience (*SD* = 1.11), and were ranked Master (n = 1), Grandmaster (n = 2), and Challenger (n = 4). According to the elite classification system (Poulus et al., 2024), the competition standard can be described as elite, encompassing international competitions. Furthermore, both success and experience at the highest level of competition are positioned on the substantial end of the continuum (ranging from minimal to substantial). The participants' in-game positions were distributed as follows: two players each in the roles of midlane and support, while one player occupied each of the jungle, toplane, attack-damage-carry positions. The players represented diverse nationalities, with one player each from Croatia, France, Germany, Greece, Poland, Sweden, and the United Kingdom.

Participating esports players were required to (1) play LoL in professional leagues (i.e., League of Legends European Championship, Prime League Pro Division, La Ligue Française), (2) have at least one year of experience, (3) earn money as an esports player, (4) be over 18 years old, and (5) speak English or German. Since health conditions significantly affect psychological and physiological stress responses, exclusion criteria for health regarding psychological (e.g., drug addiction) and physiological conditions (e.g., heart disease) were also used to narrow the focus to valid results. LoL was selected due to its status as one of the most popular esports titles, featuring an advanced competitive structure, substantial prize pools, and a large audience (League of Legends, 2024)..

Procedure

The study received ethical approvement from the lead author’s university ethics board (2020.06.10_eb_46) and preregistered through the Open Science Framework: (https://osf.io/7zudv/?view_only=ba78bdfed342470fb94783f7f97c71d3). Participants were recruited through contacting esports clubs and via personal contacts. Upon team approval, participants received information letters and consent forms. Following current guidelines, in particular for the planned cortisol measurements, participants were instructed to: (i) maintain their usual sleep routine the night before the testing and wake up at least 3 hours before the experiment, (ii) refrain from consuming anything except water, chewing gum, or smoking for at least one hour before the experiment, and (iii) abstain from alcohol consumption, brushing teeth, or engaging in intense physical training

24 hours before the experiment (e.g., for cortisol see Kirschbaum & Hellhammer, 2000; for HR and HRV see Laborde et al., 2017). Although the initial plan was to measure cortisol during training and competition, this measurement was ultimately removed. The decision was due to difficulties in collecting data from all participants, as many adhered to routines such as consuming coffee, chewing gum, or eating, which could affect saliva cortisol levels. Additionally, logistical issues, including failed transportation to the laboratory, further hindered data collection.

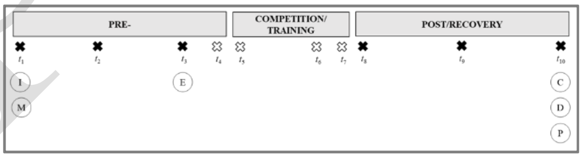
Psychophysiological stress responses were assessed pre and post-gameplay, comprising training and competitive matches. Competitive gameplay involved official league matches from the players leagues, which offered significant competitive opportunities regularly. Training sessions entailed typical practices, including 'scrims'. Scrims refer to competitive matches against other teams for practice purposes. To familiarize participants with the study design and address potential questions, as well as to minimize distractions during competition, measurements during training were initially conducted with two experimenters present (author 1 and 2). Prior to testing during training sessions (scrims), all participants received a brief project presentation and were invited to ask questions. Subsequently, training and competition testing procedures were identical (see Figure 1).

HRV devices (Bittium Faros 180°, IP67, Kuopia, Finland) were initially set up by the lead author to collect HR and HRV data continuously throughout the experiment (t1–t10). Approximately 53 min (*SD* = 14) before gameplay (t1), perceived stress, affect, motivation and perceived match importance were measured via questionnaires. The assessments of perceived stress and affect were repeated at each time point: approximately 53 min (*SD* = 14) before gameplay (t1), 37 min (*SD* = 10) before gameplay (t2), 23 min (*SD* = 10) before gameplay (t3), immediately after gameplay (t8), and 15 min (*SD* = 3) after gameplay (t9).

A broad time window before gameplay (e.g., t3) was necessary due to competitive rules in LoL, which prohibit non-players from being present 10 min before the game starts. Measurement points t4– t7 (Figure 1, white crosses) exclusively included HR and HRV measurements, with t4 marking the champion selection (players selecting and banning avatars) and t7 indicating the end of gameplay. However, the measurement point at t10 (30 min after game play) was excluded from the analysis, as teams chose to proceed immediately with subsequent scrimmages and competitive games, contrary to the initial study design consensus. At 23 min before gameplay (t3), participants completed the Sports Emotion Questionnaire (SEQ; Jones et al., 2012) to evaluate emotional responses toward the upcoming game. After each measurement, a manipulation check was conducted to ensure adherence to the study protocols. Participants were asked about their compliance with the provided instructions (e.g., abstinence from smoking and alcohol), their recent physical activity (e.g., “When did you last exercise?”), their sleep patterns (e.g., “What time did you wake up this morning?” and “What time did you go to sleep last night?”), and any relevant medication or health issues (e.g., “Do you have any chronic heart conditions or respiratory issues?”). Additionally, demographic data were collected, including weekly hours of gameplay, experience in LoL, in-game rank and points, and self-rated performance on a scale from 1 (very, very poor) to 11 (excellent).

Figure 1

Measurements during training and competition



Note. I = perceived match importance; M = perceived motivation; black crosses = perceived stress, affect grid; E = Sport Emotion Questionnaire; white crosses = HR and HRV measurements taken at 5-minute intervals, with no other measurements occurring during these times; C = manipulation check; D = demographic data; P = self-rated performance.

This procedure was repeated during competition, typically occurring on average 1.57 days (*SD* = 0.53) after training measurements, depending on each team’s competitive schedule. Training measurements were conducted from 1:30 and 6.02 pm, while competitive measurements took place between 6:49 and 09:12 pm. Although there were slight variations among teams, these time disparities between training and competition were necessary to align with team schedules and assess official esports competition.

Material and Measurements

Demographic Data, Motivation, and Perceived Match Importance

Demographic data included age, experience (i.e., practice hours per day, experience in years), nationality, current league and rank, and role in the team (i.e., top-lane, mid-lane, jungler, attack-damage-carry, supporter). In addition, smoking and drinking behavior, height, weight, and medication were assessed (Laborde et al., 2017). Furthermore, players' motivation and perceived match importance were recorded using visual analogue scales (VAS; Hayes & Patterson, 1921). These parameters were collected to ensure that the match is stimulating enough for participants (e.g., Mendoza et al., 2021). Participants were asked to indicate their motivation and match importance on two separate 100-mm vertical lines from "not at all" on the left and "extremely" on the right side of the line (motivation: "Please note how motivated you feel at this moment regarding the upcoming game."; perceived importance: "Please indicate how important you perceive the upcoming game."). These crosses will then be measured as the distance (in mm).

Perceived Stress

VAS were used to assess perceived stress intensity (Hayes & Patterson, 1921), whereby participants will be asked to indicate their perceived level of stress somewhere on the 100-mm vertical line with a cross (i.e., "Please note how stressed you feel at this moment…"). The anchors "no stress at all" and "maximum stress" are located on the left and right side of the line, respectively.

Affect

A single-item scale, the affect grid (Russell et al., 1989), was used to measure affect intensity and valence. This scale consists of a 9×9-unit square, with the anchors "unpleasant feeling" on the left and "pleasant feeling" on the right. For arousal, high arousal is located at the top and sleepiness at the bottom. The participants were required to make one cross on the grid ("Please rate how you are feeling right now").

Emotions

The Sport Emotion Questionnaire (see SEQ; Jones et al., 2012) was used to assess emotions related to competition. The SEQ provided information on positive and negative dimensions of emotion immediately before a competitive match using five subscales, namely "anxiety", "dejection", "excitement", "anger", and "happiness". To assess these subscales, participants were provided with a list of 22 adjectives (e.g., "joyful", "nervous", "energetic") and were instructed to indicate how they felt in the moment on a five-point Likert-scale ("not at all" to "extremely") in relation to upcoming game play.

Heart Rate, Heart Rate Variability, and Respiratory Rate

HR and HRV were measured using an electrocardiogram (ECG) device (i.e., Bittium Faros 180°, IP67, Kuopia, Finland) attached to two disposable ECGs (Ambu L-00-S/25, Ambu GmbH, Bad Nauheim, Germany). Similar to previous studies on cardiac vascular activity (e.g., Laborde et al., 2021), the negative electrode was placed in the right infraclavicular fossa, while the positive electrode were placed on the left lower abdomen. To assess cardiac vagal activity and avoid limitations from respiration (Hill et al., 2009), RMSSD were extracted using the software Kubios HRV Premium (University of Eastern Finland, Kuopio, Finland). Kubios' medium correction algorithm was applied to identify and exclude sections containing more than 5% artifacts. In addition, RR was measured in milliseconds to gain a better understanding of whether potential changes in RMSSD are related to cardiac vagal activity (e.g., Laborde et al., 2017; Thayer et al., 2011). RR was analyzed using the ECG-derived respiration algorithm of Kubios (Tarvainen et al., 2014). To analyze HR, HRV, and RR a 5-min interval were used (Laborde et al., 2017). During game play these intervals focused on the first 5 min (t5), the last 10 -5 min (t6), and the last 10 min of game play (t7).

Performance Parameter

To assess players' performance, the following parameters were collected: kill-death-assist ratio (KDA), gold, and self-rated performance. The outcome, KDA, and gold income were automatically processed by the game. Since game statistics have been argued to be limited in capturing (athlete) performance (e.g., Campo et al., 2019; Sharpe et al., 2022), players were asked to rate overall performance to also address player's subjective experience of their performance. In accordance to Robazza et al. (2012), participants were asked to rate their performance approximately 15 min after game play (t9) from 1 (i.e., “very, very poor”) to 11 (i.e., “excellent”).

Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics version 29 (IBM Corp., Armonk, NY, USA). Prior to analysis, data were examined for normality using the Kolmogorov-Smirnov test and screened for outliers, defined as values exceeding three standard deviations from the mean (Tabachnick & Fidell, 2019). Cases with missing data were excluded from the analysis using listwise deletion (Kang, 2013). A paired samples t-test was used to test hypothesis H1 regarding the differences in perceived motivation and perceived match importance between training and competition. To test the second hypothesis (H2) regarding differences in psychological (affect, emotions, perceived stress) and physiological stress (HR) between training and competition conditions, a series of repeated measures analyses of variance (ANOVA) were conducted (Field, 2017). Effect sizes for significant differences were calculated using Cohen's d, with interpretations based on Cohen's (1988) guidelines: small ($0.2 \leq d < 0.5$), medium ($0.5 \leq d < 0.8$), and large ($d \geq 0.8$). To address the third hypothesis (H3) concerning the predictive relationship between stress responses and esports performance, stepwise multiple regression analyses were performed (Hair et al., 2018). Stress-related variables (HR, affect, emotions, perceived stress) measured at three time points (t1-t3) were entered as independent variables, while in-game performance metrics (KDA ratio, gold accumulated, self-rated performance) served as dependent variables. The stepwise method was chosen to identify the most significant predictors while minimizing multicollinearity issues (Chatterjee & Hadi, 2015). We acknowledge that stepwise regression has limitations, such as potential overfitting (Smith, 2018). Although the Enter method might be more suitable given our small sample size, its complexity and our study’s constraints led us to choose the stepwise method as a practical approach.

Results

Motivation and perceived match importance showed a difference between training and competition. In training, motivation scored 5.23 (*SD* = 1.11), contrasting with a higher score of 7.34 (*SD* = 1.56) in competition (p = .048; d = -.938). Similarly, perceived match importance was lower in training (*M* = 5.93; *SD* = 1.25) than competition (*M* = 7.59; *SD* = 1.62; p = .058; d = -0.882).

As shown in Figure 2, perceived stress in training and competition demonstrated a similar pattern, with the highest score reported immediately after gameplay (t8). At t2 a difference in perceived stress was demonstrated, with the competitive group scoring significantly higher than the training group (p = .049; d = -0.929).

Regarding affect, a significant difference in arousal was found at t8 with 7.00 (*SD* = 1.83) in training and 7.86 (*SD* = 1.68) in competitive settings (p < .001; d = -2.268). Pleasure scores were significantly higher in competition than training at t1 (p = .009; d = -1.419), t2 (p = .022; d = -1.155), t3 (p = .015; d = -1.269) , and t8 (p = .035; d = -1.025). The changes in affect are illustrated in Figure 3. In general, affect demonstrates higher scores for arousal and valence during training compared to training.

With exception of happiness, no significant differences were found in the positive and negative dimensions of emotion immediately before gameplay, as indicated by the five subscales of the SEQ (Jones et al., 2012) — between the training and competition group (see Figure 4). Specifically, happiness was higher during training compared to competition (p = .039; d = 0.996).

Except for t1, t2, t3, and t8 (55 min, 37 min, and 23 min before gameplay, immediately after gameplay), significant differences in HR were found between competition and training (see Figure 5). Specifically, participants displayed higher HRs at t4 (p = .036; d = -1.014), t5 (p < .013; d = -1.329), t6 (p < .003; d = -1.817), t7 (p < .001; d = -2.240), and t9 in competition than training settings (p < .001; d = -2.874). Regarding HRV, RMSSD exhibited statistically significant differences between training and competition settings at t5 (p = .043; d = 0.970) and t6 (p = .011; d = 1.358; see Figure 6). As indicated in Figure 7, RR demonstrated a significant difference with higher values during training than competition at t4 (p = .039; d = 0.995), t5 (p = .022; d = 1.161), t6 (p = .005; d = 1.608) t7 (p = 002; d = 1.890), and t9 (p = 002; d = 2.541).

In addition, anxiety correlated with the kills achieved (r = -.827; p = .022) and assists (r = -.850; p = .015). Additionally, kills were related to pre-game motivation (r = -990; p = .009), valence 53 min before the game (r = -.774; p = .041), and 37 min before the game (r = -.759; p

= .048), while assists also correlated with valence 53 min (r = -.773; p = .041) and 37 min before the game (r = -.759; p = .048). Anxiety also correlated with kills (r = -.827; p = .022) and in-game assists (r = .850; p = .015) in competition, while kills were associated with the following aspects: motivation (r = -.880; p = .009), valence 53 min before (r = -.774; p = .041), and 37 min before the competition (r = .868; p = .011). Additionally, assists correlated with valence 37 min and 53 min before the competition (r = .-773; p = .041; r = -.759; p = .048).

Figure 2

Perceived Stress: Training vs. Competition

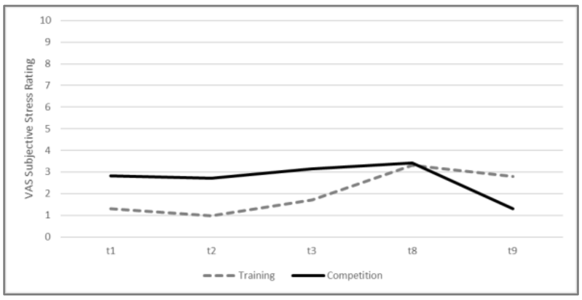
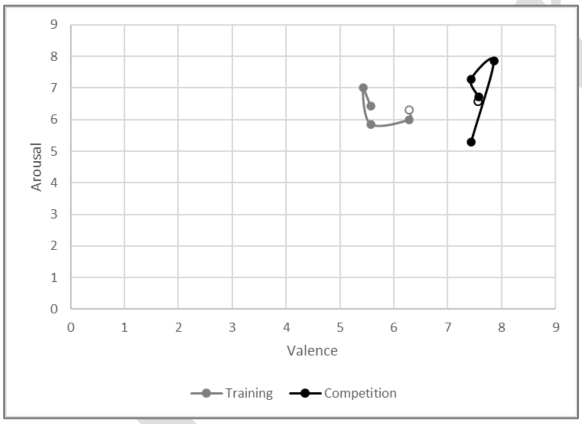


Figure 3

Affect: Training vs. Competition



Note. t_1 is indicated by the white dot.

Figure 4

Positive and Negative Emotions Before Gameplay: Training vs. Competition

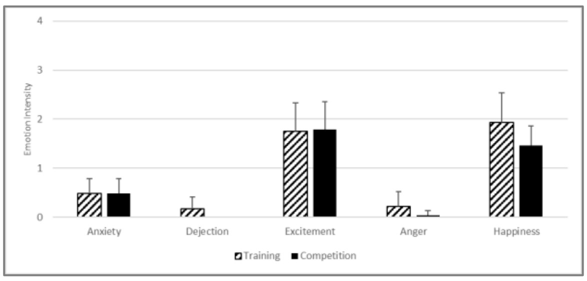


Figure 5

Heart Rate: Training vs. Competition

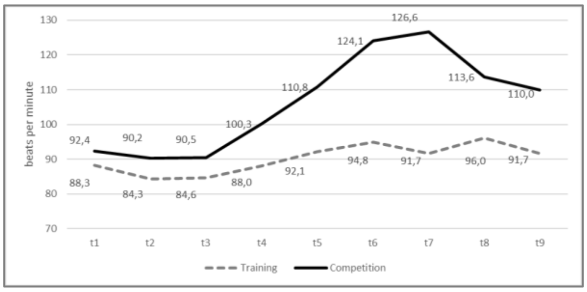


Figure 6

Heart Rate Variability (RMSSD): Training vs. Competition

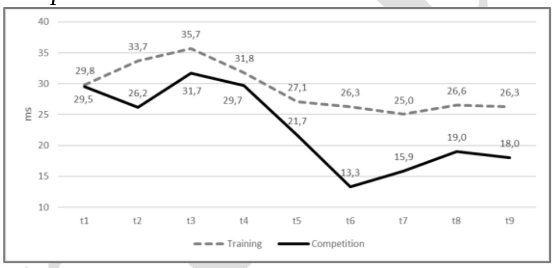
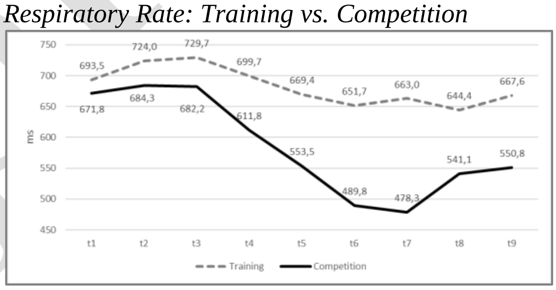


Figure 7

Respiratory Rate: Training vs. Competition



Discussion

The findings aimed at examining the psychological and physiological stress responses during competitive gameplay in comparison to training, and their predictive relationship with performance. Consistent with our hypotheses, significant differences were observed in motivation and perceived match importance, with higher scores during competition (H1). Perceived stress was significantly higher in the competitive group approximately 37 min before gameplay (t2), partially supporting our hypothesis of heightened stress responses in competition (H2). Arousal and pleasure (affect) displayed few significant differences, primarily related to greater pleasure during competition. Despite higher happiness during training, no significant differences were found in the five dimensions of emotions immediately before a competitive match, as measured by the SEQ subscales (Jones et al., 2012). While players exhibited higher HRs during competition compared to training (at t4, t5, t6, t7, and t9), RMSSD showed differences between training and competition settings at t5 and t6. Additionally, RR demonstrated differences, with higher values during and after gameplay in training compared to competition. The correlation analyses unveiled significant relationships between anxiety levels and gameplay performance in esports (H3). Anxiety negatively correlated with kills and assists, indicating a potential impact on player performance. Furthermore, anxiety was linked to pre-game motivation and valence, suggesting its influence on player appraisals and emotional state before competition. Kills and assists also showed correlations with pre-game motivation and valence, emphasizing the interplay between psychological factors and in-game performance in esports competitions. While this study revealed a trend with training matches being lost and competitive matches being won, suggesting a potential association between heightened arousal and favourable performance outcomes, further research and larger sample size are needed to substantiate this preliminary observation and explore the intricate dynamics of arousal in different competitive contexts.

Overall, these findings substantiate that psychological and physiological stress responses are heightened during competitive gameplay compared to training. The findings of the current study align with the predictions of the Model of Neuroendocrine and Mood Responses to a Competitive Situation (Salvador & Costa, 2009), as well as empirical evidence from traditional sports research (e.g., García-León et al., 2003). However, the absence of cortisol data limits our ability to fully explore the neuroendocrine aspects of the stress response, particularly hypothalamic-pituitary-adrenal axis activity. The observed differences in motivation, perceived match importance, and psychophysiological stress responses between training and competition settings corroborate the model's proposition that competition is associated with heightened cognitive appraisal and subsequent stress responses. This suggests that the stress-performance relationship in esports may operate in a similar manner to traditional sports, despite the unique cognitive and motor demands of esports. The elevation in perceived stress, heart rate, and affective changes during competition further support the notion that competition serves as a distinct stressor that triggers robust psychological and physiological responses (e.g., Leis et al., 2022; Salvador, 2005). This is consistent with previous research in traditional sports highlighting the relevance of cognitive appraisal in shaping pre-competition stress responses (e.g., Lobinger et al., 2018; Mendoza et al., 2021). The current findings expand this understanding to the esports context, suggesting that the cognitive appraisal of a competitive situation as challenging or threatening may similarly impact stress responses and, in turn, influence performance outcomes in esports players. Moreover, the correlations between self-rated performance, valence, and performance metrics (e.g., kills, assists) align with previous research demonstrating the influence of psychological states on subjective and objective performance assessments in sports (Lautenbach & Lobinger, 2018; Oliveira & Oliveira, 2014). This further highlights the multifaceted nature of the stress-performance relationship and the importance of integrating sport psychology practices to support esports players in effectively regulating their cognitive, emotional, and physiological states during competition.

Furthermore, the correlations between self-rated performance and valence, and the negative correlations between kills and arousal and anger, partially support that psychological states influence subjective performance assessments and performance metrics (Lautenbach & Lobinger, 2018; Oliveira & Oliveira, 2014). These findings align with recent investigations indicating that competitive esports players experiencing heightened stress tend to report elevated levels of cognitive anxiety, increased threat appraisals, and exhibit suboptimal gaze behaviour (i.e., search rate and pupillometry), ultimately resulting in poorer action performance (Sharpe et al., 2024a). In summary, the findings contribute to and affirm existing theoretical and empirical foundations, highlighting the multifaceted nature of stress-performance relationship (e.g., Lautenbach & Lobinger, 2018; Ortega & Wang, 2018). While this study highlights the value of further investigating the stress-performance relationship in esports, particularly given the anticipated absence of external factors, esports such as LoL present unique challenges, such as low perceived value as noted in this study. These findings also underscore the importance of integrating sport psychology practices and support within esports (e.g., Swettenham et al., 2024).

Limitations

A primary limitation of this study is the small sample size, resulting in lacking generalizability. A challenge encountered during the data collection phase was the withdrawal of some players from competitive measurements (n = 7). This introduces the potential for selection bias and may affect the representativeness of the final sample, warranting caution when interpreting findings. In addition, training matches were lost while competition matches resulted in victory introduces a potential confounding variable. The divergent performance outcomes raise questions about the influence of external factors that may not have been adequately controlled for (e.g., performance opponent team), impacting the internal validity of the study. Furthermore, the absence of cortisol data is a limitation restricting the exploration of a critical dimension of the stress response, specifically hypothalamic-pituitary-adrenal axis activity. Moreover, this study did not implement controls for players' utilization of self-regulation strategies during training and competition, which may have impacted the players' psychophysiological stress responses (for overview of coping strategies in esports, see Leis et al., 2024). Moreover, the study did not address all aspects of the Model of Neuroendocrine and Mood Responses to a Competitive Situation (Salvador & Costa, 2009), such as antecedents (e.g., personality, social status) and outcome appraisals (e.g., mood, causal attribution), suggesting the need for future research on its application to esports. The study focused on a particular esports domain, namely LoL. As such, caution is advised when extrapolating the results to different esports genres characterized by diverse cognitive and physical demands.

Practical Implications

The insights gained from the present study provide several practical implications for players, coaches, and practitioners in esports. Acknowledging the impact of cognitive appraisal on stress responses and performance outcomes underscores the importance of pre-competition (mental) preparation. While mental preparation should be tailored to individual players, strategies could include self-talk, imagery, pre-performance routines, breathing techniques, or reappraisal and mindset interventions (Behnke et al., 2024; Leis et al., 2023; Sharpe et al., 2024b), depending on the athletes optimal arousal levels. In addition, goal setting have been shown to positively influence motivation and performance in sports (e.g., Lehner & Schuster, 2023), with process goals demonstrating the largest effect on performance (d = 1.36), compared to performance (d = 0.44) and outcome goals (d = 0.09; Williamson et al., 2022). To support players implementing self-regulation strategies, monitoring of psychophysiological stress parameters, such as HR and emotions, can facilitate continuous performance optimization. A longitudinal approach could allow for identification of individual stress response patterns, adjustments to training and competition, and sport psychology interventions. Supplementing these measures, educational programs focusing on the role of cognitive appraisal (e.g., Sharpe et al., 2024) or the stress-performance relationship could be a valuable resource for players and coaches (e.g., Smith et al., 2019; Swettenham et al., 2024). This approach could support players in reflecting on their cognitive appraisal, individual stress response, and coping strategies. To achieve greater outcomes, the players' broader environment (e.g., coaches, parents) should be acknowledged (e.g., Henriksen et al., 2014). It is imperative to recognize that the effectiveness of these strategies is dependent upon a long-term perspective, emphasizing continuous effort over quick fixes.

Future Research

Future research should build upon the insights from the current study by expanding participant samples and/or incorporating longitudinal research designs to better explore the relationship between psychological, physiological, and performance metrics (e.g., Leis & Lautenbach, 2020). Additionally, identifying key parameters for indexing performance (e.g., Sharpe et al., 2022) is crucial for understanding the stress-performance relationship. Importantly, future studies should include cortisol measurements to fully capture the sympathetic nervous system activity and provide a complete picture of the physiological stress response (e.g., Salvador & Costa, 2009). Intervention strategies aimed at regulating stress during training and competitive situations in esports. Initial insights have been provided by recent studies, such as those focusing on adapted coping effectiveness training (Poulus et al., 2023), team-building strategies (Swettenham & Whitehead, 2022), and reappraisal and mindset interventions (Behnke et al,, 2024; Sharpe et al., 2024). However, more research is needed as highlighted by differing results. For example, both Behnke et al. (2024) and Sharpe et al. (2024) reported that mindset interventions had a positive effect on appraisals, however, only Sharpe et al. (2024) demonstrated a positive impact on performance. Investigating the efficacy of interventions strategies in esports will contribute to the development of targeted and evidence-based stress regulation interventions tailored to the unique demands of esports. To address recruitment challenges with professional players, future research should focus on building early relationships with esports teams (e.g., players, coaches, management). Study designs may be flexible to accommodate team schedules and utilize non-intrusive, time-efficient data collection methods that can be integrated in teams routines. Developing familiarity with team environments and building rapport are essential for accommodating participants and effectively communicating the value of findings through follow-up presentations, tailored workshops, or partnerships. Integrating the study into training sessions can also normalize participation and emphasize its relevance.

Conclusion

This study highlights the heightened psychological and physiological stress responses experienced by esports players during competitive gameplay compared to training. The findings confirm the significant role of motivation and perceived match importance, as well as the interplay between anxiety and performance metrics, emphasizing the complex relationship between cognitive appraisal and stress responses in competitive contexts. Despite limitations such as the small sample size and absence of cortisol measures, these results provide valuable insights for players, coaches, and practitioners, underscoring the importance of tailored mental preparation and self-regulation strategies. Future research should build on these findings by expanding participant samples, exploring longitudinal designs, and investigating effective stress regulation interventions tailored to the unique demands of esports. Overall, this research contributes to a deeper understanding of the psychophysiological dynamics in esports, paving the way for enhanced performance and well-being among players.

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Author Contributions

Oliver Leis: Methodology, Investigation, Data Curation, Formal analysis, Writing Original Draft, Funding Acquisition, Project administration; **Gantima Praisan**: Investigation, Writing – Review and Editing; **Ismael Pedraza-Ramirez**: Writing – Review and Editing; **Benjamin T Sharpe**: Writing – Review and Editing, Formal analysis; **Sylvain Laborde**: Writing – Review and Editing; **Franziska Lautenbach**: Conceptualization, Methodology, Writing – Review and Editing, Funding Acquisition

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