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Physiological and Perceptual Response to a Live Collegiate Esports Tournament

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ABSTRACT

International Journal of Exercise Science 13(6): 1418-1429, 2020. Competitive esports has grown rapidly across the globe justifying a need to quantify the physiological stress response to this environment. The purpose of this study was to describe the physiological and perceptual responses in a live collegiate esports tournament. Male members of the University of Mississippi Esports team (n = 14; age = 19.8 ± 1.0 years; BMI = 24.1 ± 5.5) completed the study during the esports Egg Bowl. Heart rate (HR) and heart rate variability (HrV) were collected pre-, during, and post-competition. Rating of perceived exertion for the session (S-RPE) and mental fatigue were collected post competition. Mean HR during competition were significantly elevated compared to mean pre- and post- (131.4 ± 19.0 bpm vs. 97.1 ± 19.9 bpm and 101.9 ± 17.4 bpm; p = 0.000) and peak HR during competition were significantly elevated compared to peak pre- and post-(188.1 ± 32.9 bpm vs. 119.6 ± 20.1 bpm and 119.9 ± 16.3 bpm; p = 0.000). R-R intervals were significantly lower in-competition (465.71 ± 68.99) compared to pre- (643.64 ± 138.54) or post- competition (616.07 ± 109.98; p = .000). No significant differences were found in rMSSD, (ln) rMSSD, SDNN, or NN50 across the three measurements. LF was lower post- competition than pre-competition (d = 0.278). Participants indicated moderate mental fatigue (3.7 ± 1.2; on a scale of 1-7). These findings demonstrate competing in esports causes a physiological stress response. Given the elevated HR, further understanding of the chronic physiological stress to competitive esports is warranted.

KEY WORDS: Video games; heart rate; HrV; RPE; mental fatigue

INTRODUCTION

Electronic sports (esports) most commonly refer to organized competitive video gaming in front of live audiences at the amateur and professional levels. Popular games at the present include Fortnite, Counter Strike: Global Offensive, Dota 2, and League of Legends (38). Competitions are streamed and watched by people all around the world (7). Often there are trophies and prize monies awarded to the victors.

The proliferation of esports has been both rapid and unremitting since their inception. Today, the top players in the world can earn seven figures in one year by competing in and winning some of the biggest esports tournaments (39). In 2014, there were over 67 million League of Legends players monthly, with an estimated 27 million people playing daily, and the company's annual revenue approached $1 billion (29). Fortnite, which is available to play for free, generated over $300 million dollars in the month of May 2018 alone from in-game purchases (17). Rapid growth has also taken place in the viewership of esports. The 2014 League of Legends championship garnered 27 million viewers, while the NBA Finals, according to ESPN, had only 15.5 million viewers that same year (7). A growing number of U.S. universities now offer esports scholarships, up from one program at Robert Morris University in 2014 to over 200 programs to date (21, 6). Varsity esports are governed by the National Association of Collegiate esports (NACE), and major U.S. college athletic conferences are now offering sanctioned esports conference championships (e.g., the Big 10). Scholarships of up to $30,000 are awarded for winning tournaments (34). Finally, the 2022 Asian Games are considering esports as a medal event for the first time in history (8).

Despite the remarkable surge of popularity in esports, academic literature addressing the physiological stress response to playing esports is currently nonexistent. Although there has been considerable debate about where esports fall within the greater culture of sports, and these debates are explored in other publications (16), it is undeniable that esports represent a nascent field of study for physiologists. Although esports may share and sometimes even exceed the fandom and viewership of traditional sports, they are played entirely from sedentary positions. Sedentary behavior, which is most commonly defined as activities with energy expenditure in the range of 1.0 to 1.5 metabolic equivalents of task (METs; (1), is known to be associated with negative health outcomes. Competing in esports, however, is likely not eliciting the same physiological stress response as working at a desk, sitting quietly while reading, or watching television, and therefore necessitates further research. If competitive esports instead act as an external stressor on cardiovascular function despite being played from sedentary positions, and esports players are training and competing for hours each day, the sport's impact on health should be known.

Although evidence is scant regarding esports, there is a wealth of literature examining the effects of exercise and conventional athletics on heart rate (HR; 12, 20, 38) and more recently on heart rate variability (HrV; 25). HrV is a measure of the variation in the intervals between each heartbeat and the time-domain indices quantify the amount of HrV observed during monitoring periods. A high HrV indicates greater parasympathetic regulation, and is both healthy and desirable, whereas low HrV indicates greater sympathetic stimulation and is related with an increased risk of cardiac issues including sudden cardiac death (40). During exercise, sympathetic activity increases while parasympathetic activity declines, influencing HrV. Previous research indicates that exercise intensity and cardiovascular stress may determine HrV responses (23), and in a study using college age males, it was reported that HrV did not return to baseline values in the 30-minute post exercise recovery period (15). While recovery HR is a well-established marker of cardiac health, recovery HrV may be an indicator related to training load and recovery, though more research is needed in this area.

In relation to esports, researchers have reported overweight and obese males to display increases in cardiovascular response when playing videogames in a non-competitive gaming environment (35). Additionally, anecdotal reports of League of Legend players experiencing heart rate responses above 180bpm during tournaments exist, although these are unconfirmed. A recent study utilizing College esports competitors in League of Legends did not observe any changes in hormonal markers (testosterone, cortisol [stress marker], and DHEA) playing against computer opponents. However, correlations did exist between the time spent playing (15-27 minutes) and changes in these markers (13). This suggests that longer playing durations may plausibly have a greater physiological impact, though this data was collected during a simulation and not in a competitive live environment, which may be needed to observe a stress response.

The global rise of esports shows no signs of slowing down. Given the paucity of research in the area, investigations are warranted to better understand how the body responds to the playing esports, and specifically to esports competitions. The purpose of this study was therefore to describe the physiological stress response to a live competitive collegiate esports tournament. A secondary aim was to examine perceptual responses to playing esports during competition, which can shed light on the appropriateness and utility of commonly used perceptual response measures in exercise to esports (e.g., rate of perceived exertion [RPE] and mental fatigue). The results of this study represent a first step in our understanding of the health impacts of participating in competitive esports, and in the measurement of perceptual responses to esports.

METHODS

Participants
University of Mississippi students who were varsity members of the esports team and would be competing in the upcoming inaugural esports Egg Bowl tournament were invited to participate in this study. Of the 32 esports players competing in the 7 games that made up event, 18 agreed to participate across 5 games: (5 Overwatch, 3 Super Smash Bros., 3 Rocket League, 2 Counter Strike: Global Offensive, and 5 Call of Duty: Black Ops 4 players; League of Legends and Rainbow Six Siege players declined to participate). Each player played only one game in the tournament.

Protocol
This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (26). Prior to participation, esports players read and signed a written informed consent form approved by the referent institutional review board, and completed a questionnaire that included items related to their health history, exercise history, and gaming behaviors (e.g., hours per week spent playing). Height (cm) and body mass (kg) were collected from participants via self-report. All data were collected during the esports Egg Bowl tournament, which took place in October 2018 between the sanctioned esports clubs from the University of Mississippi and Mississippi State University. The esports Egg Bowl was held at the Pavilion at Ole Miss. Tournament rules indicated that the first team to reach four wins secured the championship and was awarded a trophy for their efforts. The live tournament averaged 200 fans throughout the duration of the event.

All participants were fitted with a Polar H10 (Polar Electro Inc.; Bethpage, NY) heart rate monitor alongside the Elite HRV application for mobile devices (Elite HRV, Asheville, NC, USA). Throughout the event, three measurements periods of HR and HrV were taken from each participant: pre-competition, in-competition, and post-competition. The pre-test was a five minute session between 15 and 25 minutes prior to the competition, the in-competition session spanned the entirety of participant's active competition, and the post-test was a five minute session taken immediately post-competition.

All measurements were taken from a seated position. Participants were required to sit in a quiet room separate from the audience and arena stage for five minutes prior to the pre- and post-test measurement sessions. After the pre-test measure, participants proceeded to the warm up area, which was a room with computers. When it was their turn to compete, they moved to the stage. The in-competition measurement session began immediately upon the participant sitting on the stage, spanned the entirety of the participant's active competition, and ended immediately following the conclusion of their esports match. When their competition was over, participants exited the stage, and made their way to the same quiet room in the arena where their pre-test measurement was taken. After a five-minute rest, the post-test measurement was collected.

Perceptual responses to the live esports tournament were measured using two single item scales: 1-10 RPE scale (41), where participants ranked their perceived exertion on a scale of 1-10, and mental fatigue, where participants were asked to rate their mental fatigue on a scale of 1-7 (Performetric Inc.; Braga, Portugal). Data were collected from these scales during the five-minute resting period prior to the post-competition HR measurement.

Statistical Analysis

To examine HR and HrV data generated from the Elite HRV smartphone application, a repeated measures Analysis of Variance (ANOVA) was used to interpret: HR, R-R intervals, root mean square of the successive differences (rMSSD), natural log applied to the rMSSD (rMSSDln), standard deviation of R-R intervals (SDNN), number of pairs of successive NN intervals that differed by more than 50 ms (NN50) between the pre-competition, in-competition, and post-competition phases of the study. A paired samples t-test and Cohens d was utilized for pre-post low frequency: high frequency ratio (LF: HF ratio), low frequency (LF), and high frequency (HF). Analyses were conducted using SPSS 25.0 software (IBM, Chicago, IL, USA). Results were considered significant at $p \leq 0.05$. HrV and in-competition HR data was not available on 4 of the competitors due to failure to adhere to protocol (1 Overwatch player, 1 Rocket League player, and 2 Call of Duty players; e.g., recording was not started upon sitting on stage or stopped immediately post competition). Thus, 14 participants were retained for final analyses. The sample size calculations for a repeated measures study design with a moderate effect size (0.45) yielded a minimum sample size of 10 in order to attain a statistical power of 0.80 in the variable of HR.

RESULTS

Descriptive statistics are presented in Table 1. HR response data are depicted in Figure 1. Results indicated that mean HR during competition was significantly elevated compared to pre-competition HR (131.4 ± 19.0 bpm vs. 97.1 ± 19.9 bpm and 101.9 ± 17.4 bpm; $p = 0.000$; partial $\eta 2 = .837$). Participants had an average peak HR during competition of 188.1 ± 32.9 bpm, which was significantly greater than peak pre- and post-competition HR (119.6 ± 20.1 bpm and 119.9 ± 16.3 bpm; $p = 0.000$; partial $\eta 2 = .808$).

Table 1. Participant Characteristics (*n* = 14).

Variable	Mean ± *SD*	Range
Age (years)	19.8 ± *1.0*	18 – 22
Height (cm)	179.5 ± *7.3*	167.6 – 195.6
Bodyweight (kg)	*77.2* ± *15.1*	60.0 – 117.9
BMI	24.1 ± *5.5*	16.6 – 39.53
Hours of esports per week	18.9 ± *11.6*	6 – 50
Hours of exercise per week	3.9 ± *2.4*	0 – 10
Days per week of exercise	3.5 ± *2.2*	0 – 7

Note. SD = standard deviation; cm = centimeters; kg = kilograms; BMI = body mass index

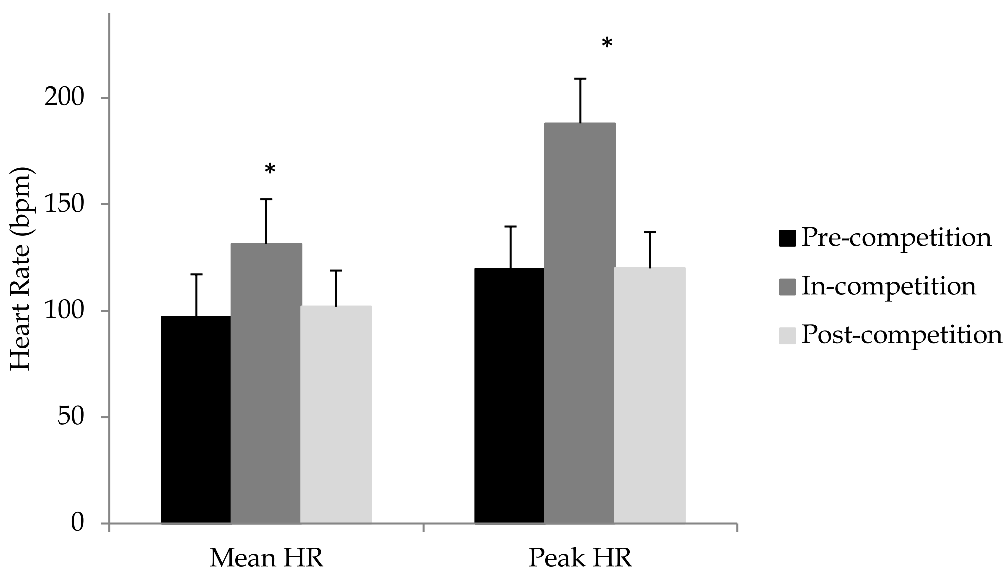

Figure 1. Peak and mean heart rates prior to, during, and post- esports competition
Note. * = HR during competition significantly different pre- and post-competition ($p = 0.000$)

Table 2 displays the results related to HrV. R-R intervals were significantly lower in-competition when compared to pre- and post- competition levels. No significant differences were found in rMSSD, (ln) rMSSD, SDNN, NN50 across the three measurements. LF was significantly lower post- competition when compared to pre-competition ($d = 0.278$), and there were no differences found between HF ($d = 0.318$) and LF: HF ($d = 0.297$), between pre- and post-competition measurements.

Table 2. Comparison of HrV data pre- in- and post- esports competition.

Variable	Pre-competition mean ± *SD*	In-competition mean ± *SD*	Post-competition mean ± *SD*	partial η^2	*p*
R-R interval	643.64 ± 138.54	465.71 ± 68.99	616.07 ± 109.98	0.789	.000
rMSSD (ms)	25.67 ± *17.48*	15.5 ± *12.34*	23.72 ± *18.07*	0.472	.223
ln(rMSSD) (ms)	3.0 ± *0.77*	2.51 ± *.69*	2.86 ± *0.90*	0.316	.249
SDNN (ms)	49.05 ± *24.97*	42.90 ± *20.31*	43.07 ± *20.56*	0.176	.705
NN50 (ms)	34.43 ± *43.53*	144.35 ± *295.43*	30.64 ± *48.71*	0.291	.161
LF (ms^2)	1445.96 ± *1134.14*	-	1043.49 ± *912.07*	-	.000
HF (ms^2)	494.55 ± *526.84*	-	325.83 ± *341.81*	-	.046
LF:HF	4.47 ± *2.96*	-	5.54 ± *3.62*	-	.260

Perceptual responses from the session RPE and mental fatigue scales are presented in Table 3. Participants reported a mean RPE of 3.7 out of a maximum of 10, and a mean mental fatigue rating of 3.7 on a scale of 1 – 7.

Table 3. Session RPE and mental fatigue scales.

Variable	Mean ± *SD*
Session RPE	3.3 ± *2.2*
Mental Fatigue	3.7 ± *1.2*

DISCUSSION

The primary purpose of this study was to describe the responses to competing in a live esports tournament on HR and HrV among esports players. Although competitive esports have only been introduced recently, their propagation has been rapid and unrelenting. Given the growing relevance of esports globally, it is imperative that the health impacts of competing in esports be explored. The HR and HrV measurements that were collected during a live esports collegiate tournament in this study represent initial insight into the health impacts of competitive esports.

In addition to exploring physiological responses to esports competitions, the present study is, to the best of the author's knowledge, the first to describe gaming and exercise behaviors among a sample of varsity collegiate esports competitors. Participants in this study reported playing videogames for an average of 19 hours per week. Of note, one study participant reported playing an average of 50 hours of videogames each week, and 10 participants reported playing 20 or more hours per week. This is somewhat similar to the results of a previous study examining 115 elite and professional esports competitors, who reported training for their esports approximately of 5.28 hours per day, 7 days per week, year-round. Interestingly, an average of 1.08 hours of their training included physical exercise, which 55.6% of the players surveyed in that study believe supports their esports performance (18). Though this was not measured in the present study, future researchers may want to explore the different training protocols employed by esports competitors.

Esports are played from sedentary, semi-reclined positions, and sedentary behavior has been associated with a host of negative health consequences including obesity, type II diabetes, some cancers, and premature mortality (14). There have also been noted associations between time spent playing videogames and a higher BMI in multiple paradigms including children (24), adolescents (33) and adults (42). The mean BMI for participants in the present study, however, classified them in the normal range (19.9-24.9). Further, participants in this study reported exercising an average of approximately 4 hours per week, which is greater than the recommended amount set by the national physical activity guidelines. Previous researchers have suggested that high levels of sedentary behavior and physical activity can co-exist, and the time spent being sedentary can still negatively impact health (27). Newer evidence in children indicates moderate-vigorous physical activity and vigorous physical activity may improve health odds independent from sedentary behavior, though the reason for this is not well understood (19). Regardless, it is important to note that one participant reported 0 hours of weekly exercise, emphasizing the need to encourage exercise among esports players. Additionally, total sedentary time was not measured in this study, only time spent training for esports. Other sedentary behaviors participants likely engage in, such as study time, sitting during classes, etc. was not accounted for in this research. Future researchers may wish to examine the sedentary and physical activity habits among esports players to better understand their overall health.

The HR data collected during this study included a pre-competition HR, a mean in-competition HR that spanned the entire active phase of each participant's game, the peak HR reached during competition, and a recovery HR. The pre-competition HR values in this sample were elevated compared to the average resting HR ranges defined by the American College of Sports Medicine (ACSM; 60-100 bpm). This suggests there is an anticipatory arousal response to esports, which is a well-documented phenomenon across many other paradigms (e.g., males prior to traditional athletic competitions (29); and prior to public speaking (5), though this is the first exploration among esports players prior to competition.

The mean and peak in-competition HR are some of the most important findings of this study. Playing esports in a live competition elicited a mean HR of 131 bpm, and players reached a mean peak HR of 188 bpm in this sample. These HRs are more consistent with vigorous aerobic activity than with a sedentary activity, and the peak HR can be compared with peak HRs reached during maximal aerobic testing (2). Heart rate is controlled by the two branches of the autonomic nervous system. The sympathetic nervous system (SNS), which releases the hormones (epinephrine and norepinephrine) to accelerate the heart rate, and the parasympathetic nervous system (PNS), which releases the hormone acetylcholine to slow the heart rate (31). Sympathetic and parasympathetic effects on the intrinsic HR predominantly determine the actual HR at any given time. Given the elevated HRs that were observed, esports competition triggered a clear sympathetic response. This provides further evidence that participating in esports does not produce the same physiological stress response as other sedentary behaviors (e.g., sitting quietly and reading or working on a computer), despite the shared attribute of being seated or reclined across activities. These findings also raise major health concerns related to cardiovascular reactivity hypothesis, which assumes that psychological stressors promote the development of cardiovascular disease; and the idea that repetitive elevations of cardiovascular activity through chronic videogame playing in the absence of physical activity may affect long-term regulation of cardiovascular activity (30). Although an increased cardiovascular response has been observed in other sedentary situations, such as habitual gamblers during seated casino gambling (22), it is more alarming in esports because esports are wider-reaching globally, and are dominated by youth who may have already engaged in these activities for many years and will likely continue to do so. Understanding the long-term impacts of their physiological stress response on the body may become a critical need in the very near future.

Although this is the first investigation to examine cardiovascular response during a competitive esports tournament across several games, some previous literature does support the findings. In a sample of overweight/obese males playing videogames in a non-competitive environment, an increase in perceived stress levels, systolic blood pressure, and HR was observed when compared to watching television (35).

Recovery HR collected from participants also conveyed important information. The mean recovery HR was 101.9, which is elevated from a healthy resting HR. The speed with which a person's HR returns to the same bpm as at rest is an important indicator of overall physical health. Given the nature of this study, which took place on the day of a live competition, a true resting HR was not collected from participants (i.e., there was an arousal response). Future researchers are encouraged to investigate recovery HR in esports players to better understand the health impacts of esports and possibly help aid in training recommendations.

Another primary aim of the current investigation was to describe the effects of active tournament competition on short term measures of HrV in esports competitors through the comparison of R-R intervals, SDNN, NN50, HF, LF:HF ratios, rMSSD, and ln(rMSSD). HrV was measured pre- and post- competition over 5-minute periods that followed 5 minutes of seated rest. The use of 5-minute measures has established norms across multiple paradigms (9, 23, 34), but to date has not been examined in esports players. Only the R-R intervals and HF showed a significant difference from pre- to post (Table 2). The noticeable changes in both R-R intervals and HF clearly demonstrate a stress response in the participants. Given the increased heart rate observed during the competition, the reduction in R-R intervals is expected.

In traditional athletes, HrV has been utilized as a measure to track recovery and fatigue. Soccer players with a lower fitness status or higher perceived fatigue demonstrated larger reductions in lnRMSSD during acute training (9). Further, utilization of weekly changes in lnRMSSD from training may be useful for preventing the accumulation of fatigue in female soccer players (10). HrV has even been utilized to examine mental stress during computer work over short- (36, 11) and long-durations (28). Using HrV as a fatigue monitoring strategy could potentially be adapted to esports competitors to monitor training load. With the introduction of a cognitive stressor, healthy individuals show a more immediate response in HrV markers and subsequently stabilize for the duration of the task when compared to individuals with chronic fatigue syndrome (3). Given the mean amount of esports training reported in hours per week was ~19, with some playing up 50 hours per week, there is a need to examine different modalities to monitor fatigue and overtraining in this group. In future studies, HrV data could be collected alongside recordings of other physiological responses within esports competitors to further understand the effects of esports on the human body with chronic playing.

Another original aspect of the present study was the exploration of perceptual responses in relation to esports. Session RPE was used although it was originally developed to examine exercise intensity. The most flagrant difference between esports and traditional sports are that esports players are not physically active during their competitions. Although player's elevated HR signify a physiological stress response to the stimulus, esports competitors are not physically exerting their bodies in competition. RPE specifically asks participants to rank their level of "exertion," and specifically is referring to physical exertion. Participants in this study reported a mean of 3.3 out of 10, which corresponds to "moderate," and is understandable given the lack of full body movement, though it does not align with their in-competition HR. This indicates RPE may not be an appropriate tool for measuring the perceptual responses during esports competitions, and specifically that the word 'exertion' may not adequately capture what esports players are feeling. Although it may not be exertion, esports players are experiencing something during their competition, and there must be a more appropriate word to describe it. Future researchers may consider exploring more appropriate means of measuring perceptual responses to esports and validating these against objective markers.

Mental fatigue was also examined in this study as the second perceptual response measurement. Participants reported their mental fatigue to be a mean of 3.7 out of 7 immediately post competition. Despite the short duration of each individual's competition (~30 minutes in duration), participants felt cognitively fatigued. Given the elevated HR observed in all three phases of this study (pre-, in-competition, and post), further understanding the psychological responses to competitive esports in the tournament setting is critical to adequately address the entire esports experience.

It is also suggested that future researchers continue to explore the physiological stress from participating in esports tournaments. One limitation of the current investigation is the variety of games that were being played, which may each elicit different physiological stress responses from the player. While more research is needed, the current results suggest that participating in a live esports tournament elicits a stressful physiological stress response. There may potentially be a long term impact from the physiological stress in esports competitors, and what impact that stress has on overall wellbeing has yet to be determined.

There are several other limitations to be noted in this study. The sample size was limited to 14 participants. Although a larger sample size may have provided more robust results, the purpose of this study was to provide a first observation of the physiological stress response to competitive esports. Future researchers should consider measuring these responses in larger and more diverse populations (e.g., younger children, professional competitors, etc.). Additionally, participants self-reported their height and weight, which were used to compute BMI. Although objective measurements would have provided more precise results, self-report data has been shown to accurately identify overweight and obesity in young adults (4). Physical activity was also measured via self-report. An objective measure to assess physical activity and sedentary behavior is recommended for future research. Despite these limitations, the results of this study can still be used to better understand the impacts of playing competitive esports on the body. They can also serve as a platform for future researchers to explore the health consequences of playing esports which can ultimately be used to improve the health of esports players, and potentially even be used to improve esports performance.

Despite their burgeoning popularity, competing in esports is still relatively novel, dominated by youth, and spurred on by ever-evolving technological advances like improved streaming capabilities. While there has been considerable attention paid to where esports fit within the greater definition of "sport," little of the discussion has addressed the physiological aspects of being a competitive esports player. This investigation is among the first to begin addressing that need, and given that this modern field of competitive gaming is projected to become a billion-dollar industry in 2019, the more we can learn about this cohort, the better.

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