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Letter - More physiological research is needed in esports

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We read with interest two recent publications surrounding physiological stressors, and testing and monitoring devices (of particular interest, the electrocardiogram [ECG]), within a non-competitive and competitive esports setting, 'Psychological and physiological stress in non-competitive and competitive esports settings: A systematic review', and 'The potential of physiological monitoring technologies in esports'[1, 2]. In 2020, the esports audience grew to a monumental 495 million people globally, whilst simultaneously surpassing the billion-dollar revenue milestone, with a year-on-year growth rate of +15.7% [3]. Due to the competitiveness of the esports industry, understanding the energy expenditure and cognitive load of elite esports players may inform future research and application of exercise and nutrition interventions for improved performance. The purpose of this letter is to encourage discussion of physiological research within esports, and to promote esports as a viable study area for exercise physiology and sports science researchers and the like.

Background of Esports and Physiological Investigation

Despite the exponential growth of the industry, there is limited literature investigating the physiological and cognitive demands of the sport. Much of the scientific literature investigates the psychological and sociological factors associated with the esports. The review by Leis and Lautenbach [1] highlighted that during competition, heart rate (HR), low frequency/high frequency ratio, and blood pressure were significantly higher than resting conditions in one study. After competition, there were increases in cortisol levels, as well as HR and ejection fraction within winners and losers, when compared to baseline measures. Another study

IJESPORTS

investigated the HR response of twenty three young men (Age= 21±1.8 years) in the esport: '*Fortnite*'[4]. This showed that over a 3-hour training session, the peak HR response during gameplay was significantly higher when compared to the peak resting HR (120±16 bpm vs. 81±11bpm). The paper also hypothesised that these values may increase if the players performed on a live stage during competition, as opposed to at home. This also indicates that energy expenditure (total amount of energy expended) during competitive gameplay would be significantly different when compared to their resting metabolic rate. This may be due to endocrinal and emotional responses that stimulate the sympathetic nervous system which would in-turn increase energy expenditure. These studies highlight an increased physiological response to gameplay. Although the systematic review stated that their review is a foundation to understanding psychophysiological stress within esports, there needs to be further in-depth studies investigating the demands of competitive gameplay.

A study specifically investigated the metabolic and physiological responses of non-competitive video games within twenty-one 7-to 10-year-old boys[5]. Whilst the participants played a [video] game, the study simultaneously assessed blood pressure, and HR, whilst also being attached to a metabolic cart that measured ventilation, tidal volume, and respiratory rate. This study demonstrated significant increases in HR, systolic and diastolic blood pressure, ventilation, respiratory rate, and subsequently energy expenditure during gameplay across all participants, which is in line with previous studies in similar areas.

As mentioned previously, there is limited research that has investigated the physiological demands of elite level competitive esports [players] during competitive gameplay. Some variables which should be investigated include heart rate variability (HRV) and energy expenditure of esports athletes during competitive gameplay, in order to better understand the physiological demands of competitive esports. From these studies, specific physical performance interventions may be developed and implemented into competitive teams to improve performance outcomes. Also, by quantifying energy expenditure within the population, it creates a platform for further scientific investigation, such as nutritional interventions.

Exercise and Cognitive Function

There is a large amount of literature that has clearly shown that with just an acute bout of exercise, aerobic or resistance training, there is a significant increase in cognitive performance[6]. Furthermore, individuals that are more physically active and follow chronic exercise regimens have improved cognitive performance and resistance to mental fatigue when compared to inactive sedentary populations [7]. This is caused by an increase in cerebral blood flow, triggering neurogenesis (formation of neurons), synaptogenesis (formation of synapses) and angiogenesis (formation of new blood vessels) within the brain. Through increased sedentary time and physical inactivity, this may cause a decline in cognitive function as well as increasing the risk of morbidity and all-cause mortality within all populations. By engaging in moderate-to-vigorous physical activity, specifically the Australian physical activity guidelines, this trend is decreased, which may improve cognitive function and aging. Therefore, it is hypothesised that by implementing specific training protocols within these athletes, there will be an increase in performance outcomes, which may provide beneficial for gaming teams and organisations.

Cognitive Fatigue

Acute decreases in cognitive function can be referred to as cognitive fatigue. Cognitive performance is the ability to sustain attention and vigilance on a set task. Prolonged periods of attention and sustained focus can cause cognitive overload, which causes cognitive fatigue. As esports athletes are sedentary for long periods of time, also requiring sustained periods of attention and focus, cognitive fatigue is highly prevalent within this population. Comparatively, it has been highlighted through other studies, that cognitive fatigue decreases driver performance, resulting in an increase in mental effort, which is a major contributor to transportation accidents[8, 9]. Cognitive fatigue decreases cognitive function which can be seen through lessened accuracy and reaction time within cognitive tasks. As esports athletes rely heavily on cognitive function for performance, cognitive fatigue would likely decrease their performance during competitive gameplay.

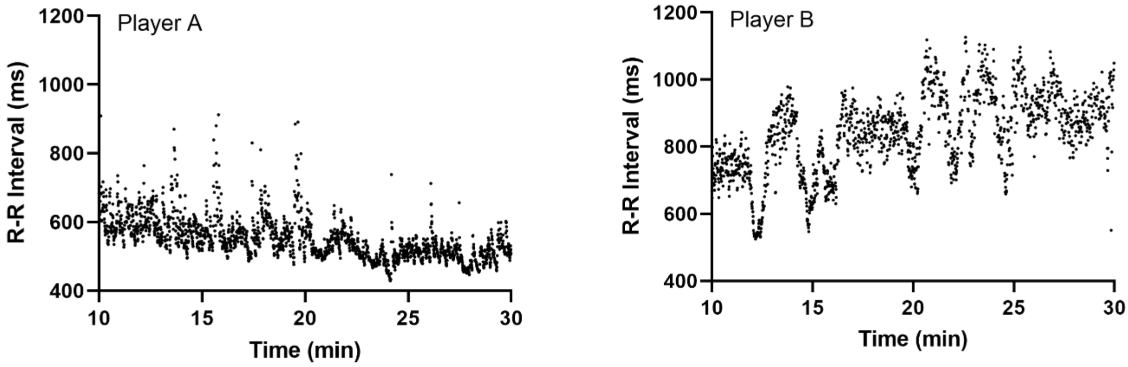
Pilot Study

The authors are conducting a study which aims to investigate the metabolic demand and cognitive fatigue of elite esports athletes. One of the variables of interest is the heart rate variability (HRV) of the players. These data, along with measures of oxygen uptake, ventilation, and electroencephalography, will aim to help researchers and practitioners/performance coaches better understand elite esport athlete metabolic demand and cognition. Prior to this, pilot HRV data were collected on two *League of Legends (LoL)* players (18 and 19 years of age) during competitive practice gameplay in the Oceanic Challenger Series.

The most common way to assess HRV is through electrocardiogram (ECG). HRV is the variation over time of the period between consecutive heartbeats, which is dependent on the extrinsic regulation of the HR[10]. It is thought that HRV has the capability of reflecting the hearts ability to adapt during unpredictable changing circumstances by quickly responding to unpredictable stimuli[10]. Data collection was achieved by attaching a 5-lead ECG to the players, whilst they played competitive matches, with continual timestamping of important in-game engagements (e.g. team fights, 1 vs. 1 fights, deaths, kills etc.) that may trigger an increased HR response. Initially, the real-time ECG data and HR of the players showed significant increases above resting values during in-game engagements. The players self-reported their perceived fitness and exercise/physical activity regimens prior to testing. From this information, it appeared that the player who reported higher weekly physical activity behaviours displayed lower resting HR and decreased HRV to in-game situations when compared to their teammate who reported minimal weekly physical activity. This would be in line with previous studies demonstrating that fitness level and increases in physical activity can decrease HRV[11]. This may suggest that physical fitness and weekly activity may be a significant moderator to HRV within these athletes. Future studies may find benefit in quantifying weekly physical activity or cardiovascular fitness to use as a variable for comparison across participants.

It should be noted here that the data collected is only a small sample, and several limitations (including differences in player roles) are present. A more comprehensive investigation into the HRV within this population will assist in establishing if there is a clear relationship between HRV and physical fitness between players. See Figure 1 for selected HRV data for two elite players during competitive gameplay. The data is from 10 minutes to 30 minutes of a round, as the initial 10 minutes of the game are not as active. Notice the distinct variation between two elite players within the same game. It should be noted that the Player A self-reports a high level of cardiovascular fitness, compared to the Player B who self-reports to be mostly sedentary. A higher average and peak HR response, as well as increased HRV can be seen with Player B.

Figure 1: Individual player R-R interval data for the middle 10-30 minutes of gameplay during a competitive practice round.



Results

This pilot-data has investigated the HRV within *LoL* athletes with comparison to self-reported physical fitness levels, which still requires a more comprehensive investigation. Although, there are still many parameters and relationships that are yet to be investigated in respect to HRV within elite esports athletes, some research questions can be developed to investigate other variables that affect HRV within an esports population.

Conclusion

Research into the physiological demands of elite esports athletes during competition, could assist in creating a greater scientific understanding and spotlight for the sport. With this, further investigations may occur in which we can develop a greater understanding of the nutritional, psychological, physical performance determinants of the sport.

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