CASE REPORT

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Energy Expenditure during eSports – A Case Report

Energieverbrauch bei der Ausübung von eSports – eine Fallstudie

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Summary

› **Problem:** The popularity of eSports has grown in recent years, although its characterization as a sport is controversial and there arise concerns about its health-promoting character. The aim of this case study was to show the effects of eSports on the cardiovascular system and on energy expenditure (EE) and to compare them with those occurring during dynamic exercise.

› **Methods:** A male amateur e-athlete (32 years, 184 cm, 60 kg) played a 30-minute video game during which heart rate (HR) and oxygen consumption ($\dot{V}O_2$) were monitored. On another day, 30min cycle ergometer exercise was performed where HR was adjusted to that of the eSports game by changing exercise intensity. Glucose concentration was determined in both tests.

› **Result:** HR increased from 85 bpm to 137 bpm and was almost identical in both tests. In contrast, $\dot{V}O_2$ and EE were about three times higher during cycling ($\dot{V}O_2$ ergometer: 0.72 L/min, eSports: 0.28 L/min; EE ergometer: 3.55 kcal/min, eSports: 1.38 kJ/min). Blood glucose slightly increased during eSports (+0.7 mmol/L) while it decreased during cycling (-2.2 mmol/L).

› **Conclusion:** During eSports, elevated HR is not related to EE as is the case during dynamic exercise. eSports, therefore, represents a pure mental stress response, which is supported by the opposite behavior of the glucose concentration in eSports compared to physical exercise.

Zusammenfassung

› **Problem:** Die Popularität des eSports hat in den letzten Jahren zugenommen, obwohl seine Charakterisierung als Sportart umstritten ist und Bedenken hinsichtlich seines gesundheitsfördernden Charakters aufkommen. Ziel dieser Fallstudie war es, die Auswirkungen des eSports auf das Herz-Kreislauf-System und den Energieverbrauch (energy expenditure, EE) aufzuzeigen und mit denen bei körperlicher Aktivität zu vergleichen.

› **Methodik:** Ein Amateur-E-Sportler (32 Jahre, 184 cm, 60 kg) spielte ein 30-minütiges Videospiel, während dessen Herzfrequenz (HF) und Sauerstoffverbrauch ($\dot{V}O_2$max) bestimmt wurden. An einem anderen Tag wurde ein 30-minütiger Radergometertest durchgeführt, bei welchem die HF durch Änderung der Trainingsintensität an die des eSports-Spiels angepasst wurde. Die Glukosekonzentration wurde in beiden Tests bestimmt.

› **Ergebnis:** Die Herzfrequenz stieg von 85 1/min auf 137 1/min und war bei beiden Tests nahezu identisch. Im Gegensatz dazu waren $\dot{V}O_2$ und EE beim Radfahren mehr als dreimal so hoch ($\dot{V}O_2$-Ergometer: 0.721 L/min, eSports: 0.28 L/min; EE-Ergometer: 3.55 kcal/min, eSports: 1.38 kJ/min). Der Blutzucker stieg während des eSports leicht an (+0,7 mmol/L), während er auf dem Radergometer sank (-2,2 mmol/L).

› **Schlussfolgerung:** Während des eSports geht eine erhöhte Herzfrequenz nicht mit einem gesteigerten Energieverbrauch einher, wie dies bei sportlicher Aktivität der Fall ist. eSports stellt daher eine rein mentale Stressreaktion dar, was durch das entgegengesetzte Verhalten der Glukosekonzentration beim eSport im Vergleich zu sportlicher Aktivität bekräftigt wird.

KEY WORDS:
Oxygen Consumption, Cardiovascular System, Heart Rate, Video Game, Exercise Intensity

SCHLÜSSELWÖRTER:
Sauerstoffverbrauch, kardiovaskuläres System, Herzfrequenz, Videospiel, Trainingsintensität

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Introduction

Whether the European soccer championships or the Olympic Games or other events in public sports – almost every traditional sport event is canceled or postponed for an unknown period of time due to the COVID-19 pandemic. Furthermore, private sporting activities were only possible to a limited extent before the first loosening of the restrictions came into force in early May 2020. Video gaming respectively electronic Sports (eSports) seemed to be a promising alternative for many people during this time. According to the telecommunications company Verizon, the US American market is experiencing an increase in gaming activity of up to 75% during peak gaming hours and there has also been a significant increase in streaming activities on Twitch (3).

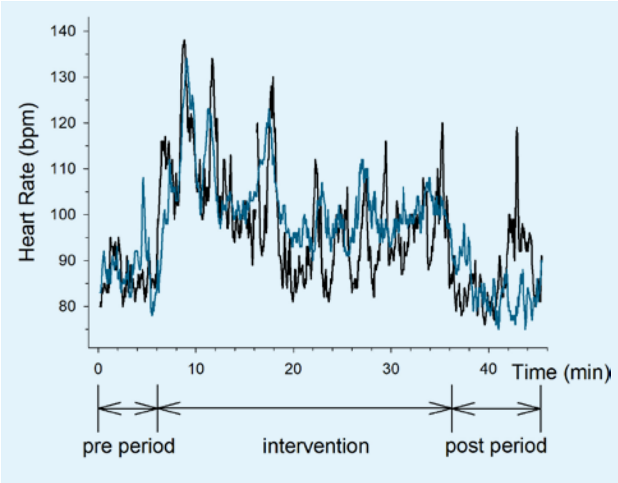

Figure 1

Heart rate during 30 min lasting units of eSports and cycle ergometer exercise. Blue=ergometer; black=eSports.

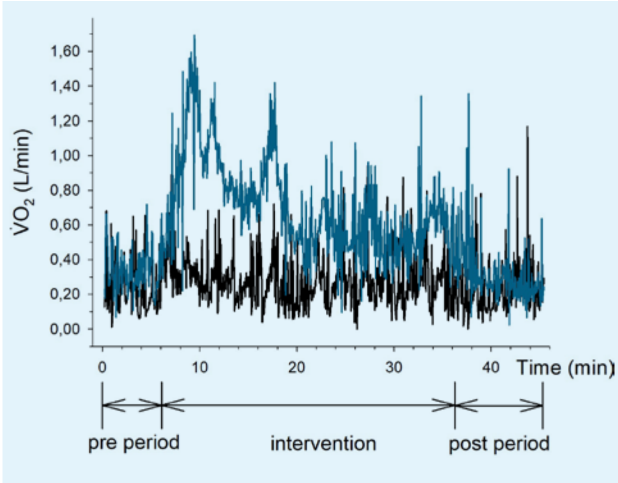

Figure 2

Oxygen consumption (VO_2) during 30 min lasting units of eSports and cycle ergometer exercise. Blue=ergometer; black=eSports.

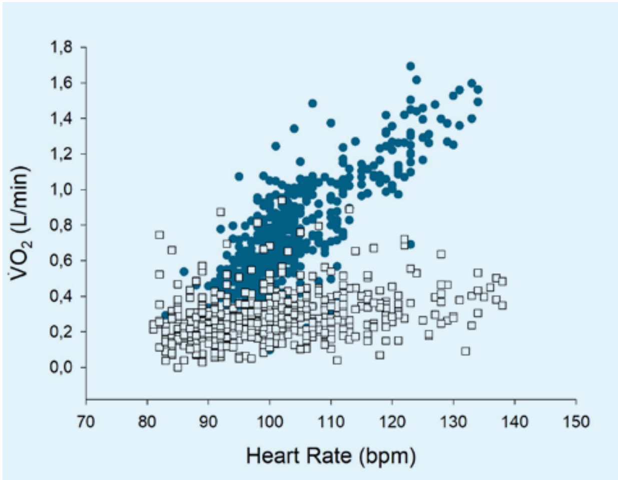

Figure 3

Relationship between Heart Rate and Oxygen consumption (VO_2) during 30 min lasting units of eSports (r=0.29) and cycle ergometer exercise (r=0.78). Blue=ergometer; black=eSports.

Although controversial in its characterization as a sport (7, 13), eSports is gaining acceptance in the world of athletics as is proven by the rising amount of national and international eSports events organized for professional athletes which are attended by millions of spectators (6). Besides the professional athletes, in daily life millions of mostly young people (4) practice eSports for several hours a day playing sports simulations like FIFA or tactical first-person shooter games like Counter-Strike on their consoles or computers.

From the medical aspect, however, there arise more and more health concerns because of the sedentary nature of the sport and accompanying poor posture; eSports athletes are likely to have musculoskeletal injuries. Additionally, these athletes may have metabolic disturbances resulting from light-emitting diode computer monitors as well as mental health concerns regarding gaming addiction and social behavior disorders (15).

On the other hand, expert opinions assume that the stress-load of e-athletes can be compared with athletes in traditional sports. They achieve similar levels of cortisol as racing drivers and the heart rate of 160-180 bpm is equivalent to that of a marathon runner (8, 9). But whether the cardiovascular stress in eSports is associated with higher energy expenditure as it is the case during endurance training and might, therefore, be even associated with positive health effects, has to our knowledge not yet been described in the literature.

Therefore, the aim of this study was to compare the energy expenditure during an eSports game with that during an equivalent bout of exercise on a cycle ergometer in order to show whether eSports can be seen as physical strain or must be considered exclusively as mental stress. The study was planned in a cross-over design with >10 subjects. Because of the Corona-dependent restrictions, however, only one subject finished the complete test battery before the first lockdown. Because of its actual content, the results from this subject are presented here as a case study.

Methods

A male amateur e-athlete (32 years, 184 cm, 60 kg), who spends an average of 10 to 15 hours / week on eSports, was tested. All investigations were conducted in accordance with the ethical principles of the "Declaration of Helsinki" on Ethical Principles for Medical Research on Humans (14) and the test protocol was approved by the local ethics committee of the University of Bayreuth. The test person received detailed written and oral information about the tests, including information about the content and procedure and about possible risks. He signed a declaration of consent and could terminate the study at any time without further explanations.

The design consisted of two tests. First, the subject performed a 30-minute game on Paladins Champions of the Realm, (Hi-Rez Studios, Alpharetta, Georgia, USA), an objective-based online-multiplayer first-person shooter on PlayStation 4 (Sony, Minato, Tokio, Japan). Heart rate (Polar H7, Polar Electro Oy, Kempele, Finnland) and spiroergometric parameters (breath-by-breath analysis, METALYZER® 3B, CORTEX Biophysik GmbH, Leipzig, Germany) were monitored continuously in sitting position 10min before, over the entire course of the game, and until 10min thereafter. For determination of lactate and glucose concentrations (BIOSEN S-Line Lab+, EKF-diagnostic GmbH, Barleben, Deutschland) blood samples were taken from a hyperemized earlobe before, every 10min during gaming as well as immediately and 10min after finishing.

Table 1

Spirometric and metabolic data obtained during eSports and cycle ergometer exercise. VO_2=Oxygen consumption; RER=Respiratory exchange ratio; EE=Energy expenditure; V_E=Ventilation; Lac=Blood lactate concentration; Glu=Blood glucose concentration. Data are presented as the mean ± standard deviation (SD).

		PRE	PHASE I	PHASE II	PHASE III	POST
VO_2(L/min)	eSports	0.24 ± 0.16	0.30 ± 0.12	0.26 ± 0.14	0.28 ± 0.15	0.24 ± 0.17
	ergometer	0.35 ± 0.14	0.93 ± 0.28	0.66 ± 0.25	0.56 ± 0.11	0.33 ± 0.19
RER	eSports	0.88 ± 0.04	1.01 ± 0.10	0.85 ± 0.08	0.84 ± 0.04	0.80 ± 0.08
	ergometer	0.89 ± 0.03	0.94 ± 0.05	0.92 ± 0.04	0.88 ± 0.03	0.89 ± 0.03
EE (kcal/min)	eSports	1.18 ± 0.78	1.52 ± 0.61	1.26 ± 0.68	1.37 ± 0.73	1.15 ± 0.82
	ergometer	1.72 ± 0.69	4.63 ± 1.39	3.27 ± 1.24	2.74 ± 0.54	1.62 ± 0.93
V_E (L/min)	eSports	9.8 ± 4.7	14.2 ± 4.1	10.9 ± 4.6	12.0 ± 4.2	9.3 ± 4.5
	ergometer	12.9 ± 3.9	26.1 ± 5.2	21.0 ± 5.6	18.5 ± 4.3	12.6 ± 5.2
Lac (mmol/L)	eSports	1.22	1.16	1.02	1.19	1.16
	ergometer	1.16	2.70	1.65	1.20	1.02
Glu (mmol/L)	eSports	5.1	5.1	5.7	5.8	5.7
	ergometer	5.5	4.4	4.1	3.3	3.7

In the second part performed on a separate day, the subject completed a test with aerobic load on a cycle ergometer (Lode Excalibur Sport, Lode B.V., Groningen, Netherlands) with the identical duration as the eSports unit. During the test, the load was manually adjusted continuously to the heart rate curve obtained before, during and after the eSports test. The spiroergometric parameters as well as the lactate and glucose concentrations were measured as described above.

The spirometry data were obtained breath by breath and were calculated for every 5sec. Because the stress level varied during the game we analyzed the data for three intervals lasting 10min each. Because only one subject was tested no statistical analysis except a linear regression analysis for changes in heart rate vs. changes in oxygen consumption ($\dot{V}O_2$) were performed.

Results

The heart rate during the eSports unit increased from approx. 85 bpm to 137 bpm during the first 10 min interval and oscillated at elevated level during the whole time of gaming (Figure 1). During cycle ergometer exercise HR was adjusted to almost identical values and only slightly exceeded the eSports values at the end of exercise. In contrast, $\dot{V}O_2$ did not change during eSports, but was clearly elevated during ergometer exercise (+0.6 L/min during the first interval) (Figure 2). While $\dot{V}O_2$ was only slightly correlated to HR during eSports (r=0.29), there was a close relationship during ergometer exercise (r=0.78, p<0.001; Figure 3).

Energy expenditure was almost not affected by eSports, but was clearly increased during ergometer exercise (Table 1). During eSports, ventilation increased by approx. 50% and RER was elevated during the first interval. During ergometer exercise ventilation was doubled without effecting RER (Table 1).

Blood glucose concentration showed an opposite behavior, slightly increasing during eSports and decreasing during ergometer exercise. Lactate concentration was only slightly increased at the beginning of ergometer exercise (Table 1).

Discussion

The most important result was that eSports provoked a typical stress response as is demonstrated by increased heart rate which was hardly related to any change in energy expenditure as it occurs during physical exercise.

The increase in heart rate from 85 to 137 b/min during gaming was lower than reported for elite e-athletes who are characterized by up to 160-180 bpm during international competitions (9). To our knowledge, despite eSports is popular among millions of people worldwide there are no data available describing the cardiovascular reaction in leisure e-athletes. The increase in heart rate in this case study, however, corresponds to other stress situations like car driving (10), examinations (12), parachuting (2) or emotional stress situations (11) which can be exclusively referred to the activation of the sympathetic nervous system and may therefore be representative for eSports at low or intermediate performance level. The oscillation in heart rate also proves the heterogeneous demand of the prevailing game situations making it difficult to characterize a general cardiac reaction to eSports.

Adjusting the heart rate during the ergometer test can be judged as successful. There is no difference between the two tests during the first 10min interval; in the following two intervals the HR in the ergometer test is only slightly above that in eSports (Table 1).

During dynamic exercise, there exists a close relationship between the heart rate response and oxygen consumption (1) which is also present in this case study. During eSports, however, no noteworthy relationship exists indicating the absence of any remarkable metabolic demand. In a comparison of heart rate, metabolic and hormonal responses to maximal psycho-emotional stress during motor car racing and physical stress, i.e. cycle ergometer exercise, Schwaberger (10) found very similar results as we did in this case report. He reported a similar heart rate response under both conditions with a strong accompanying increase in $\dot{V}O_2$ only during physical exercise. The increase in catecholamine concentration was much more pronounced after psycho-emotional stress leading to higher plasma glucose and free fatty acid concentration. Also in our study, glucose concentration tended to increase during eSports hinting to elevated adrenaline effects on glycolysis.

To our knowledge there exists no data concerning the effects of eSports on metabolism and energy expenditure in the literature. Also this study just presents the results of a comparison of a relative short unit of eSports with moderate intensity and physical exercise in one single subject which, however, are in line with previous studies on psycho-emotional and physical stress.

In summary, it can be stated that the physiological processes during eSports differ clearly from those of dynamic exercise. The positive health effects associated with physical activity, i.e. elevated energy expenditure combined with an adequate cardiovascular response, could not be observed during eSports. Here, the increased heart rate is due to psychological stress without having the same metabolic effects as endurance exercise. eSports can therefore not be recommended as an adequate alternative to physical activities. Nevertheless, we are aware that eSports is not a homogeneous discipline and varies considerably concerning intensity and duration. Although not investigated here, eSports requires a level of neuromuscular performance (5), which is hardly demanded in any established sport. On the other hand, children and adolescents, in particular, often spend several hours a day playing eSports, so the effects of frequent stress situations on the cardiovascular system, on the metabolism and also on potentially harmful interactions between both should be examined more in detail. The present case report is therefore a suggestion and a request to investigate these relationships, which may be important for a large number of people. In doing so, we suggest studies considering the multidimensional character of eSports and the large number of game titles within different genres.

Conflict of Interest

The authors have no conflict of interest.

References

(1) **ÅSTRAND P-O, RYHMING I.** A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work. J Appl Physiol. 1954; 7: 218-221. doi:10.1152/jappl.1954.7.2.218

(2) **FALK B, BAR-ELI M.** The psycho-physiological response to parachuting among novice and experienced parachutists. Aviat Space Environ Med. 1995; 66: 114-117.

(3) **GOODWIN J.** On coronavirus lockdown, gamers seek solace and community in video games. USA Today 2020. 2020. https://eu.usatoday.com/story/tech/2020/04/03/coronavirus-gaming-offers-connection-amid-covid-19-social-distancing/5086472002/ [June 24th 2020].

(4) **HALLMANN K, GIEL T.** eSports – competitive sports or recreational activity? Sport Manage Rev. 2018; 21: 14-20. doi:10.1016/j.smr.2017.07.011

(5) **VAN HILVOORDE I, POT N.** Embodiment and fundamental motor skills in eSports. Sport Ethics Philos. 2016; 10: 14-27. doi:10.1080/17511321.2016.1159246

(6) **HOLDEN JT, RODENBERG RM, KABURAKIS A.** Esports corruption: gambling, doping, and global governance. Maryl J Int Law. 2016; 32: 236-273. doi:10.2139/ssrn.2831718

(7) **JENNY SE, MANNING RD, KEIPER MC, OLRICH TW.** Virtual(ly) athletes: where esports fit within the definition of "sport.". Quest. 2017; 69: 1-18. doi:10.1080/00336297.2016.1144517

(8) **RUDOLF K, GRIEBEN C, ACHTZEHN S, FROBÖSE I.** Stress im eSport– Ein Einblick in Training und Wettkampf. ESport Conference "Professionalisierung Einer Subkultur?". Germany, Bayreuth, 2016.

(9) **SCHÜTZ M.** Sportwissenschaftler: eSports-Profis sind wahre Athleten. Deutsche Welle 2016. 2020. https://www.dw.com/de/sportwissenschaftler-esports-profis-sind-wahre-athleten/a-19011581 [June 24th 2020].

(10) **SCHWABERGER G.** Heart rate, metabolic and hormonal responses to maximal psycho-emotional and physical stress in motor car racing drivers. Int Arch Occup Environ Health. 1987; 59: 579-604. doi:10.1007/BF00377921

(11) **TAGGART P.** Emotional stress. Curr Probl Cardiol. 1983; 7: 4-29. doi:10.1016/0146-2806(83)90034-8

(12) **THARION E, PARTHASARATHY S, NEELAKANTAN N.** Short-term heart rate variability measures in students during examinations. Natl Med J India. 2009; 22: 63-66.

(13) **THIEL A, JOHN JM.** Is eSport a 'real' sport? Reflections on the spread of virtual competitions. Eur J Sport Sci. 2018; 15: 311-315. doi:10.1080/16138171.2018.1559019

(14) **WELTÄRZTEBUND.** WMA Deklaration von Helsinki -Ethische Grundsätze für die medizinische Forschung am Menschen. WMA-Generalversammlung. 2013; 35: 1-10.

(15) **ZWIBEL H, DIFRANCISCO-DONOGHUE J, DEFEO A, YAO S.** An osteopathic physician's approach to the esports athlete. J Am Osteopath Assoc. 2019; 119: 756-762. doi:10.7556/jaoa.2019.125