

INFLUENCE OF COMPUTER GAMES ON HUMAN PHYSIOLOGICAL FUNCTIONS

Bibiána Ondrejová

Department of Biomedical Engineering and measurement, Faculty of Mechanical Engineering, Technical University of Kosice, Letná 1/9, 042 00, Košice, Slovakia, bibiana.ondrejova@tuke.sk (corresponding author)

Teodor Tóth

Department of Biomedical Engineering and measurement, Faculty of Mechanical Engineering, Technical University of Kosice, Letná 1/9, 042 00, Košice, Slovakia, teodor.toth@tuke.sk

Monika Michalíková

Department of Biomedical Engineering and measurement, Faculty of Mechanical Engineering, Technical University of Kosice, Letná 1/9, 042 00, Košice, Slovakia, monika.michalikova@tuke.sk

Marianna Trebuňová

Department of Biomedical Engineering and measurement, Faculty of Mechanical Engineering, Technical University of Kosice, Letná 1/9, 042 00, Košice, Slovakia, marianna.trebunova@tuke.sk

Jozef Živčák

Department of Biomedical Engineering and measurement, Faculty of Mechanical Engineering, Technical University of Kosice, Letná 1/9, 042 00, Košice, Slovakia, jozef.zivcak@tuke.sk

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Abstract: Video games are popular leisure activity for all ages and therefore it is needed to examine their psychological and physiological effects. The aim of the presented paper is to point out possible changes in physiological functions due to playing computer games and to present them in a pilot study. Part of the work is the categorization of video games and a systematic overview of studies aimed at examining and confirming or refute their connection. The purpose of this pilot study is to measure blood pressure and human heart rate while playing different video games and to evaluate possible changes in the game. The methodology of the experiment includes demographic data, measured values during the monitoring of individual subjects and the measuring means used.

1 Introduction

A popular leisure activity for many people is playing video games. For gamers, gaming can be seen as a fun distraction or a hobby, and their popularity continues to grow. According to various surveys, it is clear that despite the rapid development of gaming consoles, many people prefer to play games on personal computers. The increasing prevalence of video game play among people has led to research into their potential positive or negative psycho-physiological effects. Research suggests that depending on the content of the game, gambling can affect physical and mental health [1-4].

The aim of the presented work is to investigate the short-term effects of video games on human physiology in a pilot study. Using the available measurement technology, the cardiovascular parameters of the subjects playing different types of games during a uniform time limit were examined.

1.1 Overview of studies

The measuring devices used in the studies were diverse, with the automatic pressure gauge being the most commonly used. Digital automatic pressure gauges mostly work on so-called oscillometric principle. During the

measurement, a cuff is placed on the upper limb, typically on the shoulder or wrist, which is pressurized to a value at which the artery is securely constricted and no blood flows in it. Periodic pressure changes occur as the cuff pressure decreases. Pressure changes are caused by volume pulsation in the arteries [5,6].

These oscillations are transmitted to the measuring device via the cuff pressure, where they are evaluated. Thus, the pressure gauge does not determine the values of systolic and diastolic pressure, but the value of the so-called mean arterial pressure and both limits are calculated by the software of the device [7,8].

An interesting measuring technology was used of "Smart" clothing from Hexoskin® in a study from 2020. It allows remote monitoring of health in real time and display data on a smartphone or tablet using the Bluetooth function. Smart clothing was developed for personal experiments and was also used by health researchers to study physiology of elite and professional athletes to optimize their physical health. Hexoskin® incorporates physiological sensors into intelligent textile materials to monitor ECG, heart rate, heart rate variability, respiratory rate, respiratory volume and other activity measurements such as step counting and energy expenditure. This technology may be suitable for this type of experiment, as

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it allows continuous measurement without disturbing the player while playing [9,10].

In a horror video game study, they used a Biopac technique to measure electrodermal activity, heart rate and respiratory rate. Biopac provides a complete combination of hardware and software with a range of electrodes, cables, transducers and stimulus options for the secure collection of physiological signal data. BIOPAC supports a wide range of experimental protocols - from simple to complex - and are designed to enable researchers with different levels of experience to acquire, analyze and interpret scientific data [11].

In a 2018 experiment, they used a "Runner cardio watch" from TomTom to measure their heart rate. This watch has two heart rate measurement options, with a built-in optical sensor directly in the watch or via an external sensor mounted on the chest. The heart rate is measured by LED light that penetrates the surface of the skin and the wall of blood vessels. The sensor is located on the wrist and captures the changing reflections of light that change with the blood flow. Due to their size and location, they provide comfort when playing video games and data is imported directly into the smart device [12].

A 12-lead ECG was used in a study to examine the cardiovascular side effects of video games in boys aged from 7 to 10 years. The device senses the electrical potentials that the heart muscle generates during its operation and thus also records the heart rate. However, the connected limb and thoracic leads could interfere with the player during play and it is also not appropriate to measure as the subject moves, as the electrical potentials of the skeletal muscle may be recorded [12].

2 Methodology

The chosen technology was an automatic blood pressure monitor, which was also the most widely used technology for measuring cardiovascular values in the presented studies.

Four subjects aged from 22 to 29 years (three men and one woman) were asked to complete the questionnaire with basic information. Subjects answered questions about age, gender, game preferences, gaming experience, and health.

When asked how skilled subjects are in playing video games, the first and second subject stated very well skilled and the third subject stated not very skilled. The first and second subject stated that they were considered to be players and the third and fourth subject to be considered casual players.

2.1 Subjects monitoring before the experiment

An overview of the average values of blood pressure and heart rate in subjects during the day is important for the final comparison. These values can be used to compare video game values with activities other than exercise or relaxation. The subject's blood pressure and heart rate were measured for three days and the values recorded were attributed to the respective activity. Ten measurements

were made per day, the first measurement being the morning after waking up and the last before going to bed. Fluctuations in values could be caused by work during the day, physical activity or exercise. The first three subjects have a sedentary job and work most of the time at the computer. The fourth subject works manually.

Table 1 Questions and answers of subjects

Questions	Subject no. 1	Subject no. 2	Subject no. 3	Subject no. 4
<i>Age</i>	29	26	22	29
<i>Gender</i>	man	man	woman	man
<i>Do you consider yourself a regular / occasional player or a "non-player"?</i>	Regular player	Regular player	Casual player	Casual player
<i>How long have you been playing games on a regular basis?</i>	17 years	13 years	-	-
<i>How many hours a week do you play regular games?</i>	More than 20 hours	More than 3 hours	-	-
<i>What are your game preferences ?</i>	Action RPG	Action RPG	Simulations	Horror
<i>Are you treating some chronic diseases?</i>	no	no	no	no

2.2 Factors influencing measurement

Participants were introduced to the rules for measuring blood pressure and heart rate correctly using an automatic sphygmomanometer. During the monitoring, the participants measured the blood pressure by themselves and recorded the values, which were later processed. For the objectivity of the measurement, participants were asked not to smoke, consume alcohol / caffeine and eat just before the measurement and the experiment itself.

2.3 Measuring equipment

A digital Omron Class M3 (Figure 1) shoulder cuff blood pressure monitor was used to measure blood pressure and heart rate.

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Figure 1 Omron M3 digital automatic pressure monitor

The device has several functions such as motion detection during measurement, detection of arrhythmia and irregular pulses, control of a correctly fitted cuff and memory for two users. The manufacturers state a pulse measurement accuracy of 5% and a pressure measurement accuracy of ± 3 mmHg. The measuring range provides at a blood pressure from 0 to 299 mmHg and at a heart rate from 40 to 180 beats / min.

2.4 Game environment

In order to compare the different effects of several genres of video games, three popular genres were selected, namely action RPG, survival horror game and FPS game. The hypothesis is that in more intense or exciting games, there will be a difference in blood pressure and heart rate before play than during and after play. The games were selected on the basis that the players did not have experience with specific games. This could affect the results as players may react differently to the game than when they play it for the first time. However, when choosing an existing game, there is no control over the design of the game, which can be limiting in terms of the various non-life passages. Therefore, before playing, it was necessary to set specific storyline "missions" that the games offer and the player was directly exposed to the story. In the horror game, it was necessary for the player to empathize with the story and to evoke the atmosphere and a feeling of fear, it was necessary to complete the whole story with the introductory trailers.

For the survival horror game, a game from 2017 called "Resident evil 7: Biohazard" was selected. The game called "Call of Duty: World War II" from 2017 was chosen as the FPS game. From the action RPG, the game called "Fallout 4" was chosen, which takes place in a post-apocalyptic world. According to "The Entertainment Software Rating Board", video games have a rating of M ("Mature"), ie suitable for people aged 18 and over, and according to PEGI, games are suitable for at least 18 years old players.

2.5 Difficulty of the games

At the beginning of each game, the subjects chose the difficulty of the game according to their playing experience. Video games usually offer the player three to four options to choose from, and the system of rules or the

number of challenges may change depending on this choice.

2.6 The course of the experiment

The experiment was run one player at a time, who was familiar with the rules. After completing the questionnaire, they sat in front of the computer on which the selected video game was prepared and set up. After five minutes of sitting and resting, their blood pressure and heart rate were measured. These values were recorded and subsequently the players were acquainted with the genre of the game, the name and the principle of control of the game.

Interfering elements were removed as much as possible during play and measurement. As the game began, a stopwatch was set up every ten minutes to measure physiological functions. Since the playing time per game was 60 minutes, more frequent measurements could mean that the player would not be able to concentrate on the game and this would be counterproductive. After ten minutes, the game was paused and the pressure gauge cuff was put on. The measurement started and the values were recorded. Simultaneously with the game, the game was recorded using the "recording" function, which is available in the game panel of the Windows 10 operating system. By this way, it was possible to later describe the game situation before the measurement during the game. During more action passages, it would be possible to realistically compare the values with the values of calmer passages for each game and each subject. These recordings were saved automatically when the recording was stopped. At the end of the game period, the video game was paused and the last reading during the game was immediately measured. In the end, the player remained still for five minutes, then he was measured for the last time and the values were recorded as values after the game.

There was a slight twilight in the room where the measurement was made, as this factor can also affect the intensity of the gaming experience. Subjects played games during different parts of the day, ie. in the morning (8:00 - 12:00), in the afternoon (12:00 - 17:00) or in the evening (17:00 - 00: 00). For this fact, it was appropriate to compare the values from the game time and from monitoring in the same part of the day.

Table 2 Average values during gaming compared to the average values from the monitoring of the first subject

Game	Subject no. 1	Subject no. 2	Subject no. 3	Subject no. 4
FPS game	afternoon	evening	morning	evening
Horror game	afternoon	evening	morning	evening
Action RPG	afternoon	afternoon	morning	evening

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3 Evaluation of results and discussion

The measurement results reflect the current situation at the time of the measurement and are influenced by the current situation. Therefore, it is important to record the course of the game in order to associate an action in the game, e.g. distance / near combat with a change in blood pressure or heart rate.

3.1 Summary of the measured data of the first subject

In Figure 2 is a graphical representation of the measured values of systolic pressure (SP), diastolic pressure (DP) and heart rate (HR) of the first subject. In the legend, the games are marked in order, the so-called FPS game (G1), survival horror game (G2) and action RPG (G3).

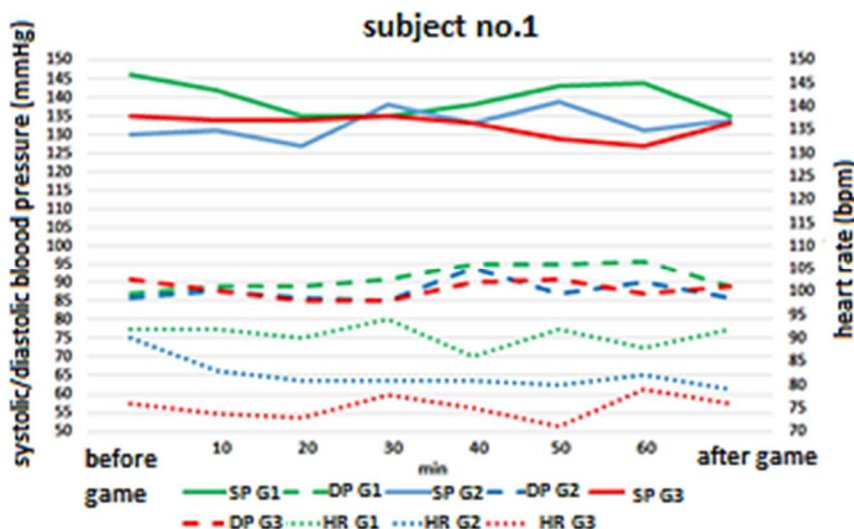


Figure 2 Graphical representation of the measured data of the first subject

As a consequence of these measured data, it is clear that the systolic blood pressure of the first subject fluctuated maximally during FPS play, while the diastolic blood pressure fluctuated minimally. The data were measured differently during the horror game, when the diastolic pressure and the mild systolic pressure fluctuated maximally. The heart rate was relatively stable during the horror game. Playing an action RPG caused the slightest fluctuation in the first subject's cardiovascular values.

During the FPS game, the average blood pressure and heart rate were significantly higher compared to the average rest value. At the same time, the average values during the playing of the FPS game are also higher compared to the average value during the workload.

Playing a horror game caused only a negligible difference in systolic blood pressure compared to the average rest value. The average diastolic pressure and heart rate during the horror game were significantly higher compared to the average rest value. The value of the average systolic pressure during the workload is slightly lower than the value of the systolic pressure during the horror game. There is no significant difference in the values of diastolic pressure and heart rate during horror play compared to the values during workload.

During the action RPG, the average values differ significantly compared to the values during the rest only in diastolic pressure, which was significantly higher during the game. During the action RPG game, the average

systolic blood pressure values were significantly lower than the average values during the workload. The average value of diastolic pressure during play does not differ significantly from the value during workload.

Table 3 Average values during gaming compared to the average values from the monitoring of the first subject

Subject no. 1	Systolic blood pressure mmHg		Diastolic blood pressure mmHg		Pulse bpm	
	min	max	min	max	min	max
While playing (FPS game) average	140		93		90	
Highest and lowest value	144	134	96	89	94	86
While playing (Horror game) average	133		88		81	
Highest and lowest value	139	127	94	85	83	80
While playing (Action RPG game) average	132		88		75	
Highest and lowest value	139	127	91	85	79	71
Average value during workload	136		86		80	
Average value during rest	132		81		77	

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3.2 Summary of the measured data of the second subject

In Figure 3 is a graphical representation of the measured values of systolic pressure, diastolic pressure and

heart rate of the second subject. In the legend, the games are marked in order, the so-called FPS game, survival horror game and action RPG.

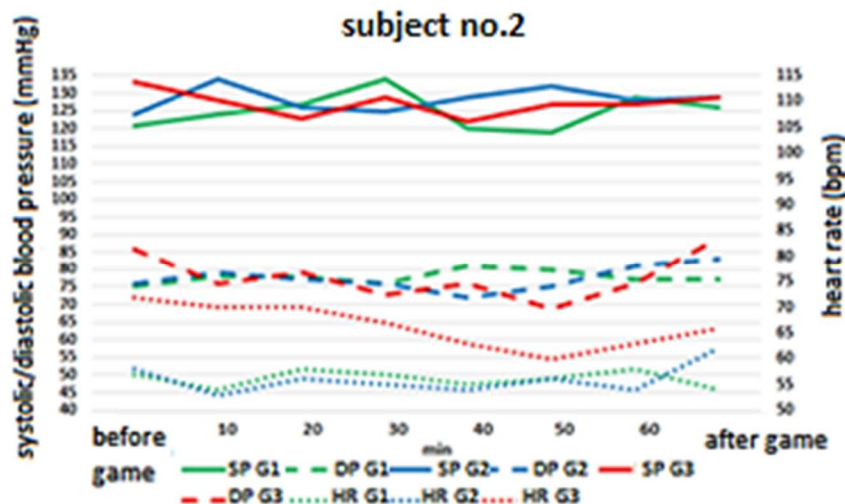


Figure 3 Graphical representation of the measured data of the second subject

As a result of playing the FPS game, the maximum fluctuation of systolic pressure was recorded, while the diastolic pressure and heart rate were stabilized. As a result of playing the horror game, a slight fluctuation in blood pressure and minimal fluctuations in heart rate were found. The systolic pressure during the action RPG was relatively stable. Playing an action RPG was affected by fluctuations in diastolic blood pressure and a decrease in the other person's heart rate.

During the FPS game, the average systolic and diastolic pressures were significantly higher compared to the average rest value. At the same time, the average values of blood pressure during playing the FPS game are identical compared to the average value during the workload. The heart rate during FPS play is lower compared to the average value during rest and workload.

Playing a horror game caused only a negligible difference in systolic blood pressure compared to the average rest value. The average diastolic pressure and heart rate during the horror game were significantly higher compared to the average rest value. The value of the average systolic pressure during the workload is slightly lower than the value of the systolic pressure during the horror game. There is no significant difference in the values of diastolic pressure and heart rate during horror gameplay compared to the values during workload.

During the action RPG, the average values differ significantly compared to the values during the rest only in diastolic pressure, which was significantly higher during the game. During the action RPG, the average systolic blood pressure values were significantly lower than the average values during the workload. The average value of diastolic pressure during play does not differ significantly from the value during workload.

Table 4 Average values during gaming compared to the average values from the monitoring of the second subject

Subject no. 2	Systolic blood pressure mmHg		Diastolic blood pressure mmHg		Pulse bpm	
	While playing (FPS game) average	126		78		56
Highest and lowest value	134	119	81	76	58	54
While playing (Horror game) average	129		77		55	
Highest and lowest value	134	125	81	72	56	53
While playing (Action RPG game) average	126		75		66	
Highest and lowest value	129	122	79	69	60	70
Average value during workload	127		78		67	
Average value during rest	118		64		64	

3.3 Summary of the measured data of the third subject

In Figure. 4 is a graphical representation of the measured values of systolic blood pressure, diastolic blood pressure and heart rate of a third subject. In the legend, the games are marked in order, the so-called FPS game (H1), survival horror game (H2) and action RPG game (H3).

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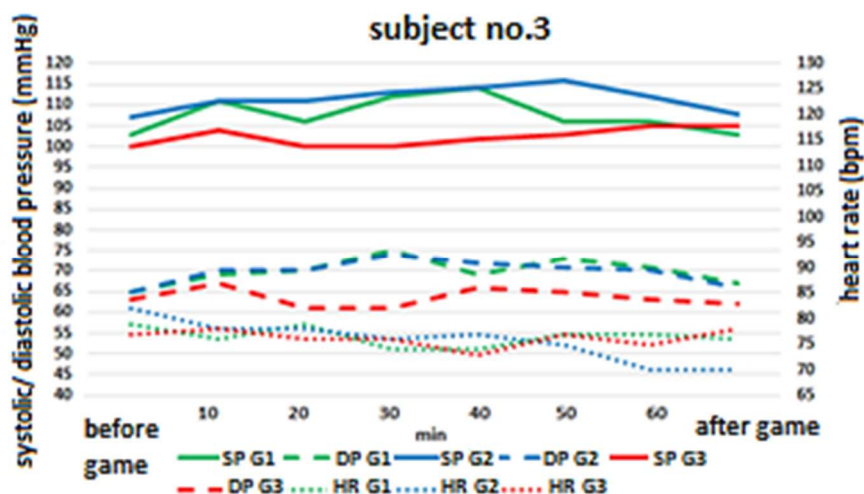


Figure 4 1 Graphic representation of measured data of a third subject

Increased systolic pressure when comparing values before and after playing was recorded only when playing an action RPG by 5 mmHg. After playing the FPS game, the subject had the same systolic pressure as before the game. After playing the horror game, there was no significant difference in systolic pressure before and after playing. There was no significant difference in diastolic pressure values before and after playing in any of the measurements. The heart rate after playing a horror game dropped by up to 12 beats compared to a lot before playing. In other games, there was no significant difference before and after playing in heart rate values.

Table 5 Average values during gaming compared to average values from third subject monitoring

Subject no. 3	Systolic blood pressure mmHg		Diastolic blood pressure mmHg		Pulse bpm	
	min	max	min	max	min	max
While playing (FPS game) average	109		71		76	
Highest and lowest value	114	106	75	69	79	74
While playing (Horror game) average	113		71		76	
Highest and lowest value	116	111	74	70	78	75
While playing (Action RPG game) average	102		64		76	
Highest and lowest value	105	100	67	61	78	73
Average value during workload	115		69		70	
Average value during rest	108		67		64	

During the FPS game, the average diastolic pressure and heart rate were higher compared to the average rest

value. The difference in average systolic pressure during FPS play is negligible compared to the rest value. At the same time, the heart rate during playing the FPS game was also higher compared to the average value during the workload. During play, the average systolic pressure was lower than during workload. There is no significant difference in the values of diastolic pressure during the horror game compared to the values during the workload. The average heart rate during FPS play is significantly lower than the value during workload.

Playing a horror game caused an increase in systolic blood pressure compared to the average rest value. The average diastolic pressure and heart rate during the horror game were significantly higher compared to the average rest value. The value of the average systolic pressure during the horror game was slightly lower than the average value during the workload. There is no significant difference in the values of diastolic pressure during the horror game compared to the values during the workload.

The subject's blood pressure was even lower than his average resting value while playing the action RPG. The heart rate was significantly higher during play. During the action RPG game, the average systolic blood pressure was significantly lower than the average during workload. The average heart rate during play is significantly lower than the value during workload.

As a result of playing the FPS game, the maximum fluctuation of systolic pressure was recorded, while the diastolic pressure and heart rate were stabilized. As a result of playing the horror game, a slight fluctuation in blood pressure and minimal fluctuations in heart rate were found. The systolic pressure during the action RPG game was relatively stable. Playing an action RPG game was affected by fluctuations in diastolic blood pressure and a decrease in the heart rate of a third subject.

3.4 Summary of measured data of the fourth subject

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In Figure 5 is a graphical representation of the measured values of systolic pressure, diastolic pressure and heart rate of a fourth subject. In the legend, the games are

marked in order, the so-called FPS game, survival horror game and action RPG game.

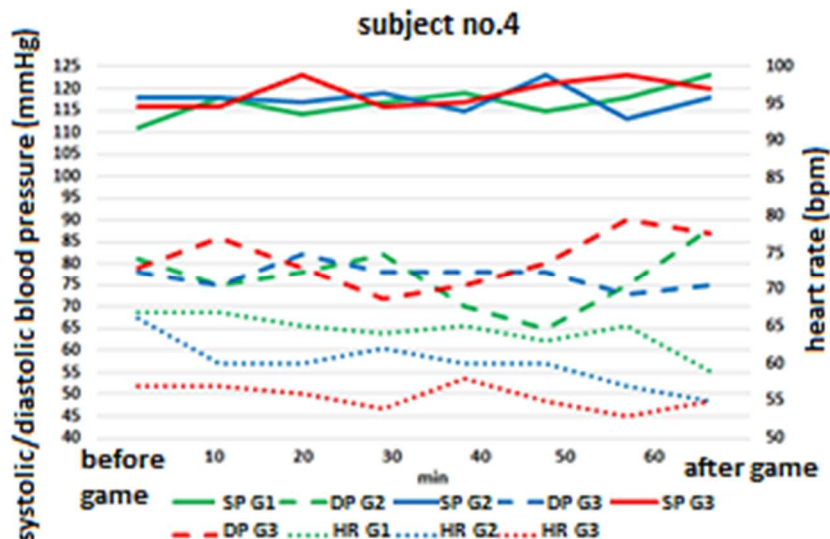


Figure 5 Graphical representation of the measured data of the fourth subject

As a consequence of these measured data, it is clear that the systolic blood pressure of the fourth subject fluctuated maximally during the horror game, while the diastolic pressure fluctuated minimally. The data were measured differently during the action RPG game, when the maximum diastolic pressure and mild systolic pressure fluctuated. The heart rate was relatively stable while playing the action FPS game. Playing the FPS game caused the slightest fluctuation in the fourth subject's cardiovascular values.

During the FPS game, the average blood pressure was higher compared to the average rest value. At the same time, the average values during the playing of the FPS game are also lower compared to the average value during the workload. The average heart rate during FPS play was lower compared to the average value during rest and workload.

Table 5 Average values during gaming compared to the average values from the monitoring of the fourth subject

Subject no. 4	Systolic blood pressure mmHg		Diastolic blood pressure mmHg		Pulse bpm	
	min	max	min	max	min	max
While playing (FPS game) average	117		74		65	
Highest and lowest value	119	114	82	70	67	63
While playing (Horror game) average	118		77		60	
Highest and lowest value	123	113	82	73	62	57
While playing (Action RPG game) average	119		81		56	
Highest and lowest value	123	116	90	72	58	53
Average value during workload	120		81		74	
Average value during rest	113		78		69	

The average systolic blood pressure during the horror game was significantly higher compared to the average rest value. Playing a horror game caused only a negligible difference in diastolic pressure compared to the average respite. The value of the average systolic pressure during the workload is slightly higher than the value of the systolic pressure during the horror game. The average diastolic pressure and heart rate were lower during the horror game compared to the average during the workload.

During the action RPG, the average systolic pressure was significantly higher compared to the values during the rest and almost the same compared to the values during the workload. Playing an action RPG, the average systolic blood pressure values were significantly lower than the average values during the workload. The average value of diastolic pressure during the action RPG game is the same as the value during the workload and slightly higher compared to the rest value. The average heart rate during play was lower compared to the average value during rest and workload.

4 Conclusions

A person's physical and mental health is primarily related to his or her lifestyle, which is also affected by the way he or she relaxes. The massive increase in the use of modern technology has caused people to use their free time

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to relax by playing video games. Examining the effect in both the short and long term is relevant because video games can have a potentially positive as well as a negative impact on human health. These hypotheses are based on research that scientists have been conducting for years, and their opinions differ, as there are many influencing factors, such as the periodicity of video games [3,4].

The aim of the presented work was to investigate the effect of playing video games from the point of view of human physiology in the pilot study by evaluating three cardiovascular parameters. The correlation between the measured values and the game event was found through the available measuring technology and the recording of the game event. Consistent with the results, no risk fluctuations were found and the values recorded were within physiological standards. As this is a pilot study designed to test the functionality and the research process, the results cannot be generalized. The research part of the work was limited by the epidemiological situation in Slovakia.

For a more objective assessment of the measured values during play, it would be necessary to use a device that ensures continuous measurement of the player's cardiovascular values, such as electrocardiography. In this way, it would be possible to record all values and thus eliminate the regular interference of the player during the game. To determine the risk of playing games, research could be focused on chronically ill patients (eg hypertension) under the supervision of a doctor. This method of research and its results can have the benefit of a recommendation for regular players suffering from a chronic illness. An interesting alternative to research would be to measure and monitor people with gambling addiction for several consecutive days, and the results would be averaged. There are different gaming platforms whose resulting effects on the player may vary and could be compared.

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Review process

Single-blind peer review process.