

ORIGINAL SCIENTIFIC PAPER

Changes in Physiological Indicators during the first Bungee Jump

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Abstract

During a bungee jump, numerous physiological responses occur in the body of a jumper, such as mild dizziness, increased sweating, and rapid breathing. The aim of this study was to determine the changes in the physiological parameters of subjects before, immediately before and after the first bungee jump, by monitoring the heart rate, blood pressure and perception of fear. Subject sample was formed by 17 students of the Faculty of Kinesiology from Zagreb, who did not have experience with bungee jumps until the beginning of the research. The sample of variables was made of the values of heart rate, systolic and diastolic blood pressure, and perception of fear. The results indicated that prior to the jump, the heart rate and blood pressure values were within the limits of normal values and the perception of fear was very small. Immediately before the jump, the heart rate and blood pressure increased and the perception of fear increased significantly. After the jump, there was a normalization of the heart rate, blood pressure, and reduced perception of fear. The results of this study suggest that there are many physiological reactions in the human body happening during high-adrenaline activities.

Key words: blood pressure, extreme sports, heart rate, perception of fear, student population

Introduction

The development of sports in the past century was intended to reduce health risks of athletes. Without risk factor, some sports would probably lose their main characteristics and interest of the public. For the risk to be a factor that makes a sport attractive there must be a real possibility for injury and the presence of death. According to this characteristics, the term extreme sports have become a universal name for adventure sports with serious health risks and possible fatal outcomes. Brymer (2005), defined extreme sports as independent leisure activities where the most likely outcome of a mismanaged mistake or accident is death. The free climbing, mountain biking, extreme skiing, parkour, free running, bungee jumping, rafting, free diving, cliff diving, hang gliding, ice climbing, surfing, B.A.S.E. jumping are the most known examples of extreme sports.

Bungee jumping is one of the most popular extreme sports today and it is characterized by a jump from the top of a tall structure (bridge, platform, mountain) to the sea or land with

an elastic rope tied to the feet.

The first bungee jumps can be traced to the South Pacific islands and the initiation ritual of young boys into manhood in the Vanuatu tribe, in which boys jumped from the high ground into the sea with vines tied to their feet, demonstrating their masculinity (Ronca, 2009). The beginnings of modern bungee jumping date back to the 1980s, where there was jumping off of the bridge in Bristol, England. Later this sport spread to America, New Zealand, Australia and France and from there to the entire world (Sagert, 2008). This sport is especially popular among young people who are prone to activities that cause strong emotional reactions and the result is increased levels of adrenaline hormone.

During the bungee jump, there are numerous physiological reactions happening in the jumper's body, such as changes in heart rate, increased blood pressure and stress hormone activation (Zimmerman, Loew, & Wildt, 1992). Williams, Taggart and Carruthers (1978) observed electrocardiogram and plasma catecholamine concentrations of 11 healthy men



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monitored during two rock climbing ascents. Mean heart rates were 166 ± 20.4 bpm and 120 ± 10.2 bpm during first and second ascent. Authors concluded that heart rate values were significantly increased during rock climbing ascents. Schwaberg (1987) was investigated a group of 20 drivers during car races (Formula Ford and Renault-5-Cup) and during progressive bicycle ergometer in the laboratory. Heart rate during car racing reached a mean level of 174.3 ± 14.1 bpm, corresponding to 90% of the maximal heart rate achieved at the end of exhaustive ergometer. The author concluded that heart rate values were significantly increased during car racing. Hennig, Laschewski and Opper (1994) on a sample of 12 volunteers between the ages of 25 and 30, monitored their mood, heart rate, blood pressure and saliva. Authors found that the blood pressure was increased before and after the jump and subjective estimate of anxiety suddenly increased before the jump and significantly decreased after the jump.

Height vertigo, a visually induced syndrome commonly experienced on top of high structures is manifested by a subjective instability of posture and locomotion coupled with a fear of falling and vegetative symptoms. It is similar to motion sickness in that both are acute 'physiological symptoms' which spontaneously remit after termination of the inducing stimulus situation. Height vertigo generally has been attributed to psychopathological processes such as neurotic acrophobia or neurasthenic dizziness (Brandt, Arnold, Bles, & Kapteyn, 1980). Alpers and Adolph (2008) conducted a study on a sample of 35 healthy males between 18 and 42 years of age and investigated the relationship between fear, dizziness, and body sway during height exposure. Results indicated that participants experienced less fear during pre-exposure and post-exposure than during exposure. Fear was also greater during pre-exposure as compared to post-exposure. Participants experienced less dizziness during pre-exposure and post-exposure than during exposure. Dizziness was also greater during pre-exposure as compared to post-exposure. Increased body sway was evident during exposure in comparison to the pre-exposure situation and the post-exposure situation. Authors found that the perception of fear and body sway was increased before, during and after the height exposure. Brymer and Schweitzer (2013) conducted a study on a sample of 15 extreme sports participants (10 men and five women aged 30 to 70 years). They explore participants' experience of fear associated with participation in extreme sports. Participants in this study report that facing fear in extreme sports and learning to participate despite the intensity of the fear facilitates the management of fears in other aspects of life.

According to the literature review, there are a few studies who investigated physiological reactions in extreme sports. This topic is important for research because of the increasing number of people who are participating in this type of sports.

Therefore the aim of this study was to examine changes in the physiological parameters of participants before, immediately before and after the first bungee jump, by monitoring their heart rate, blood pressure and perception of fear.

Methods

A sample of subjects was formed by students of the Faculty of Kinesiology from Zagreb. A total of 17 subjects (8 female and 9 male subjects), aged 20-25 and who had no prior experience with bungee jumping, participated in the research. Before the start of the research, the subjects' health status was assessed to be satisfactory and they were explained the goals, the procedure and the possible consequences of the research. Study was approved by the Ethics Commission of the Faculty of Kinesiology in Zagreb. Each participant voluntarily provided written informed consent before participating.

The research was conducted near Zadar at Maslenica bridge (55 m height) under the supervision of licensed bungee jumping supervisors. A sample of variables was made of the heart rate values measured 10 min before the jump, immediately before the jump and 10 min and 20 min after the jump. The automatic blood pressure monitor was used to measure the systolic and diastolic blood pressure values 10 min before the bungee jump, 2 min before the jump, 2 min after the jump and 10 min and 20 min after the bungee jump. From the obtained values, mean arterial blood pressure was calculated for each subject. The perception of fear was estimated 20 min, 10 min and 1 min before the bungee jump using a fear scale (Chapman, & Kirby-Turner, 2002).

Statistical data processing was conducted using a software package Statistica ver. 10.0 for Windows. Descriptive indicators (arithmetic mean and standard deviation) of the variables heart frequency, blood pressure and perception of fear were calculated for the obtained data. In order to determine the differences in the heart rate frequency, blood pressure and fear perception between the series of repeated measurements, Friedman's Anova was used, and for determining sex differences the Mann - Whitney U test was used. All analysis was used at the statistical significance $p=0.05$.

Results

Heart rate

Descriptive heart rate indicators of the total sample ($N=17$) and sample by sex (8 female and 9 male subjects) are shown in Table 1. The heart rate (bpm) 10 min before the jump was significantly higher than the usual average values (60-90 bpm). Immediately before the bungee jump, the heart rate reached the highest values during the measurement (159-160 bpm). Ten minutes after the bungee jump, the number of heart beats per minute dropped to almost normal levels, and 20 min after the jump, the heart rate was within the limits of normal values (Table 1).

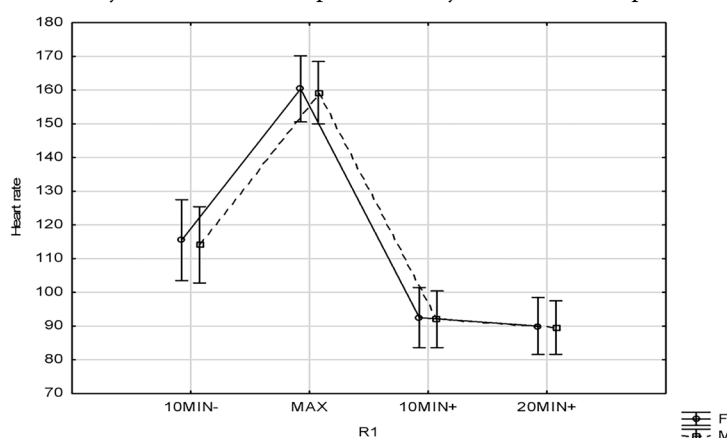
Table 1. Average heart rate values (beats/min) before and after the bungee jump, and results of Mann - Whitney U test

HR	Mean \pm SD (female)	Mean \pm SD (male)	Rank Sum (female)	Rank Sum (male)	U	Z	p
10MIN-	115.50 \pm 15.30	114.11 \pm 16.44	73.50	79.50	34.50	0.10	0.92
MAX	160.38 \pm 8.68	159.22 \pm 15.86	78.00	75.00	30.00	0.53	0.60
10MIN+	92.50 \pm 12.21	92.00 \pm 11.50	72.50	80.50	35.50	0.00	1.00
20MIN+	90.00 \pm 10.86	89.56 \pm 11.47	72.50	80.50	35.50	0.00	1.00

Legend: (HR) heart rate; (10 MIN-) heart rate 10' before the jump; (MAX) heart rate immediately before the jump; (10MIN+) heart rate 10' after the jump; (20MIN+) heart rate 20' after the jump

The average heart rate of the male subjects 10 min before the bungee jump was 114.1 bpm, while in the female subjects it was 115.5 bpm (Picture 1). The average heart rate of the male subjects immediately prior to the bungee jump was 159.2 bpm, while in the female subjects it was 160.4 bpm.

The average heart rate of the male subjects 10 min after the bungee jump was 92.0 bpm, while in the female subjects it was 92.5 bpm. The average heart rate of male subjects 20 min after the bungee jump was 89.5 bpm, while in the female subjects it was 90.0 bpm.



Picture 1. Heart rate values (beats/min) for males and females before and after the bungee jump

Friedman’s Anova was used to determine the significance of differences in heart rate values measured at four time points (10 min before the jump, immediately before the jump and 10’ and 20’ after the jump). Significant differences in results at all four time points were found in heart rate values (ANOVA Chi Sqr.=47.95; p=0.00), but statistically significant differences were not found in the results by sex (Table 1).

Blood pressure

Blood pressure variables are expressed by the values of systolic and diastolic blood pressure measured 10 min, 2 min before the bungee jump, and 2 min, 10 min and 20 min after the bungee jump and the median arterial blood pressure (Lurbe et al., 2009). Descriptive indicators of blood pressure variables of the sample by sex (8 female and 9 male subjects)

are presented in Table 2. Systolic blood pressure values 10 min before the bungee jump was lower in female subjects, while diastolic blood pressure was lower in male subjects compared to female subjects. Two minutes before the bungee jump, blood pressure values increased, and at that point, the systolic pressure was lower in female subjects, while the diastolic pressure was lower in the male subjects. Two minutes after the bungee jump, the blood pressure values decreased and at this point, the systolic and diastolic blood pressure values were lower in the female subjects than in the male subjects. Blood pressure values ten minutes after the bungee jump further decreased and at that point, the systolic and diastolic pressure values were lower in the female subjects than in the male subjects. Twenty minutes after the bungee jump, the systolic blood pressure values decreased even more.

Table 2. Average blood pressure values (systola/diastola) before and after the bungee jump, and results of Mann -Whitney U test

BP	Mean ± SD (female)	Mean ± SD (male)	Rank Sum (female)	Rank Sum (male)	U	Z	p
10 - sys	137.13±16.96	144.33±14.12	61.50	91.50	25.50	-0.96	0.34
10 - dia	86.25±7.44	84.44±7.78	76.00	77.00	32.00	0.34	0.74
2 - sys	147.25±25.18	157.89±29.59	64.50	88.50	28.50	-0.67	0.50
2 - dia	93.88±12.84	91.78±13.27	78.00	75.00	30.00	0.53	0.60
2 + sys	140.75±27.92	142.89±9.55	65.00	88.00	29.00	-0.63	0.53
2 + dia	83.50±11.81	88.33±9.54	66.00	87.00	30.00	-0.53	0.60
10 + sys	123.25±18.75	134.89±12.23	56.50	96.50	20.50	-1.44	0.15
10 + dia	83.25±10.50	84.33±7.05	62.50	90.50	26.50	-0.87	0.39
20 + sys	119.38±13.93	133.89±16.47	56.50	96.50	20.50	-1.44	0.15
20 + dia	87.88±6.58	82.33±8.79	87.00	66.00	21.00	1.40	0.16

Legend: (BP) blood pressure; (10 - sys) systole 10’ before the jump; (10 - dia) diastole 10’ before the jump; (2 - sys) systole 2’ before the jump; (2 - dia) diastole 2’ before the jump; (2 + sys) systole 2’ after the jump; (2 + dia) diastole 2’ after the jump; (10 + sys) systole 10’ after the jump; (10 + dia) diastole 10’ after the jump; (20 + sys) systole 20’ after the jump; (20 + dia) diastole 20’ after the jump

The average value of mean arterial blood pressure in the male subjects 10 min before the bungee jump was 104.4 and in the female subjects, it was 103.2. Immediately before the bungee jump, the mean arterial blood pressure value in the male subjects was 113.8, while in the female subjects it was 111.7. The mean arterial blood pressure of the subjects 10 min after the bungee jump was 101.2, while in the female subjects it was

96.6. The average value of mean arterial blood pressure of the male subjects 20 min after the bungee jump was 99.5, while in the female subjects it was 98.4. The average values of mean arterial blood pressure of female subjects were lower than the values of male subjects at all time points of measurement. In blood pressure variables, Friedman’s Anova was used to determine the significance of differences in values measured at

five time points (10', 2' before the jump and 2', 10', 20' after the jump). Significant differences in results at all five time points were found in blood pressure values (ANOVA Chi Sqr.=21.54 p=0.00), but statistically significant differences were not found in the results by sex (Table 2).

Perception of fear

The perception of fear was estimated at 20 min, 10 min and 1 min before the bungee jump using a fear scale. Descriptive indicators for the total sample and sample by sex (8 female subjects and 9 male subjects) are shown in Table 3. The perception of fear 20 min before the bungee jump was very small, the subjects perceived almost no fear at all

at that moment. Ten minutes before the bungee jump, the perception of fear increased, but the values were still low. Immediately before the bungee jump, the perception of fear in all subjects was further increased and at that point reached the highest level during the research. The average perception of the fear in the male subjects 20 min before the bungee jump was very low while in the female subjects it was moderate. The average perception of fear in the male subjects 10 min before the bungee jump was still low while in the female subjects it was moderate. The average perception of the fear of the male subjects immediately before the bungee jump was moderate while in the female subjects it was very high.

Table 3. Average fear perception before the bungee jump, and results of Mann - Whitney U test

FP	Mean ± SD (female)	Mean ± SD (male)	U	Z	p
20'	3.13±2.23	0.56±1.01	13.50	2.12	0.03*
10'	3.50±2.51	1.11±0.93	17.00	1.78	0.08
1'	4.75±2.49	1.78±1.64	12.50	2.21	0.03*

Legend: (FP) fear perception; (20') fear perception 20' before the jump; (10') fear perception 10' before the jump; (1') fear perception 1' before the jump; *p<0.05

Friedman's Anova was used to determine the significance of differences in fear perception. Values measured at three time points found significant differences in results at all three time points (ANOVA Chi Sqr.=16.22 p=0.00). Mann Whitney U test determined statistically significant differences between the results of the male and female subjects at 20 minutes and 1 minute before the jump (Table 3). On average, female subjects had a greater perception of fear throughout the study compared to male subjects.

Discussion

The aim of this study was to determine the changes in the physiological parameters of subjects before, immediately before and after the first bungee jump, by monitoring the heart rate, blood pressure and perception of fear.

The heart rate 10 minutes and immediately before the jump for the total sample was significantly higher than the normal values (60 to 90 beats per minute). Ten minutes after the bungee jump, the number of heart beats per minute dropped to almost normal levels, and 20 minutes after the jump, the heart rate was within the limits of normal values. Similar results were also obtained by van Westerloo et al. (2011) who, on a sample of 20 volunteers aged 18-35, divided into two groups, experimental and control, determined the increase in heart rate before the first bungee jump and immediately before the jump and a decrease in heart rate after the jump in the control group which was not treated with beta-blockers. Schedlowski and Tewes (1992), on a sample of 36 parachutists with differing degrees of experience, found greater heart rate values in inexperienced parachutists than experienced ones. Increased arousal and perception of danger activated the sympathetic nervous system and stimulated adrenaline hormone production, which caused a physiological response of accelerated heart rate and blood flow. The body reacted in such a way that large muscle groups rapidly filled with blood to prepare for a quick reaction or to take flight from the threat.

The mean arterial blood pressure before the jump was within the limits of normal values but immediately before the jump increased above normal values. Two minutes after the

jump decreased to normal levels and 10 minutes after the jump dropped to normal levels. Similar results were obtained by Dutch researchers van Westerloo et al. (2011), who found an increase in mean arterial blood pressure immediately prior to the jump and its decrease after the jump in subjects of the experimental group treated with beta-blockers, but also in the control group that was not treated with beta-blockers. An increase in the perception of danger caused adrenaline hormone secretion and sympathetic nervous system activation, which triggered a physiological reaction of cardiovascular system acceleration and narrowing of blood vessels, as well as increased mean arterial blood pressure. Considering the muscular contraction, this physiological response is most similar to the static load, in which the blood supply through the active muscles is reduced or completely shut off, depending on the strength of the muscular contraction that mechanically stops the blood flow through the blood vessels, and a significant increase in systolic and diastolic pressure can be observed.

The values of fear perception before the jump were low. Immediately before the jump, the perception of fear of all subjects reached the highest level during the research. Monasterio et al. (2016) studied psychobiology of stress in B.A.S.E. jumpers. They divided the study sample into three classes of jumpers. "Masterful" jumpers (class 1), "trustful" jumpers (class 2) and "courageous" jumpers (class 3). People in class 3 (N=23) were described as "courageous" because they were anxious, less self-directed and less cooperative than the others, but faced the challenge of the jump with firm determination despite being the least experienced. Their cortisol reactivity was similar to "masterful" class one despite their being much less experienced and confident, but their alpha-amylase levels were the highest of the three groups. The authors concluded that the people with least experience in extreme sport had the highest anxiety level. Similar findings were also recorded by Hennig, Laschefski and Opper (1994), who, on a sample of 12 volunteers between the ages of 25 and 30, monitoring their mood, heart rate, blood pressure and saliva, found that the subjective estimate of anxiety suddenly increased before the jump and significantly decreased after the jump. Immediately before the jump

the perception of danger in the subjects was at the highest level and because of the increased secretion of the adrenaline hormone from the adrenal gland, the frequency of breathing, blood pressure, sweating and alertness all increased due to increased perception of danger, while after the jump all these physiological reactions significantly decreased, returning within the limits of normal values.

Future studies have to investigate and other physiological indicators before, during and after bungee jump such as the hormonal reaction of the body with a goal to explain even more specific effects of extreme sports on a human body. Furthermore, the use of appropriate experienced control group with more than one bungee jump in direct comparison to group with just one bungee jump would be helpful to explain these physiological changes even more detailed.

Before, during and after the first bungee jump, many physiological responses occurred. Prior to the jump, the heart rate and median arterial blood pressure values were within the limits of normal values and the perception of fear was very small. Immediately before the jump, due to increased perception of danger and adrenaline secretion, the heart rate and median arterial blood pressure increased, while the perception of fear increased significantly. After the jump, the heart rate and mean arterial blood pressure normalized, and the perception of fear reduced. The results of this study show that many physiological responses occur in the human body during high-adrenaline activities.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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