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Original Research Article

Parachuting training improves autonomic control of the heart in novice parachute jumpers

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ABSTRACT

This study aimed to investigate the acute effect of skydiving and the chronic effect of parachute jump training on the cardiac response in novice and trained parachuters.

The study included 11 experienced skydivers (expert group), aged 35.9 ± 7.2 years, and 12 students (novice group), aged 27.9 ± 7.2 years. Participants underwent 10-unit training in accelerated freefall (AFF) from an altitude of 4000 m.

In experts, the highest HR was noted during the phase of opening of the parachute and during the landing phase, and in pre-training novices during the phase of exit from the plane and the descent by parachute. Mean standard deviation of NN intervals (SDNN) was higher in experts than pre-training novices.

In novices, post-training values of SDNN, root mean square of successive differences (RMSSD), and the low/high frequency oscillation ratio (LF/HF) were higher, and HF and LF were lower, than pre-training values. In experts the values of SDNN, RMSSD, LF, HF, and total power spectrum (TP) were significantly higher and LF/HF significantly lower than in pre-training novices.

Novice compared to experienced skydivers are characterized by higher modulation of the sympathetic, and lower modulation of the parasympathetic autonomic nervous system (ANS). Chronic effects of 10-unit AFF training are characterized by decreased modulation of the sympathetic nervous system, increased total power spectrum of HRV, and increased activity of the parasympathetic nervous system. The changes in ANS modulation suggest that parachute training leads to a reduction of the stress response and improves autonomic control of cardiovascular function in novice skydivers.

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1. Introduction

Skydiving is one of the most popular aviation sports, which raises the question how extreme and changing environmental conditions affect humans [1]. Anxiety reactions play an important role in aviation safety.

The process of overcoming anxiety in extreme situations is associated with markedly accentuated sympathetic activation, as shown by the increase in heart and respiration rates and by elevated catecholamines and suppressed levels of cortisol and testosterone, with contributions of both alpha-adrenergic and beta-adrenergic receptors. The increase in HR is caused primarily by emotional tension, rather than physical stress [2–4]. Overcoming such reactions is an individual characteristic of each jumper and is strongly dependent on the aviation experience related to training and the number of jumps performed [5,6].

The circulatory system reacts by acceleration of the heart rate, increased systolic blood pressure, and increased blood flow through the working muscle, thereby increasing cardiac output without significant changes in stroke volume. The increased blood flow through the active tissue compensates partly or fully the reduced oxygen saturation [7,8].

To evaluate the dynamic changes of heart control by the autonomic nervous system (ANS), the analysis of heart rate variability (HRV) is used [9]. The HRV method is used in clinical trials in assessing the impact of sports training on the regulation of heart rate and the impact of environmental changes on the functions of the autonomic nervous system [10,11]. Endurance training enhances parasympathetic activity and reduces the activity of the sympathetic nervous system, reduces heart rate at rest, and during submaximal efforts significantly increases the sinus variability recorded as changes of HRV [12,13].

Acute cardiovascular adaptation responses to environmental conditions of skydiving are modified in the process of flight training. It has been shown that in similar circumstances of the aeronautical environment, experienced parachute jump instructors show lower values of heart rate compared to students entering flight training [14]. One can expect that parachute training conducted under the environmental conditions of altitude and experience gained in the training process will also modulate changes in autonomic tone [3,15].

The aim of this study was to investigate acute effects of skydiving and chronic effects of parachute jump training on the cardiac response in novice and trained parachuters.

2. Method and materials

2.1. Participants

The study included 23 volunteers: 11 jump instructors (expert group; EG) and 12 students (novice group; NG) of the free fall training method (accelerated freefall – AFF). The criteria for inclusion in the group of students were male sex, lack of medical contraindications for jumping, no more than one parachute jump completed prior to the study, and written consent to participate in the research program.

Criteria for inclusion in the group of instructors included being an officially licensed skydiving instructor with at least 5 years of professional experience, and written consent to participate in the research program.

Subjects were requested to avoid performing any intensive physical exercise, drinking coffee, smoking cigarettes, or using drugs.

The general characteristics of study participants are shown in Table 1. The study participants were informed about the methods and purpose of the study. The project was approved by the local Research Ethics Committee (application no. SKE 01-24/2008).

2.2. Procedure

The study was conducted during the summer on the airfields of domestic flying clubs. Weather conditions during the research were comparable for all participants performing skydiving. In the process of AFF training students performed 10 jumps.

The within-subjects design was used to analyze the effect of AFF training, and the between-subject approach was used to investigate the effects of long-term experience in expert vs novice jumpers. Additionally, the acute effects of parachute jumping were analyzed by sampling records of HRV before, during and after jumping.

Physical environmental indicators and selected physiological indices were recorded simultaneously during skydiving with a Ventus device made at the Military Institute of Aviation Medicine [16]. It continuously recorded the following measurements: an electrocardiogram (ECG), acceleration in three axes (X, Y, Z), altitude, and atmospheric pressure. Ventus recordings were transferred to the computer and analyzed using the Ventus device and a dedicated HRV tool.

Table 1 – General characteristics of study participants.

Variables	Expert group		Novice group	
	Mean ± SD	Min–max	Mean ± SD	Min–max
Age (years)	35.9 ± 7.20	27.0–54.0	27.9 ± 7.20	20.0–48.0
Body mass (kg)	85.6 ± 8.50	75.0–105	84.8 ± 8.10	73.0–103.0
Height (m)	1.81 ± 0.04	1.76–1.88	1.83 ± 0.07	1.72–1.93
BMI	26.2 ± 2.30	22.4–31.4	25.4 ± 1.74	22.7–28.1
Number of jumps	1836 ± 1396	800–5000	0.42 ± 0.51	0.00–1.00
Training practice (years)	15.2 ± 7.6	8–36	0	0

BMI – body mass index.

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