

List of contents

	Abbreviations.....	11
1	Introduction.....	13
2	Theoretical studies of the research.....	15
	2.1 The autonomic nervous system.....	15
	2.2 The sympathetic and parasympathetic branch.....	17
	2.2.1 The sympathetic nervous system	17
	2.2.2 The parasympathetic nervous system.....	18
	2.2.3 The cardiovascular system.....	19
	2.3 Heart rate variability	21
	2.3.1 Electrocardiogram	22
	2.3.1.1 Training and the electrocardiograph.....	23
	2.3.2 Time domain.....	23
	2.3.3 Frequency domain - spectral analysis of heart rate variability.....	24
	2.3.3.1 The spectral components.....	25
	2.3.4 Respiratory sinus arrhythmia	27
	2.3.5 Reliability of heart rate variability.....	28
	2.3.6 The effect of physical exercise on heart rate variability.....	29
	2.3.6.1 Heart rate variability and exercise.....	29
	2.3.6.2 The changes in heart rate variability components with increasing exercise intensity.....	30
	2.3.6.3 The long term effect of exercise upon heart rate variability.....	31
	2.3.6.4 Recovery of heart rate variability after acute exercise.....	32
	2.3.7 The effect of the environment and altitude on heart rate variability.....	33
	2.3.8 The effect of age on heart rate variability.....	34
	2.3.9 The relevance of heart rate variability to some psychological problems.....	36
	2.4 The sport training in swimming.....	37
	2.4.1 The principles of sport training.....	38
	2.4.2 Endurance and sprint training in swimming.....	40
	2.4.3 Planning yearly training programmes.....	41
	2.4.3.1 Examples of microcycle.....	42
	2.4.3.2 Daily planning.....	43
	2.4.4 Training intensity.....	44
	2.4.5 Overtraining.....	46
	2.4.5.1 Prevention of overtraining.....	48
3	The aims and hypothesis.....	49
	3.1 Aim.....	49
	3.1.1 The partial aims.....	49
	3.2 Hypothesis.....	49
	3.3 Research questions.....	49

4	Methods	50
	4.1 Subjects.....	50
	4.2 The place and period of the experiment.....	52
	4.3 Procedures.....	53
	4.3.1 Spectral analysis of heart rate variability.....	53
	4.3.2 The VarCor PF6.....	53
	4.3.3 The orthostatic test.....	55
	4.3.4 Fast Fourier transformation approach.....	56
	4.3.5 Methods of spectral analysis of heart rate variability.....	56
	4.3.6 The list of the heart rate variability parameters.....	57
	4.3.7 Complex indexes of heart rate variability.....	59
	4.4 Logarithmic analysis the period changes for the spectral analysis of heart rate variability.....	62
	4.5 Statistical analysis.....	64
5	Results	65
	5.1 The evaluation of the ANS activity in swimmers.....	65
	5.2 The comparison among the swimmer groups.....	66
	5.2.1 The comparison between the young and adult swimmers in complex indexes of HRV.....	66
	5.2.2 The comparison between Olomouc and Zlin swimmers in complex indexes of HRV.....	67
	5.2.3 The comparison between the three swimmer groups.....	68
	5.3 The relationships between the intensity of training before and after measurements and the complex indexes of HRV.....	69
	5.4 Longitudinal case-study.....	73
	5.4.1 A dynamics of the SA HRV parameters throughout a training week.....	73
	5.4.2 The effect of long-term training exercise on the periodical changes of SA HRV parameters.....	75
	5.4.3 The effect of training exercise on the development of the SA HRV parameters.....	75
6	Discussion	77
	6.1 The evaluation of the ANS activity in swimmers.....	77
	6.2 The comparison among the swimmer groups.....	81
	6.2.1 The comparison between the young and adult swimmers in complex indexes of HRV.....	81
	6.2.2 The comparison between Olomouc and Zlin swimmers in complex indexes of HRV.....	83
	6.2.3 The comparison between the three swimmer groups.....	85
	6.3 The relationships between the intensity of training before and after measurements and the complex indexes of HRV.....	87
	6.4 Longitudinal case-study.....	92
	6.4.1 A description of the dynamics of the SA HRV parameters throughout a training week.....	92
	6.4.2 The effect of the long-term swimming training on the periodical changes of the SA HRV parameters.....	93

6.4.3	The effect of swimming training on the development of the SA HRV parameters.....	95
6.5	Limitation of the study.....	95
7	Conclusion	97
8	Summary	100
9	References	104
10	Appendixes	118
1	A daily questionnaire for the swimmers.....	118
2	Addition results.....	120
4.1	The classification of physiological distributions of the age depended parameters of HRV for all swimmers (n=21)...	120
4.2	The difference between young and adult swimmers in age dependent parameters of HRV (n=21).....	121
4.3	The difference between Olomouc and Zlin swimmers in age dependent parameters of HRV (n=21).....	122
11	Tables	
1.	The classification of the HRV parameters according to exercise and age dependence.....	35
2.	A recommended plan for one-session training.....	44
3.	General statistical characteristics of investigated groups.....	50
4.	The comprehensive parameters as factors and its representation.....	59
5.	Weight of the parameters.....	60
6.	The ranges in normality of the HRV parameters.....	61
7.	The classification of physiological distributions in complex indexes of HRV for all swimmers	65
8.	The differences between young (Y) and adult (A) swimmers in complex indexes of HRV (n=21).....	66
9.	The difference between Olomouc (O) and Zlín (Z) swimmers in complex indexes of HRV (n=21).....	67
10.	The differences between the young swimmers from Olomouc (O) and Zlin (Z) and Adult (A) swimmers in the complex indexes of HRV (n=21).....	68
11.	The correlations between the complex indexes of HRV and the intensity of training before and after the measurement (Swimmer A, n= 35).....	69
12.	The correlations between the complex indexes of HRV and the intensity of training before and after the measurement (Swimmer B, n= 33).....	70
13.	The correlations between the complex indexes of HRV and the intensity of training before and after the measurement (Swimmer C, n= 43).....	71
14.	The correlations between the complex indexes of HRV and the intensity of training before and after the measurement for the three swimmers (n= 111).....	72
15.	The differences between the values of complex indexes of SA HRV during the days of the training week in a case-study.....	73

16. The periodical changes of the parameters of SA HRV in the case-study swimmer (S).....	75
---	----

12 Figures.....	
1. The sympathetic and parasympathetic branches.....	16
2. The electrical conduction system of the heart.....	20
3. R-R intervals of heart rate by the EKG diagram.....	21
4. The components of spectral analysis of heart rate variability VLF...	26
5. The orthostatic test shows the physiological difference between supine and standing position.....	55
6. The normal value in TS of the physiological range.....	61
7. The normal value in VA and SVB of the physiological range	62
8. The normal value in TP of the physiological range is.....	62
9. The amplitude of power PSD of TS for the periodical changes of given parameters throughout the time row by means of FFT analysis.....	63
10. The dynamic of the complex indexes of SA HRV within a training week.....	74
11. A development of given SA HRV parameter throughout the training preparation in a case study swimmer.....	76
12. The normal distribution of measured values of vagal activity in swimmers.....	78
13. Graph of the average values of the young and Adult swimmers in complex indexes of HRV.....	81
14. Graph of the average values of Olomouc and Zlin swimmers in complex indexes of SA HRV.....	83
15. Graph of the average values of Olomouc, Zlin, and Adult swimmers in complex indexes of SA HRV.....	85
16. Illustration of the correlation of TS and the INT before for all case studies (A, B and C).....	88
17. Illustration of the correlation of TS and the INT after for all case studies (A, B and C).....	89
18. The trend of the intensity of training in relation to the TS for swimmer C.....	91
19. The pattern of ANS activity within the training week in case-study swimmer (S).....	92

Power of very low frequency component	
The square root of the mean squared differences of successive R-R intervals	
Beat-to-beat R-R intervals	
Respiratory sinus arrhythmia	
Spectral analysis of heart rate variability	
Sympathetic nervous systems	
Sympatho-vagal balance	