Increased vagal tone in soldiers with above average physical fitness serving in military special forces

Cechy hiperwagotonii wśród żołnierzy o ponadprzeciętnej wydolności fizycznej służących w jednostkach specjalnych

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Abstract. Intensive physical activity changes the sympatho-vagal balance and influences cardiovascular function by increasing vagal tone. The aim of the study was to investigate which changes in rhythm and sympatho-vagal balance can be observed in soldiers serving in military special forces (SF group) in comparison with soldiers serving in regular units (RU group). In a group of 194 soldiers (124 SF and 70 RU) the electrocardiographic assessment was based on 24-h Holter recordings and physical capacity was objectified by ergospirometry. SF group was characterized by lower 24-hours mean HR (63 ±8 bpm vs 68 ±8 bpm, p <0.0005), minimal HR (45 ±5 bpm vs 42 ±8 bpm, p <0.0005) and maximal HR (111 ±19 bpm vs 119 ±17 bpm). They also more frequently presented features of increased vagal tone: bradycardia <50 bpm (98% vs 83%) and pauses exceeding 2 sec (22% vs 9%, p =0.018). Soldiers serving in military special forces present above average physical fitness. In consequence rhythm and conjunction changes typical for the athlete's heart phenomenon can be observed in this population. In some cases it may be advisable to perform exercise test and/or 24-hour electrocardiographic monitoring to exclude abnormalities other than related to increased vagal tone.
Key words: bradycardia, cardiovascular system, physical fitness, soldiers, vagal tone

Streszczenie. Intensywny wysiłek fizyczny zmienia równowagę współczulno-przywspółczulną oraz wpływa na funkcjonowanie układu sercowo-naczyniowego poprzez zwiększenie aktywności wagalnej. Celem było zbadanie, które zaburzenia rytmu serca i równowagi współczulno-przywspółczulnej można zaobserwować wśród żołnierzy jednostek specjalnych (grupa SF) w porównaniu z żołnierzami zwykłych jednostek (grupa RU). W grupie 194 żołnierzy (124 SF i 70 RU) przeprowadzono 24-godzinne monitorowanie elektrokardiogramu metodą Holtera oraz ergospirometrię. Grupa SF charakteryzowała się mniejszą 24-godzinną średnią HR (63 ±8 bpm *vs* 68 ±8 bpm, p <0,0005), minimalną HR (45 ±5 bpm *vs* 42 ±8 bpm, p <0,0005) i maksymalną HR (111 ±19 bpm *vs* 119 ±17 bpm). Częściej prezentowali cechy zwiększonego napięcia nerwu błędnego: bradykardię <50 bpm (98% *vs* 83%) i pauzy dłuższe niż 2 s (22% *vs* 9%, p =0,018). Żołnierze SF prezentują ponadprzeciętną wydolność fizyczną. W tej grupie można zaobserwować zmiany rytmu i przewodzenia typowe dla serca sportowca. W niektórych przypadkach należy rozważyć przeprowadzenie testu wysiłkowego i/lub 24-godzinnego monitorowania metodą Holtera w celu wykluczenia nieprawidłowości niezwiązanych z hiperwagotonią.
Słowa kluczowe: bradykardia, układ sercowo-naczyniowy, wydolność fizyczna, żołnierze, wagotonia

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Introduction

High-intensity training is often related to morphological changes in the heart and its function, commonly referred to as the athlete's heart. Depending on the type of physical training, mainly endurance or strength exercise, two kinds of structural remodeling of the heart have been suggested: eccentric and concentric left ventricular hypertrophy [1,2]. This classification, however, is not an absolute, but rather a relative concept since there

are no pure pressure or pure volume load exercises [1]. Regular intensive physical activity changes not only the structure of the heart but also influences its function by changing the sympatho-vagal balance of the autonomic nervous system [3]. The more intensive and long lasting exercise, the greater is the dominance of parasympathetic or vagal tone, which leads to specific rhythm disturbances, such as: sinus bradycardia, sinus arrhythmia (mostly related to respiration), sinus pauses and wandering atrial pacemaker. Typical conjunction disturbances are first degree atrio-ventricular block, Mobitz type I second degree atrio-ventricular block, and atrioventricular dissociation [3-6]. The above mentioned disturbances seem to be benign and disappear during exercise or even while changing the position from supine to sitting or standing. Most studies on rhythm and conjunction disturbances in athletes are based on changes registered in 12-lead electrocardiograms [7-9].

Aims

The aim of the present study was to investigate which changes in rhythm and sympatho-vagal balance can be observed in soldiers serving under high psychosomatic stress in comparison with soldiers serving in regular units. We hypothesize that those soldiers, trained above average, may present similar cardiovascular phenotype as athletes. Thus, some electrocardiographic features should not be interpreted as abnormalities but the reflection of increased vagal tone. We based our assessment on 24-h Holter electrocardiographic recording in two groups of soldiers: serving in military special forces and regular military units. Their physical capacity was objectified by ergospirometry.

Materials and methods

Study group

The first subgroup comprised of 124 young to middle-aged males (between 25–45 years of age) serving at least 12 months in military special forces (SF group), who were exposed to special psychophysical burdens associated with the specificity of military service, i.e. the operations in places of regular military conflicts, at altitudes >2000 m above the sea level, in very dry or humid climate. The specificity of their duties demands regular and long-term training. Therefore, it was assumed that they are individuals of above average physical fitness. The second subgroup consisted of 70 healthy, young to middle-aged males (between 25–45 years of age) of average physical fitness serving in regular military units (RU group).

All participants were volunteers and signed written informed consent. Exclusion criteria comprised: (1) known cardiovascular disease before enrollment (such as coronary artery disease, heart failure, hypertension of 2nd grade, significant arrhythmias); (2) symptoms raising suspicion of these illnesses; (3) known skeleto-muscular and (4) pulmonary diseases, (5) disabilities that did not allow following the study protocol. The study protocol was approved by the local ethics committee of the Military Institute of Medicine.

Diagnostics

The study protocol consisted of 2 days of testing, on which each participant underwent physical examination with special attention focused on the risk factors of cardiovascular diseases. Office systolic and diastolic blood pressure (SBP, DBP) was measured in a sitting position after 5 minutes of rest by a qualified nurse. The cut off value for hypertension was ≥140/90mmHg according to the European Society of Cardiology Guidelines [10].

The 24-hour Holter electrocardiographic monitoring was conducted with the use of three-channel recorders. Recordings were started at about 10 am (±2 hours) and finished at about 10 am (±2 hours) the next day. The subjects were directed to go to bed around 10 pm and rise around 6 am. They were advised to maintain normal daily routine except for strenuous physical exercise and consumption of alcoholic beverages. All recordings were analyzed with the use of a commercial analyzer. The final analysis focused on mean, minimal and maximal heart rate (HR), presence of bradycardia <50 beats/min and <40 beats/min, pauses >2 sec, supraventricular and ventricular extrasystoles, conjunction disturbances such as atrio-ventricular blocks or sinus block. Increased vagal tone was defined as the presence of at least one of: bradycardia <40 beats/min, pauses >2 sec, atrio-ventricular blocks or sinus block. Due to poor quality the 24-hour Holter monitoring records from 4 subjects, they were excluded from final analysis (3 in SF group and 1 in RU group).

In order to objectively assess physical fitness of participants we conducted ergospirometry (cardio-pulmonary exercise test – CPET) with ramp protocol with the use of ZAN 680 system (ZAN Messgerate GmbH; Germany). The following parameters were taken under consideration as characterizing subject's physical fitness: percentage of predicted load (% pred. load) and percentage of predicted peak oxygen uptake (% pred. peak VO_2).

Statistical analysis

The statistical analysis was performed using Statistica 10.0 (StatSoft Inc., Tulsa, USA). The distribution and normality of data were assessed by visual inspection

and the Kolmogorov-Smirnov test. Continuous variables were presented as means ±standard deviations (SD) and categorical variables as absolute and relative frequencies (percentages). The analysis of the differences between absolute values of the variables was performed with the use of t-test for normally distributed data and Mann-Whitney U-test for non-normally distributed data. The assessment of the relation between variables was performed based on Pearson and Spearman correlation coefficients.

Results

General characteristics

General characteristics of the study and control groups are presented in table 1. The study group was older than the control group and had higher body mass index. The study group also presented with lower HR and lower SBP. There was no statistical difference in DBP (but the trend toward lower values in SF group).

Physical fitness

Results of ergospirometry revealed that SF group, as it was anticipated, was characterized with higher % pred. peak load (SF versus RU: 115% versus 89%, p <0.0005) and higher % pred. peak VO_2 (116% versus 106%, p=0.002).

24-hour Holter electrocardiographic monitoring

Study group characterized with lower mean 24-hour HR (SF versus RU: 63±8 bpm versus 68±8 bpm, p<0.0005), minimal 24-hour HR (45 ±5 bpm versus 42 ±8 bpm, p <0.0005) and maximal 24-hour HR (111 ±19 bpm versus 119 ±17bpm, p <0.0005). Bradycardia <50 bpm and increased vagal tone were also more common in the SF group (SF versus RU: 98% versus 83%, p <0.0005 and 97% versus 23%, p =0.001; respectively). Pauses exceeding 2 seconds were recorded in 22% of subjects in the SF group, whereas only in 9% in the RU group (p=0.018). There was no statistical difference in the prevalence of atrio-ventricular blocks or sinus blocks (Table 2.).

Discussion

Presence of the phenomenon of the athlete's heart with its structural and functional changes in cardiovascular and autonomic nervous system forced international medical societies dealing with sports medicine to create separate criteria of electrocardiogram assessment for athletes [8-9]. These criteria have been used

Table 1. General characteristics of the study group and the control group
Tabela1. Ogólna charakterystyka grupy badanej i grupy kontrolnej

	SF group (n=124)	RU group (n=70)	P
age (years), mean ±SD	37 ±4	26 ±4	<0.0005
HR (bpm), mean ±SD	60 ±9	72 ±15	<0.0005
SBP (mm Hg), mean ±SD	120 ±10	131 ±12	<0.0005
DBP (mm Hg), mean ±SD	75 ±7	77 ±7	0.057
body weight (kg), mean ±SD	83 ±8	78 ±10	0.0001
height (cm), mean ±SD	179 ±6	178 ±6	0.42
BMI (kg/m^2), mean ±SD	26.1 ±1.9	24.2 ±2.5	0.001
current smokers, n (%)	4 (3%)	36 (51%)	<0.0005
smokers in the past, n (%)	25 (20%)	6 (9%)	0.03

BMI – body mass index, HR – heart rate, SBP – office systolic blood pressure, DBP – office diastolic blood pressure

Table 2. Results of 24-hour Holter recordings
Tabela 2. Wyniki 24-godzinnego monitorowania metodą Holtera

	SF group (n=121)	RU group (n=69)	P
mean heart rate (bpm), mean ±SD	63 ±8	68 ±8	<0.0005
minimal heart rate (bpm), mean ±SD	45 ±5	42 ±8	<0.0005
maximal heart rate (bpm), mean ±SD	111 ±19	119 ±17	<0.0005
bradycardia <50beats/ min, n (%)	118 (98%)	57 (83%)	0.007
bradycardia <40 beats/ min, n (%)	71 (59%)	34 (49%)	0.234
first degree atrio-ventricular block, n (%)	1 (0.8%)	2 (3%)	0.267
second degree atrio-ventricular block Mobitz I type, n (%)	9 (7%)	4(6%)	0.677
second degree atrio-ventricular block Mobitz II type, n (%)	2 (1.7%)	0 (0%)	0.285
advanced atrio-ventricular block, n (%)	2 (1.7%)	0 (0%)	0.285
pauses >2 sec, n (%)	27 (22%)	6 (9%)	0.018
increased vagal tone, n (%)	117 (97%)	57 (23%)	<0.0005

in cardiovascular screening of athletes before competition in order to catch those who are at risk of serious cardiac diseases or sudden cardiac death without causing unnecessary disqualifications. In present study we showed that similar rhythm and conjunction disturbances, probably as a result of increased vagal tone, can be observed in 24-hour Holter electrocardiographic recording in soldiers who undergo heavy physical training as a regular part of their service. Results of ergospirometry proved that these soldiers presented above average exercise capacity, expressed by high peak load and peak VO_2 that suggest benign character of these features.

Physical examination itself revealed typical findings connected with higher level of physical fitness, that is lower HR and lower BP. 24-hour Holter recordings showed that the study group had lower mean, minimal and maximal HR, more often presented bradycardia <50 bpm, pauses exceeding 2 seconds and increased vagal tone. We did not find difference in the prevalence of conjunction disturbances, though first and second degree Mobitz type I atrio-ventricular blocks were observed in both groups. Similarly to our study Vitasalo et al. compared 24-hour Holter recordings of 35-highly trained athletes with 35 matched controls, in which they proved that athletes had lower mean and minimal heart rates, more often presented with bradycardia and pauses exceeding 2 seconds [11]. However, they also observed higher prevalence of first and second degree atrio-ventricular blocks in athletes, which was not noted in our SF group. This may be due to the fact that these soldiers do not undergo typical athletic competition regimen but they perform individual training without following a strict protocol. On the other hand, among RU soldiers there were also some well fitted ones. The difference in age (older SF subjects) also matters.

The possibility of presence of electrocardiographic indicators of increased vagal tone in above averaged trained soldiers should be considered during periodic examinations. Most of them are just a sign of good fitness and should not be interpreted as pathology. Carefully completed anamnesis itself may reveal the cause of electrocardiographic increased vagal tone. In some cases further diagnostics may be helpful to exclude clinically relevant pathology: ergospirometry provides objective assessment of exercise capacity and 24-hour Holter monitoring helps to identify advanced conjunction disturbances. Special attention should be attached to subjects presenting symptoms (i.e. syncope, dizziness) and/or inadequate chronotropic response to exercise [12].

Limitations

The main limitation of our study is a small number of participants in the groups. Moreover, the study group was older than the control group, which results from the fact that only the most experienced and the best soldiers are qualified to serve in special units, contrary to regular units, which are the first step of their career. It may underestimate the differences. Another limitation is that the soldiers do not undergo typical controlled athletic competition regimen but train individually, without following a strict training protocol. Even though the changes in rhythm and conjunction in the study group seem to be typical for increased vagal tone, further research into electrocardiographic and echocardiographic changes is needed in order to fully assess the presence of the athlete's heart phenomenon in this special group.

Conclusion

The soldiers serving in military special forces present above average physical fitness. In consequence, rhythm and conjunction changes typical for the athlete's heart phenomenon can be observed in this population. In some cases it may be advisable to perform exercise test and/or 24-hour electrocardiographic monitoring to exclude abnormalities other than related to increased vagal tone.

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