

## **Research Potential of a Heart Rate Variability Diagnostic System for the Study of Stress and Health Risk in Peacekeeping Operations**

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### **ABSTRACT**

*Medical surveillance and medical screening for military personnel participating in Peacekeeping Missions (PKM) is required to define the effect of peacekeeping stress on their health status and to determine suspected risk indicators. The aim of the present study is to determine the effect of stress on autonomic cardiovascular control and health risk of 72 Bulgarian peacekeepers participating in PKM in Kosovo. A diagnostic system for the analysis of Heart Rate Variability (HRV) was used for psychophysiological assessment of stress and screening of health risk at peacekeeping deployment phases. Personal interviews were implemented to reveal the nature of the stressors. HRV variables and heart rate were compared between pre-deployment and re-deployment phases and between deployment phases and controls. As a response to cumulative exposure to the effect of stress on cognitive functions, we measured decreases in parasympathetic activity with  $P_{RSA}$ , and STV and decreases in baroreceptor modulation of heart rhythm with  $P_{THM}$ . Identifying peacekeepers with suspected health risk and differentiating basic types of autonomic control (as a response to level of stress) associated with referent, pre-morbid and morbid states may be an important risk indicator for the assessment of health status. The advantage of psychophysiological assessment of peacekeepers stress response at deployment phase using functional indices of stress and health risk is that it provides objective information about the impact of stress on their health.*

### **1.0 INTRODUCTION**

A key topic of military medical science and ethics in the 21st century concerns ensuring optimal health status, optimal physical and psychological fighting efficiency, high expertise and professionalism, to

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consolidate freedom in the world; protect world peace; guarantee defence, safety and security of humanity in the fight against terrorism and tyranny; and to preserve principles and values of the world democratic community.

### **1.1. The Causes for Organization of Peacekeeping Missions. Nature of Stressors.**

One of the main tasks of military medical science is to implement health surveillance, screening and risk assessment of military personnel participating in Multinational Missions, including Peacekeeping Missions (PKM). PKM organize as a response of the consequences of tyranny and terrorism. The traditional role of peacekeepers is to maintain strictly neutral presence by implementing and overseeing peace settlements, monitoring elections, and facilitating the delivery of humanitarian aid [Litz et al, 1997]. But the potential terrorist and security threats placed increased demands on military personnel in the 21st century as the military forces have to safeguard not only the regional areas but also maintain global peace [Masakowski, 2001]. This requirement forms the new identity and the new role of military forces, including peacekeepers in their task to ensure the new security environment in the 21st century.

The UN, NATO, EU, the world democratic community and the new democratic institutions of the 21st century which have had to cope with tyranny have defended the enduring principles of civilization: freedom, progress, pluralism and tolerance without which humanity can not continue developing normally. Tyranny and terrorism and their consequences are the main sources of stress for humanity and a threat to the peaceful and creative life of millions of people wherever they live and work. Terrorism is a stressor without face but it possesses its genetic sources. The cause and force of terrorism is political (fascism; communism and its extreme form bolshevism) and religious (Islamic fundamentalism) fanaticism. Today's variant of violence is provoked from archaic and unacceptable for the 21st century Islamic fundamentalism. But we representatives of the post-communistic countries remember well what was presented by the countries of the Eastern block before 1989. History showed that the consequences of all totalitarian regimes are civil wars, inter-ethnic conflicts, and humanitarian disasters.

The world democratic community has engaged in the fight against tyranny and terrorism and has upheld efforts of NATO and the UN to establish peace in conflict zones through organization of Multinational Missions. NATO and the UN have interceded and have provided peacekeeping operations, protecting civilians who are at risk, providing humanitarian relief, ensuring armed enforcement of peace, and arranging ad hoc coalitions for the maintenance of world peace.

### **1.2. Stress Exposure in Peacekeeping Missions. Psychological Health Surveillance.**

Peacekeeping missions are dangerous and are characterized by conflicts, incidents, and challenges. Therefore the task of the military medicine, which considers the health status and the psychological and physical well-being of military personnel as important indicators of operational effectiveness, is to control medical readiness [Capleton et al, 2003; Cox, 2003]. The medical readiness could be compromised during phases of peacekeeping deployment when personnel are exposed to stress. The task of medical readiness, which is studied and optimized through medical surveillance and medical screening, is to analyze, treat, preserve human health and performance, and ensure mission effectiveness.

A specific requirement for military personnel participating in these operations is the ability to maintain balance between combat readiness and the exercise of restraint [Wright et al, 2002]. Both parts of this definition presuppose that participants are exposed to: the impact of potentially traumatic combat war-zone situations (combat attack and incidents; dangerous patrols; witnessing death and injury; handling bodies), terrorist attacks, and the impact of social and psychological stressors. An extensive theoretical formulation of the stressors involved in peacekeeping is given in the study of Lamerson & Kelloway, 1996 in which they characterize peacekeeping by the occurrence of acute and/or catastrophic events in an environment replete with chronic stressors, and classify peacekeeping stressors as follows: combat stressors (direct exposure to

attack; witnessing death or injury; traumatic nature of handling dead or wounded bodies); chronic stressors (role stressors: conflict, ambiguity, overload, family stress).

A recent study of Breakwell & Spacie, 1997 identifies operations in the Gulf War and Bosnia, develops a typology of stressors dividing them into four principal types: organizational, physical, interpersonal, and psychological. Another study analyzed frustrating and potentially traumatic experiences associated with PKM in Somalia, formulated specific dimensions: positive aspects of military service (visiting a new country), positive aspects of humanitarian missions (bringing food to starving people), low-magnitude stressors (being separated from family), negative aspects of peacekeeping (not being appreciated by the Somalis), and exposure to war-zone stressors (going on patrols) [Litz et al, 1997].

Bartone & Adler, 1998 consider the constant threat of terrorism faced by deployed peacekeeping and contingency forces as one of the strongest combat and psychological stressors. They point out that the unpredictability of such threats on PKM and the contrast they present to regular daily routines when they do occur increase the risk for Post-Traumatic Stress Syndrome (PTSD) or dissociative disorders.

Except for combat stressors, peacekeeping deployment is characterized by exposure to social and psychological stressors and such challenges as helplessness, powerlessness, isolation, boredom, monotony, separation from family, role stressors, economic factors (inadequate or undeveloped infrastructure), nationalistic interests, non-recognition of human rights (ethnic tension), state corruption, organized crime, drug and people trafficking, and provocations [Carlstrom et al, 1990; Harris & Segal, 1985; Litz, 1996; Ritchie et al, 1994; Weisaeth et al, 1996; Weisaeth & Sund, 1982; Wright et al, 2002].

A specific very stressful feature during exposure to peacekeeping stressors is the requirement to exercise restraint which is regarded as a principal and crucial component of effective peacekeeping [Allard, 1995; Moskos, 1975; Wright et al, 2002]. This feature is stressful because it requires to exercise restraint in the case of provocation, danger, threat; it contributes to feelings of helplessness, increased anxiety and frustration [Litz, 1996; Moskos, 1975; Segal & Segal, 1993]; and might induce PTSD or be a mediator of the relationship between PTSD and other stressors [Litz et al, 1997]. To exercise restraint is a very stressful requirement for peacekeepers from democratic societies. Even the psyche and the physical condition of very trained and healthy participants may not endure the effects of stressors – consequences of political and religious fanaticism: genocide, atrocities, and aggression. Their psyche can not withstand the encroachment of human freedom as the participants in PKM come from democratic societies not accustomed to the repressive mechanism and structures of totalitarian regimes. The morale and psyche of military personnel during contemporary peacekeeping deployment are seriously affected by the dangerous humanitarian missions (witnessing violence, receiving hostile response from the civilian population, witnessing human degradation) [Dirkzwager et al, 2003]. The cognitive load on their psyche increases when their norms contradict with the mentality and consequences of repressive totalitarian regimes: encroachment on human being and freedom (genocide and atrocities); non-recognition of human rights; repressions; and provocations by nationalistic parties and movements. Military medical studies on combat stress during World War II, the Holocaust, Vietnam and the Gulf War reveal the effects of the same stressors and moral conflicts that mediate PTSD [Bergherr et al, 1997; Bramsen & Van Der Ploeg, 1999; Friedman et al, 1994; Green et al, 1990; King et al, 1995; Kuch & Cox, 1992; Williams et al, 1993].

The operational environment of the PKM is characterized by different chronic stressors that act separately or together and that can result in stress which affects health status and degrades performance. The nature of contemporary PKM has changed compared to previous traditional missions as conflict situations and incidents are increased. Analysis of the changing nature of contemporary PKM reveals that peacekeeping deployment comprises exposure to traumatic stressors in a context of chronic stressors (Lamerson & Kelloway, 1996). The analysis shows also that the simultaneous experience of traumatic and chronic stressors may have replicative rather than additive or specific effects [Kessler et al, 1995; Resnick et al,

1993]. Thus, both single and cumulative (repeated) exposure to potentially traumatic events may evoke symptoms consistent with a significant stress response in PKM [Bolton et al, 2001; Charney et al, 1993].

Participants are exposed to different kinds of stressful experience that may put them, independently of their good health status and high level of psychological and physical selection and training, at risk for development of medical and psychological problems (PTSD), Peacekeeper Stress Syndrome, mental health symptoms. Health services are needed for military personnel participating in PKM, as during the deployment phases the personnel may develop psychological disorders as a consequence of participation in PKM. In this component of health surveillance, psychological screening is used to determine risk indicators and to predict morbid outcomes, pre-deployment psychological issues, re-deployment acute stress reactions, and post-deployment psychological adjustment [Wright et al, 2002]. The results of Dutch investigators indicate that social support and coping strategies may be valuable aspects for preventing PTSD [Dirkzwager et al, 2003]. In a study investigating mental and physical health, pre-deployment phase and the six-month follow-up were related to higher levels of anxiety, psychological stress, depression, and somatic symptoms compared to other phases [McDonald et al, 1998]. Traditional combat and negative aspects of peacekeeping mission in Somalia led to PTSD and frustration [Litz et al, 1997]. Peacekeepers stress exposure in PKM in former Yugoslavia correlates significantly with depression and psychiatric symptoms [Bartone & Adler, 1998], and the psychological dimensions studied: isolation, ambiguity, powerlessness, boredom and danger were found to be relevant to adaptation to stress. Results from Norwegian researchers showed that PKM is associated with PTSD, anxiety, health problems, and suicidal behavior [Weisaeth et al, 1996]. Japanese researchers reveal that deployed personnel show somatization symptoms [Kodama et al, 2000]. Other studies assess the stress tolerance and the health condition of military personnel as generally good with low prevalence of PTSD [Hotopf et al, 2000; Johansson et al, 2003; Ponteva, 2000; Ponteva et al, 2000].

### **1.3. Psychophysiological Assessment of Autonomic Responses to Stress in Post-Traumatic Stress Disorder**

We give a short review of the autonomic responses to stress in combat veterans and survivors from the Holocaust with PTSD as we believe it will contribute to our understanding of the autonomic responses to stress in PKM. Despite the increasing number of studies investigating the nature of stressors in PKM, their consequences for psychological health and the intervention strategies for their prevention, at this time in military medicine there is little research on the effects of stressful peacekeeping deployment on functional state assessed by means of physiological and psychophysiological measures. The examination of functional state with psychophysiological indices in different deployment phases will contribute to: the assessment of objective health status of peacekeepers participating in PKM, to medical surveillance, and to the screening of stress and health risk as well as treatment and prevention.

In relating autonomic responses to peacekeeping stress with the autonomic responses to PTSD, we consider the following issues: exposure to traumatic and chronic stressors inducing stress reaction; autonomic responsivity and arousal in response to stress; elevation in cardiovascular activity and cardiovascular function; role of psychophysiological assessment in investigation of autonomic arousal and reactivity; chronic (repeated) autonomic responses, and cardiovascular reactivity. These processes may induce structural and/or functional disturbances, and PTSD might be a risk factor for CVD.

Considerable research has been implemented on the causes, pathophysiological mechanisms, and symptoms of PTSD. In our study we are focusing our research interest on PTSD resulting from exposure to combat stress during World War II, the Holocaust, and the Vietnam War. The nature of these traumatic events is comparable to the potentially traumatic combat situations that induce peacekeeping stress.

PTSD is a psychological illness of considerable prevalence, treatment resistance, and chronic course. Specific symptoms of PTSD are persistent reexperiencing of the traumatic event, avoidance of stimuli

associated with the trauma, and autonomic hyperarousal [Charney et al, 1993]. Indicators of increased arousal characterizing PTSD are: hyperalertness, exaggerated startle response, and increased physiological reactivity to stimuli that symbolize or resemble the traumatic event [Buckley & Kaloupek, 2001; Cohen et al, 1997; Kaloupek & Bremner, 1996; Liberzon et al, 1999; McFall et al, 1990]. The major clinical symptoms of PTSD are: autonomic disturbance, tachycardia, increased blood pressure, tachypnea, tremor, and excessive sweating [Kolb, 1987].

Psychophysiological measures are used in the study of functional mechanisms inducing autonomic arousal and physiological reactivity [Blanchard & Buckley, 1999; Buckley & Kaloupek, 2001; Cohen et al, 1997; Liberzon et al, 1999; McFall et al, 1990]. Results of psychophysiological studies on PTSD have shown that the most relevant cardiovascular measures are: heart rate, heart rate variability, blood pressure, systolic and diastolic blood pressure variability.

Different research views and hypotheses exist for the explanation of autonomic hyperarousal and increased physiological reactivity. The observed patterns of activity of autonomic cardiovascular control might be the following: increased sympathetic activity [Blanchard et al, 1991; Bremner et al, 1999; Keane et al, 1985; Kolb, 1987; Kolb, 1984]; and increased sympathetic activity and suppression of parasympathetic activity [Cohen et al, 1997; McFall et al, 1992]. Kaloupek & Bremner, 1996 suggest that in psychophysiological studies of PTSD we should explore the model of autonomic activation of Berntson et al, 1991, which includes sympathetic activation; parasympathetic withdrawal; concurrent activation in both branches with the accent on sympathetic dominance.

In research of PTSD we should also take into consideration whether traumatic exposure affects the tonic level of autonomic activity or phasic changes as reflected in the autonomically controlled functional response measures. Some of the results in this respect suggest that PTSD is characterized by elevated tonic level of sympathetic activity at rest reflected in increased heart rate, blood pressure, and increased low frequency component of heart rate variability [Blanchard, 1990; Buckley & Kaloupek, 2001; Cohen et al, 1997; Liberzon et al, 1999; Pallmeyer et al, 1986]. Other results show phasic activation of sympathetic activity in response to traumatogenic stimuli [Kaufman et al, 2002; Malloy et al, 1983; McFall, 1990; Pallmeyer et al, 1986]. Cohen et al., 1997 point out that both increases of sympathetic activity and decreases of parasympathetic activity (studied with spectral measures of heart rate variability) contribute to the changes in tonic level of autonomic activity at rest which induce autonomic hyperarousal. Contrary to these results some studies report no difference in tonic level of sympathetic activity at rest comparing PTSD and control groups [Malloy et al, 1983; McFall et al, 1992]. Phasic changes of autonomic activity to traumatogenic stimuli are characterized by activation of sympathetic function and suppression of parasympathetic activity [Blanchard et al, 1991; McFall et al, 1992]. Structural and functional changes in the cardiovascular system (increased peripheral vascular resistance and increased blood pressure) observed in PTSD are thought to be a result of chronic stress-related sympathetic activation and disturbed regulation of beta-adrenergic receptors [Amerena & Julius, 1995; Buckley & Kaloupek, 2001; Hocking-Schuler & O'Brien, 1997].

Considering that:

- The effect of stress on functional and psychological condition is the cause to be implemented in medical surveillance of health status,
- The screening of health status as an important component of medical surveillance has been extensively used to determine risk indicators and to predict morbid states,
- Psychophysiological assessment of autonomic responses in PTSD,
- The identical nature of combat stressors,

our study is an attempt to clarify whether peacekeeping stress affects the functional status of cardiovascular system and the underlying autonomic cardiovascular control. The screening of health status in deployment phases will help us to determine risk indicators and to prevent development of morbid states. Medical surveillance of the health status of peacekeepers is implemented by the research and technology opportunities of medical informatics technology. We explored opportunities of the diagnostic system for

medical surveillance and risk assessment: Heart Rate Variability for determination of stress response and deviation in autonomic regulation as an early indicator of health risk in peacekeepers participating in PKM.

The aim of the present study was to determine the effect of stress on autonomic cardiovascular control and health risk of peacekeepers participating in PKM in Kosovo.

## **2.0 METHODS**

### **2.1. Subjects**

Two groups of subjects participated in this study: military personnel and controls. The first group consisted of 72 male peacekeepers who are members of the Bulgarian armed forces whose ages ranged from 20 to 43 years (mean age,  $X \pm SD$ ,  $28.34 \pm 10.07$  yr). They were deployed on a six month peacekeeping mission in Kosovo, which was the first PKM mission they participated in. The rank of 69 individuals was soldiers and sergeants, and 3 were commissioned officers. They were selected to be physically and psychologically healthy and suited for deployment according to NATO standards. The study was longitudinal for the military personnel group. The peacekeepers were examined in pre-deployment and re-deployment phases. The control group consisted of 61 male individuals who were employees in institutions matched for age (mean age,  $X \pm SD$ ,  $28.12 \pm 9.31$  yr) to the peacekeepers. The control group is used for the first investigation of the experimental group. The following exclusion criteria were used to both groups: systolic blood pressure  $>130$  mmHg and diastolic blood pressure  $>85$  mmHg; body-mass index  $>25 \text{ kg/m}^2$ ; using of medications, alcohol, nicotine, caffeine; history of diseases.

### **2.2. Procedure**

#### **2.2.1. Computerized diagnostic system for analysis of Heart Rate Variability**

A computerized diagnostic system for medical surveillance of functional status of cardiovascular system (CVS): Heart Rate Variability (HRV) was applied. The system consists of: PC-IBM, specialized hardware and software [Danev, 1989; Nikolova, 1993] that enables the following tests for the assessment of functional state of the CVS: Cardiogram; Histogram; Scattergram; Power Spectrum Analysis of HRV, Mental and Physical Stress, Health Risk.

HRV data were determined from ten minutes of ECG recordings between 9 a.m. and 11 a.m. in supine position after a one-hour rest period. HRV data were obtained on three consecutive days and mean individual values of the measurements were calculated.

A portable electronic device was used to transform the ECG signal into RR intervals and to transmit the RR intervals to an IBM compatible PC for on-line processing. The ECG signal was transformed to RR intervals with an AC converter (QRS detector and timer, resolution time 2224 samples per second). This sampling rate gives a variation of 0.48 msec in locating the peak of R wave and results in a minimum accuracy of 99.55 % in computing heart rate up to 140 beats/min.

Time-domain and frequency-domain based HRV measures and HRV derived indices were analyzed:

#### *2.2.1.1. Time-domain HRV measures:*

X (mean RR interval) (msec), resp. mean heart rate (beats/min); Short-Term Variability (STV) (msec) (reflecting respiratory oscillations in heart rate variations); Long-Term Variability (LTV) (msec) (reflecting baroreceptor- and thermoregulatory influences on heart rate variations); Time-Domain Index (TDI) (arb. un.) (assessing sympathetic/parasympathetic influences on histogram RR interval distribution).

#### *2.2.1.2. Frequency-domain HRV measures:*

Spectral power of RR intervals in the Temperature band (0.01-0.05 Hz) ( $P_T$ ) ( $ms^2$ ) (sympathetically mediated); Spectral power of RR intervals in the Traube-Hering-Mayer band (0.06-0.14 Hz) ( $P_{THM}$ ) (sympathetically and parasympathetically mediated) ( $ms^2$ ); Spectral power of RR intervals in the Respiratory Sinus Arrhythmia band (RSA) (0.15-0.50 Hz) ( $P_{RSA}$ ) ( $ms^2$ ) (parasympathetically mediated); Frequency-Domain Index (FDI) ( $P_T/P_{RSA}$ ) (arb.un) (reflecting sympathetic/parasympathetic activity ratio). Spectral powers of RR intervals in the respective frequency bands were calculated using Fast Fourier Transform.

#### *2.2.1.3. HRV-derived indices:*

Physical Stress (PS) (arb. un.) (mathematical algorithm based on difference between measured and age-referent values derived from the time-domain HRV measures); Mental Stress (MS) (arb. un.) (mathematical algorithm based on difference between measured and age-referent values derived from the frequency-domain HRV measures); Functional Age (FA) (yr) (mathematical algorithm computing difference between measured and age-referent values of autonomic activity derived from the frequency-domain HRV measures); Health Risk (HR) (%) (mathematical algorithm derived from PS-, MS-coefficients and number of premature heart beats).

### **2.2.2. Computerized Method for Detection of Supraventricular and/or Ventricular Extrasystoles**

The determination of extrasystole type was done by using a computer method [Danev, 1989] for detecting supraventricular and ventricular extrasystoles in HRV recordings.

### **2.2.3. Personal Interviews**

Personal Interviews with peacekeepers were implemented to examine stressors. Results of interviews showed that peacekeepers were exposed to the following types of stressors: risk of terrorism; potentially traumatic combat situations (incidents of combat attacks; dangerous patrols; safeguarding of important objectives; increased risk of escalating conflicts); social and psychological stressors (deployment in new environment; provocations; work on duties; consideration with the way of life, customs, and religion of the native population; separation from family; limited access to civilian places).

## **2.3. Data Analysis**

HRV measures, HRV-derived indices and heart rate in peacekeepers and control groups are expressed as means  $\pm$  standard deviations. Means of HRV variables were compared by paired samples t-test and independent samples t-test. The differences between the mean values of HRV variables and heart rate among military personnel group at the re-deployment phase diagnosed with referent, pre-abnormal and abnormal autonomic cardiovascular control were calculated by independent samples t-test. The group was divided in terms of different types of autonomic cardiovascular control based on referent values of HR. The division was done to determine the association between abnormality in autonomic cardiovascular control and suspected pre-morbid and morbid states. Discriminant analysis was used to define which measures distinguish basic types of autonomic cardiovascular control in the re-deployment phase. A p value  $< 0.05$  was considered statistically significant.

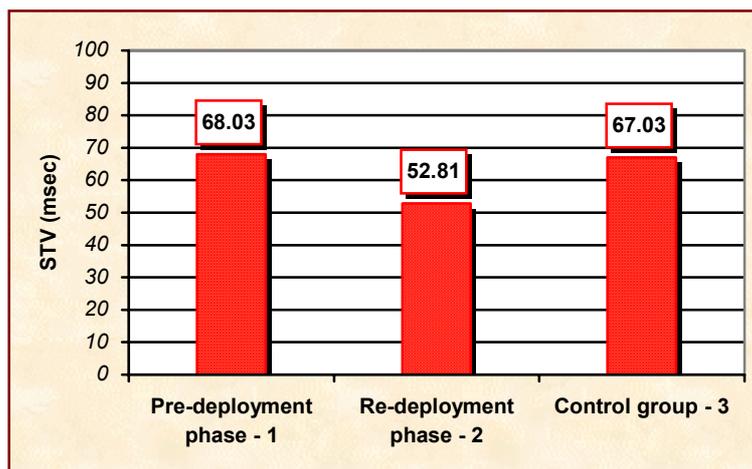
## **3.0 RESULTS**

To examine whether there are differences in level of stress exposure between deployment phases in military personnel and how they differ from controls, HRV variables and heart rate were compared between each condition by t-test. The mean values of HRV variables and heart rate in peacekeeper deployment phases and controls are presented in Table 1.

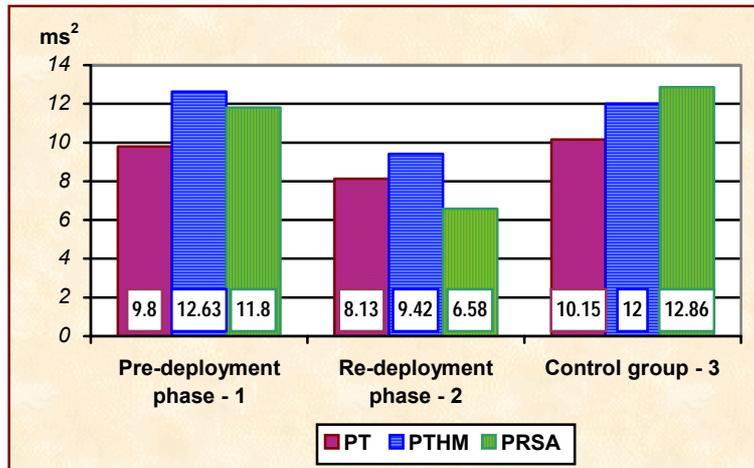
**Table 1: Means (X±SD) and p – values of time- and frequency – domain HRV measures, HRV – derived indices and heart rate in pre – deployment and re – deployment phases and in control group.**

Variables	Pre-deployment phase - 1	Re-deployment phase - 2	Control group - 3	P - value		
	X±SD	X±SD	X±SD	1-2	1-3	2-3
Heart rate (b/min)	76.5 ± 11.22	75.30± 9,32	72.31±10.35	ns	ns	ns
<b>Time-domain HRV measures</b>						
X (msec)	800.53±118.13	769.89±111.78	846.18±121.87	ns	ns	ns
STV (msec)	68.03±7.655	52.81±6.50	67.03±6.38	0.01	ns	0.01
LTV (msec)	48.39±7.56	43.53±7.34	45.21±7.34	ns	ns	ns
<b>Frequency-domain HRV measures</b>						
P <sub>T</sub> (ms <sup>2</sup> )	9.80±1.00	8.13±1.64	10.15±1.82	ns	0.02	<0.0001
P <sub>THM</sub> (ms <sup>2</sup> )	12.63±1.84	9.42±1.33	12.00±1.55	0.007	ns	0.03
P <sub>RSA</sub> (ms <sup>2</sup> )	11.80±1.65	6.58±1.56	12.86±1.38	<0.0001	ns	<0.0001
<b>HRV – derived indices</b>						
HR (%)	23.94±6.15	50,78±7,73	25.03±6.76	<0.0001	ns	<0.0001
PS (arb. un.)	-0.34±0.06	0.92±0.05	-0.12±0.03	0.007	0.5	<0.001
MS (arb. un.)	0.40±0.09	1.03±0.09	0.26±0.05	0.001	ns	<0.0001

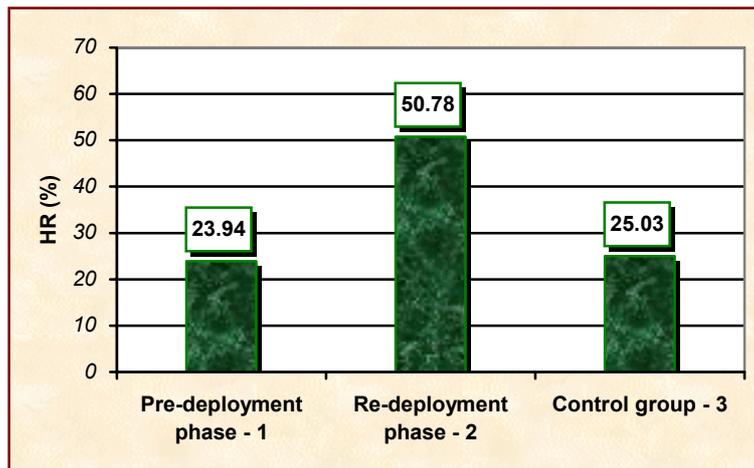
**Figure 1: Mean values of STV (msec) in peacekeepers: pre-deployment and re-deployment phases and in control group**



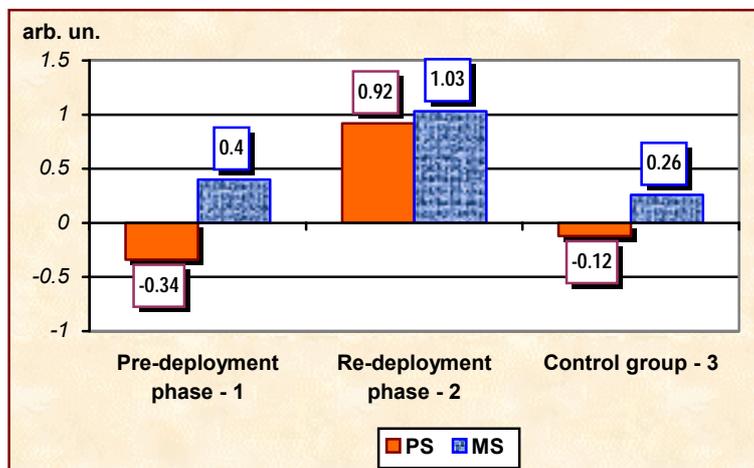
**Figure 2: Mean values of  $P_T$  ( $ms^2$ ),  $P_{THM}$  ( $ms^2$ ) and  $P_{RSA}$  ( $ms^2$ ) in peacekeepers: pre-deployment and re-deployment phases and in control group**



**Figure 3: Mean values of HR (%) in peacekeepers: pre-deployment and re-deployment phases and in control group**



**Figure 4: Mean values of PS (arb. un) and MS (arb. un.) in peacekeepers: pre-deployment and re-deployment phases and in control group**



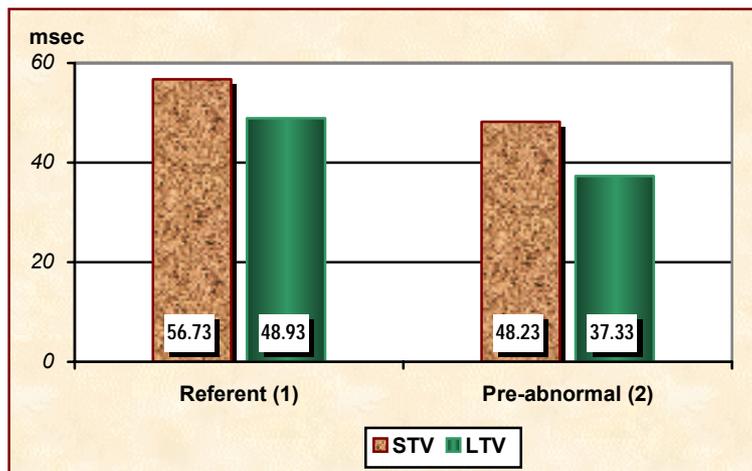
Stress was associated with a significant decrease in mean values of STV,  $P_{THM}$  and  $P_{RSA}$  in peacekeepers in the re-deployment phase compared to the pre-deployment phase. Peacekeeper stress resulted also in a significant increase in mean values of HR, PS, and MS in the re-deployment phase compared to the pre-deployment phase. Fig. 1, fig. 2, fig. 3 and fig. 4 illustrate differences in mean values of STV,  $P_{THM}$ ,  $P_{RSA}$ , HR, PS, and MS in peacekeepers in the two deployment phases. The results also revealed that mean values of STV,  $P_{THM}$ ,  $P_{RSA}$ , HR, PS, and MS differed significantly when comparing peacekeepers in the re-deployment phase with the controls (Fig. 1-4). The mean values of heart rate did not show significant differences in both peacekeeping deployment phases and between peacekeepers and controls. We did not detect supraventricular or ventricular extrasystoles in peacekeepers and controls.

Although HR was in the range of referent values it was significantly higher in the re-deployment compared to pre-deployment phase (Table 1). An increase of HR value above 65% is an indicator for the development of CVD [Danev, 1989]. To examine whether the re-deployment phase may be differentiated as a response to level of stress in different types of autonomic cardiovascular control, we believe it is justified to determine whether they are associated with pre-morbid and morbid states. For this purpose we divided the peacekeeper group studied in the re-deployment phase on the basis of referent values of HR, forming two types of autonomic cardiovascular control: referent (N61) and pre-abnormal (N11). We did not observe individuals with abnormal autonomic cardiovascular control. To examine differences in autonomic cardiovascular control and to determine the pattern of autonomic function, HRV variables and heart rate were compared by independent samples t-test. Mean values of HRV variables and heart rate in groups with referent and pre-abnormal autonomic cardiovascular control are presented in Table 2.

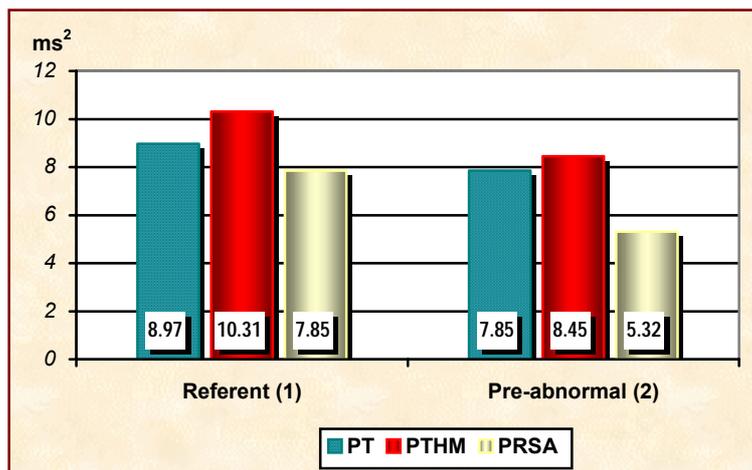
**Table 2: Means ( $X \pm SD$ ) and p – values of time- and frequency – domain HRV measures and heart rate at peacekeepers groups with referent, pre – abnormal and abnormal autonomic cardiovascular control.**

Variables	Types of autonomic cardiovascular control			P - value		
	Referent (1) $X \pm SD$	Pre-abnormal (2) $X \pm SD$	Abnormal (3) $X \pm SD$	1-2	1-3	2-3
Heart rate (b/min)	74.15 ± 10.71	77.10 ± 11.49	-	ns	-	-
<b>Time – domain HRV measures</b>						
X (msec)	789.36 ± 110.15	749.53 ± 105.09	-	ns	-	-
STV (msec)	56.73 ± 6.04	48.23 ± 5.18	-	0.01	-	-
LTV (msec)	48.93 ± 7.04	37.33 ± 6.71	-	0.01	-	-
<b>Frequency –domain HRV measures</b>						
$P_T$ ( $ms^2$ )	8.97 ± 1.04	7.85 ± 0.86	-	0.05	-	-
$P_{THM}$ ( $ms^2$ )	10.31 ± 1.41	8.45 ± 1.05	-	0.001	-	-
$P_{RSA}$ ( $ms^2$ )	7.85 ± 1.63	5.32 ± 1.47	-	0.001	-	-

**Figure 5: Mean values of STV (msec) and LTV (msec) in peacekeepers at re-deployment phase with referent and pre-abnormal autonomic cardiovascular control**



**Figure 6: Mean values of  $P_T$  ( $ms^2$ ),  $P_{THM}$  ( $ms^2$ ) and  $P_{RSA}$  ( $ms^2$ ) in peacekeepers at re-deployment phase with referent and pre-abnormal autonomic cardiovascular control**



Time- (STV, LTV) and frequency-domain ( $P_T$ ,  $P_{THM}$ ,  $P_{RSA}$ ) HRV measures significantly decreased in the peacekeepers with pre-abnormal autonomic cardiovascular control compared to peacekeepers with referent autonomic cardiovascular control. Mean values of heart rate did not show significant differences. Fig. 5 and fig. 6 illustrate differences in mean values of: STV, LTV,  $P_T$ ,  $P_{THM}$ , and  $P_{RSA}$  in peacekeepers with referent and pre-abnormal autonomic control.

Results of discriminant analysis revealed that variables that discriminate the referent and pre-abnormal types of autonomic cardiovascular control using HR as a stressogenic marker are:  $P_{THM}$ ,  $P_{RSA}$ , and MS. Results of discriminant function analysis are presented in Table 3.

**Table 3. Discriminant function analysis**

<i>Classifier</i>	<i>Groups</i>	<i>Discriminant Function</i>	<i>Percent of Correct Classification</i>
<b>HR</b>	1. HR < 25 %	$HR = -77.31 + 0.12 * P_{THM} + 0.34 * P_{RSA} + 0.76 * MS$	92.7 %
	2. HR 25 – 65 %	$HR = -112.3 + 0.19 * P_{THM} + 1.23 * P_{RSA} + 0.95 * MS$	87.6 %

## **4.0 DISCUSSION**

A diagnostic system for the analysis of HRV was used in the present longitudinal study for the psychophysiological assessment of stress and screening of health risk at peacekeeping deployment phases. HRV analysis was applied to study autonomic function as it measures reflect sympathetic and parasympathetic activity [Akselrod et al, 1981; Kitney, 1975; Porges, 1986]. HRV measures are among the most frequently used cardiovascular parameters for studying stress and workload in complex task environment [Hockey et al, 2003; Backs & Boucsein, 2000]. The health screening performed with non-invasive methods such as HRV enables the diagnosis of asymptomatic forms of Coronary Artery Disease and borderline hypertension [Stein et al, 1995].

The results of our study revealed that the autonomic cardiovascular control examined by HRV measures and HRV-derived indices is affected by peacekeeping stressors. The advantage of our study is that it enabled the longitudinal psychophysiological assessment of stress response and the screening of health risk of peacekeepers' health status in deployment phases. Both time- (STV) and frequency-domain ( $P_{THM}$ ,  $P_{RSA}$ ) HRV measures, and HRV-derived indices (HR, PS, MS) were changed as a function of peacekeeping stressors. In re-deployment compared to pre-deployment phase we observed a decrease in the mean values of  $P_{RSA}$  and STV, which is assumed to reflect Respiratory Sinus Arrhythmia and  $P_{THM}$  related to the baroreceptor modulation of heart rhythm. These results indicate a reduction of parasympathetic function and baroreceptor modulation of heart rhythm in the re-deployment phase. The control group is used for comparison with the second experimental period as it is considered that for this period of time significant changes in the control group can not occur.

Psychophysiological assessment of peacekeeper stress response at deployment phases with functional indices contributes to objective information about their health status resulting from the impact of stress. In this regard, the assessment of deployment phases (pre-deployment and re-deployment) and their comparison provide useful information for our further studies: research on pre-deployment phase might provide referent functional data before exposure to peacekeeping stress; the study of the re-deployment phase might provide functional data indicating the effects of cumulative stress. This result is consistent to a certain degree with the study of Wright et al. 2002 who examined health surveillance of peacekeepers in different deployment phases with psychological methods for screening of PTSD and depression.

The most likely mechanism for the observed functional changes in autonomic cardiovascular control is the cumulative effect of: risk of terrorist attacks, potentially traumatic combat stressors, and social and psychological stressors on cognitive functions. The results on the effect of peacekeeping stress on autonomic cardiovascular control are supported subjectively by personal interviews that reveal exposure to the simultaneous effect of risk of terrorist attacks, potentially traumatic combat stressors, and social and psychological stress. Cognitive functions are also affected by the cumulative influence of risk of terrorism, traumatic, social and psychological stressors characterizing PKM. The decrease of vagally mediated  $P_{RSA}$  and STV indicating a decline of parasympathetic activity and a decrease of baroreceptor modulation of heart rhythm in re-deployment phase might be affected by the impact of cognitive functions. Involved in these processes is a complex interaction between personal evaluation of a situation and how the individual might change the situation and accomplish successfully his mission. This result is consistent with the results of Shapiro & Katkin, 1980 who indicated that cognitive processes have an influence on physiological functioning and with the results of Wilson, 2003 who revealed that changes in cardiovascular indices are associated with the cognitive load involved in assessing the situation and taking action. The role of cognitive appraisal in the process of interaction between person and environment is pointed out as a mechanism of peacekeeping stress in several studies [Bramsen et al, 2000; Lamerson & Kelloway, 1996].

Besides the psychophysiological assessment of stress, the diagnostic system for analysis of Heart Rate Variability, enables the longitudinal implementation of screening of health risk. In our study the pattern of autonomic changes was associated with increased HR. Although the increase of HR in the re-deployment

phase was 50 % and did not reach the critical value of 65 % for development of CVD, this change is an early indicator for risk of development of pre-morbid state. As a response to level of stress at the re-deployment phase two basic types of autonomic cardiovascular control were differentiated on the basis of referent values of HR: referent and pre-abnormal. Time- and frequency-domain HRV measures decreased significantly in the pre-abnormal compared to referent autonomic cardiovascular control. Pre-abnormal autonomic cardiovascular control might be associated with suspected pre-morbid states. The variables:  $P_{THM}$ ,  $P_{RSA}$ , and MS discriminated significantly the pattern of autonomic function. Results of our occupational studies on the association of basic types of autonomic cardiovascular control (assessed by HRV) with non-specific morbidity revealed significant correlations between abnormal autonomic cardiovascular control and diseases which include in their etiology autonomic dysfunction (e.g., diabetes, hypertension, neuroses, ulcer duodeni, and autonomic disturbances) [Nikolova et al, 2003].

These changes indicate the effects of exposure to risk of terrorist attacks, potentially traumatic combat stressors, social and psychological stressors characterizing PKM in Kosovo and the cumulative effect of peacekeeping stressors on autonomic function and health risk. Our opinion is that most peacekeepers returned from mission with feeling of subjectively experienced stress, because the peacekeepers are young individuals. They are representatives of the new Bulgarian generation and as all normally democratically thinking people who participate in PKM, when they fall into an environment radically different from our country: former Yugoslavia – Kosovo, they react with stress to the consequences of a communistic regime degenerated in bloody nationalistic collisions, ethnic and religious intolerance, terror and violence. The present young Bulgarian generation, with respect to the defence of the freedom and human rights, remind us of another Bulgarian generation which in 1942 - 1943 saved 50, 000 Bulgarian Jews from Nazi concentration camps. This generation had not allowed repressions to be performed on these children, women and men.

The results of our study indicate that the peacekeepers did not show a trend for development of PTSD. We did not observe increasing activity of sympathetic function and its tonic level in deployment phases. Neither heart rate increased nor did the sympathetically mediated time- and frequency-domain HRV measures change as a function of stress. In this respect the testing of the hypothesis to associate the autonomic responses to peacekeeping stress with the autonomic responses to PTSD after exposure to combat stress indicate that the observed autonomic responses are a sign of development of stress reaction and not of PTSD-related autonomic hyperarousal. As a response to cumulative exposure to stress, parasympathetic activity and baroreceptor modulation of heart rhythm are reduced. Identifying peacekeepers with health risk and differentiating basic types of autonomic control (as a response to level of stress) associated with referent, pre-morbid and morbid states might be an important means of assessing health status. The only features that relate peacekeeping stress and PTSD are: exposure to identical traumatic combat stressors inducing stress reaction; role of psychophysiological assessment in stress investigation; stress that might be a risk factor for CVD.

## **5.0 CONCLUSIONS**

In conclusion the results of our study demonstrated:

### **5.1. Tasks of medical surveillance and medical screening**

Medical surveillance and medical screening for the Bulgarian military personnel participating in Peacekeeping Missions is required to define the effect of peacekeeping stress on their health status and to determine suspected risk indicators.

### **5.2. Research potential of Heart Rate Variability diagnostic system**

A diagnostic system for the analysis of Heart Rate Variability might be useful for the psychophysiological assessment of stress and screening of health risk at peacekeeping deployment phases. The advantage of

psychophysiological assessment of peacekeepers stress response at deployment phase using functional indices of stress and health risk is that it provides objective information about the impact of stress on their health.

### **5.3. Stress and health risk results**

These changes indicate the effects of exposure to risk of terrorist attacks, potentially traumatic combat stressors, social and psychological stressors characterizing PKM in Kosovo and the cumulative effect of peacekeeping stressors on autonomic function and health risk.

#### **5.3.1. Stress response**

As a response to the effects of cumulative exposure to risk of terrorist attacks, potentially traumatic combat stressors, and social and psychological stress on cognitive functions, we observed reduced parasympathetic activity, examined with  $P_{RSA}$ , and STV, and reduced baroreceptor modulation of heart rhythm, examined with  $P_{THM}$ . This result is consistent with the results of Shapiro & Katkin, 1980 who indicated that cognitive processes have an influence on physiological functioning and with the results of Wilson, 2003 who revealed that changes in cardiovascular indices are caused by the cognitive load involved in assessing the situation and taking action. The role of the cognitive appraisal in the process of interaction between person and environment is pointed out as a mechanism of peacekeeping stress in several studies [Bramsen et al, 2000; Lamerson & Kelloway, 1996].

#### **5.3.2. Health Risk detection. Screening basic types of autonomic cardiovascular control**

Detecting peacekeepers with suspected health risk and differentiating basic types of autonomic control: referent, pre-abnormal and abnormal (as a response to level of stress) associated with referent, pre-morbid and morbid states might be an important means of assessing health status. The variables:  $P_{THM}$ ,  $P_{RSA}$ , and MS discriminated significantly the pattern of autonomic function.

#### **5.3.3. Assessment of stress and health risk at deployment phases**

The assessment of deployment phases (pre-deployment and re-deployment) and their comparison provide useful information for our further studies: research on pre-deployment phase might provide referent functional data before exposure to peacekeeping stress; the study of the re-deployment phase might provide functional data indicating the effects of cumulative stress. This result is consistent to a certain degree with the study of Wright et al., 2002 as they examine health surveillance of peacekeepers in different deployment phases with psychological methods for screening of PTSD and depression.

### **5.4. Peacekeeping stress and PTSD**

The testing of the hypothesis to associate the autonomic responses to peacekeeping stress with the autonomic responses to PTSD after exposure to combat stress indicates that the observed autonomic responses are a sign of development of stress reaction and not of PTSD-related autonomic hyperarousal. The only features that relate peacekeeping stress and PTSD are: exposure to identical traumatic combat stressors inducing stress reaction; role of psychophysiological assessment in stress investigation; stress that might be a risk factor for CVD.

### **5.5. Bulgarian peacekeepers – representatives of the new Bulgarian generation**

The peacekeepers returned from mission with feeling of subjectively experienced stress. Peacekeepers are young individuals – representatives of the new Bulgarian generation and as all normally democratically thinking people who participate in PKM, when they fall into an environment radically different from our country: former Yugoslavia - Kosovo, they react with stress to the consequences of a communistic regime degenerated in bloody nationalistic collisions, ethnic and religious intolerance, terror and violence. The present young Bulgarian generation with respect to the defence of the freedom and human rights remind us of another Bulgarian generation which in 1942 - 1943 saved 50, 000 Bulgarian Jews from Nazi concentration camps. This generation had not allowed repressions to be performed on these children, women and men.

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## **SYMPOSIA DISCUSSION - PAPER 18**

**Authors Name: Dr Nikolova (BUL)**

**Discussor's Name: Prof. Dr von Restorff (GE)**

**Question:**

- 1) Do you have an idea about the variability of your parameters?
- 2) How much do they change from 1 week after deployment to 1 month after deployment to half a year?

**Author's Reply:**

- 1) We have measured the heart rate variability indices in three consecutive days and have taken for the analyses the individual value of the respective heart rate variability measures and heart rate, variability – derived indices.
- 2) This is our first study on investigating the effect of peacekeeping stress on functional state of the cardiovascular system. We will continue examining and assessing the stability of heart rate variability indices in determining the effect of peacekeeping stressors on the autonomic cardiovascular control and health risk of peacekeepers participating on peacekeeping missions - Kosovo, Iraq, Bosnia, Afghanistan. Results of our previous studies showed that heart rate variability parameters are stable indicators for the assessment of chronic stress and health risk.

**Authors Name: Dr Nikolova (BUL)**

**Discussor's Name: Capt (USN) Campbell (US)**

**Question:**

- 1) Assuming that you can overcome the practical, logistics challenges of taking your measurements in real-time, in an operational setting, do you see future applications of such data in predicting functional effects on cognitive features such as state of attention, or spatial/temporal memory?
- 2) In other words, do you see this type of measurement being of any real value or impact in helping commanders better understand the cognitive “state” of their troops?

**Author's Reply:**

- 1) The future applications of autonomic cardiovascular indices in predicting the effect of peacekeeping stress on cognitive functions will continue. We will continue examining the effect of peacekeeping stressors and the corresponding changes in cognitive functions on cardiovascular functional state and the underlying autonomic mechanisms. With our colleagues we will recommend to Commanders and the Military staff the real value of autonomic cardiovascular indices for the assessment of the effect of peacekeeping stressors on cognitive functions and mechanisms.

**Authors Name: Dr Nikolova (BUL)**

**Discussor's Name: Dr Jett (US)**

**Question:**

- 1) How many months was peace keepers assigned to their post?
- 2) Did you assess immune state before/after the assignment?

**Author's Reply:**

- 1) 6 months
- 2) No