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Psychophysiological Assessment of Stress and Screening of Health Risk in Peacekeeping Operations

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Medical surveillance for military personnel participating in peacekeeping missions (PKMs) is required to define the effect of stress on health status. The aim of this study was to determine the effect of stress on the autonomic cardiovascular control and health risk of 72 Bulgarian peacekeepers participating in a PKM in Kosovo. The assessment of psychophysiological stress and determination of stress characteristics were implemented with analysis of heart rate variability and personal interviews. As a response to the cumulative exposure to the effect of stress on cognitive function, we observed reductions in parasympathetic function and baroreceptor modulation of heart rhythm. The alteration in cardiovascular control was registered as decreases in short-term variability and spectral powers of cardian intervals in the respiratory sinus arrhythmia and Traube-Hering-Mayer bands. The advantage of psychophysiological stress assessment and screening of health risk in PKMs is that results indicate the mechanisms of the effects of stress on cognitive function and health status.

Introduction

Key topics of military medical science and ethics concern ensuring optimal health status, physical and psychological fighting efficiency, high levels of expertise and professionalism, protection of freedom and peace, defence of humanity in the fight against terrorism and tyranny, and preservation of principles and values of the world democratic community. Medical readiness can be compromised during peacekeeping deployment when personnel are exposed to stress. The task of medical readiness is to analyze, treat, and preserve human health and performance and to ensure mission effectiveness.

A theoretical formulation of stress is given in psychological studies. A specific requirement for personnel participating in peacekeeping missions (PKMs) is the ability to maintain a balance between combat readiness and the exercise of restraint. Both presuppose that participants are exposed to the impact of traumatic combat situations (combat attack, dangerous patrols, or witnessing death), terrorist attacks, and social and psychological stressors (role stressors, separation from family, economic factors, nationalistic interests, nonrecognition of human rights, state corruption, organized crime, and drug and people trafficking).

The requirement to safeguard global peace has placed increased demands on peacekeepers in the 21st century and forms the new identity and role of military forces. A principal component of effective peacekeeping is the exercise of restraint. This feature is stressful because it requires restraint in the case of provocation or threat; it contributes to increased anxiety and frustration and can induce post-traumatic stress disorder (PTSD). Cognitive load increases when norms contradict the mentality of repressive totalitarian regimes (encroachment on freedom, nonrecognition of rights, represions, and provocations by nationalistic movements). Military medical studies on combat stress during World War II, the Holocaust, the Vietnam War, and the Persian Gulf War revealed the effects of stress and moral conflicts that mediate PTSD.

Contemporary PKMs are characterized by exposure to stressors that affect health status and degrade performance. Single and cumulative exposures to potentially traumatic events are associated with risk for development of medical and psychological disorders, including PTSD, peacekeeper stress syndrome, and mental health symptoms. Psychological screening is used to determine risk indicators and to predict morbidity outcomes, predeployment psychological issues, redeployment acute stress reactions, and postdeployment psychological adjustment.

Despite the increasing number of studies investigating the nature of stressors in PKMs, their consequences for psychological health, and intervention strategies, there is little research on the effects of stressful peacekeeping deployment on functional state. Examination of functional states with psychophysiological indices in different deployment phases would contribute to clarifying the effects of stress on cognitive and health status, as well as subsequent treatment and prevention. In relating autonomic responses to peacekeeping stress and PTSD, we considered the following: reactions to traumatic and chronic stressors; psychophysiological assessment of autonomic arousal; and cardiovascular reactivity. These processes may induce structural and/or functional disturbances and PTSD might be a risk factor for cardiovascular disease.

Considering that the effect of stress on functional and psychological conditions is to be implemented in medical surveillance, the screening of health status has been extensively used to determine risk indicators, and psychophysiological assessment of autonomic responses in PTSD is needed, our study is an attempt to clarify whether cumulative exposure to the effect of peacekeeping stressors and corresponding changes in cognitive function affect the functional status of the cardiovascular system and underlying autonomic control. We used the heart rate variability (HRV) diagnostic system to determine stress responses and deviations in autonomic regulation, as early indicators of stress.
cators of health risk (HR). Identifying peacekeepers with suspected HR and differentiating basic types of autonomic control might represent an important premorbid indicator. The aim of the present study was to determine the effect of stress on autonomic cardiovascular control and HR of peacekeepers participating in a PKM in Kosovo.

Methods

Subjects

Two groups of subjects participated, i.e., military personnel and control subjects. The first group consisted of 72 male peacekeepers who were members of the Bulgarian armed forces (age range, 20–43 years; mean ± SD, 28.34 ± 10.07 years). They were deployed on a 6-month PKM in Kosovo, which was their first PKM. Sixty-nine individuals were soldiers or sergeants and three 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 group. The peacekeepers were examined in predeployment and redeployment phases. The control group consisted of 61 male individuals, employees in institutions, who were matched to the peacekeepers with respect to age (age, mean ± SD, 28.12 ± 9.31 years). The control group was used in the first investigation of the experimental group.

HRV Measures

A computerized diagnostic system for medical surveillance of the functional status of the cardiovascular system, HRV, was applied. The system consists of specialized hardware and software that enable the following functional tests to be performed: cardiograph analysis of the oscillatory rhythm of the arterial blood pressure regulatory system, consisting of afferent nerve impulses from arterial baroreceptors, the cardiovascular regulatory center, and vagal and sympathetic functional activity, which modulate the heart rhythm and peripheral vascular resistance. The spontaneous oscillatory rhythm has a periodicity of <30 seconds.

The spectral power of RR intervals in the temperature band (0.01–0.05 Hz) (PT) reflects the fluctuations of RR intervals in association with the thermodiagnostic variations of peripheral vascular resistance. The fluctuations in peripheral vascular resistance are accompanied by fluctuations of the same frequency in heart rate and are mediated by the sympathetic nervous system. The spontaneous oscillatory rhythm has a periodicity of 0.1 Hz and is synchronous with the fluctuations in blood pressure, the Traube-Hering-Mayer wave. The PT is thought to be sympathetically and parasympathetically mediated.

The spectral power of RR intervals in the temperature band (0.15–0.50 Hz) (PS) reflects the fluctuations of RR intervals related to the inspiratory inhibition of the parasympathetic tone. The inspiratory inhibition is caused primarily by control radiation of impulses from the medullary respiratory center to the cardiovascular center. The STV is an indicator of the RSA and is parasympathetically mediated.

Long-term variability (LTV) represents the SD of five consecutive values of RR intervals. The rhythmicity of the heart rate is influenced by fluctuations of the periodic processes in physiological systems controlling the arterial blood pressure (through baroreceptor reflexes) and thermoregulatory variations of peripheral vascular resistance. The LTV is thought to be sympathetically and parasympathetically mediated.

The frequency-domain HRV measures reflect the oscillatory rhythm of the physiological control systems controlling the variations in RR intervals in the following frequency bands: 0.01 to 0.05 Hz, 0.06 to 0.14 Hz, and 0.15 to 0.50 Hz. The spectral power of RR intervals in the respective frequency bands was calculated using fast Fourier transformation.

The spectral power of RR intervals in the temperature band (0.01–0.05 Hz) reflects the fluctuations of RR intervals in association with the thermodiagnostic variations of peripheral vascular resistance. The fluctuations in peripheral vascular resistance are accompanied by fluctuations of the same frequency in heart rate and are mediated by the sympathetic nervous system. The spontaneous oscillatory rhythm has a periodicity of <30 seconds.

The spectral power of RR intervals in the temperature band (0.01–0.05 Hz) reflects the fluctuations of RR intervals in association with the oscillatory rhythm of the arterial blood pressure regulatory system, consisting of afferent nerve impulses from arterial baroreceptors, the cardiovascular regulatory center, and vagal and sympathetic functional activity, which modulate the heart rhythm and peripheral vascular resistance. The spontaneous oscillatory rhythm in heart rate has a periodicity of 0.1 Hz and is synchronous with the fluctuations in blood pressure, the Traube-Hering-Mayer wave. The PT is thought to be sympathetically and parasympathetically mediated.

The spectral power of RR intervals in the RSA band (0.15–0.50 Hz) reflects the fluctuations of RR intervals related to the inspiratory inhibition of the parasympathetic tone. The inspiratory inhibition is caused primarily by control radiation of impulses from the medullary respiratory center to the cardiovascular center. The RSA is vagally mediated. The spontaneous oscillatory rhythm of heart rate fluctuations related to the respiratory rate has a periodicity of <10 seconds. HRV-derived indices include PS (a mathematical algorithm based on the difference between measured and age-reference values derived from time-domain HRV measures, calculated in arbitrary units), MS (a mathematical algorithm based on the difference between measured and age-reference values derived from frequency-domain HRV measures, calculated in arbitrary units), and HR (a mathematical algorithm derived from PS and MS coefficients and the number of premature heart beats).

Personal Interviews

Personal interviews with peacekeepers were implemented to examine stressors. Results of the interviews showed that peacekeepers were exposed to the following stressors: risk of terrorism, potentially traumatic combat situations (combat attacks, dangerous patrols, safeguarding important objectives, and increased risk of escalating conflicts), and social and psychological stressors (deployment in a new environment, provocations,

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Data Analyses

HRV measures, HRV-derived indices, and heart rate in the peacekeeper and control groups are expressed as means ± SDs. Means of HRV variables were compared between deployment phases, experimental and control groups, and reference and preabnormal autonomic control at the redeployment phase with paired and independent t tests. Discriminant analysis was used to define which measures distinguished types of autonomic control in the redeployment phase. A p value of <0.05 was considered statistically significant.

Results

To examine differences in levels of stress exposure between deployment phases and how they differed from control values, HRV variables and heart rates were compared between conditions (Table I). Stress was associated with significant decreases in mean values of STV, P_THM, and P_RSA for peacekeepers in the redeployment phase, compared with the predeployment phase. Peacekeeper stress resulted in significant increases in mean values of HR, PS, and MS in the redeployment phase, compared with the predeployment phase. The results also revealed that mean values of STV, P_THM, P_RSA, HR, PS, and MS differed significantly when peacekeepers in the redeployment phase were compared with control subjects. The mean values of heart rate did not show significant differences in the two peacekeeping deployment phases and between peacekeepers and control subjects.

Although HR was in the range of reference values, it was significantly higher in the redeployment phase, compared with the predeployment phase (Table I). To examine the association between autonomic control and suspected premorbid states, we divided the peacekeeper group studied in the redeployment phase on the basis of reference values of HR. Two types of autonomic control, reference (n = 61) and preabnormal (n = 11), were formed. We did not observe individuals with abnormal autonomic control. To determine the pattern of autonomic function, HRV variables and heart rate were compared with t tests. Mean values of HRV variables and heart rate in groups with reference and preabnormal autonomic control are presented in Table II.

Time-domain (STV and LTV) and frequency-domain (P_T, P_THM, and P_RSA) HRV measures significantly decreased in the peacekeepers with preabnormal autonomic cardiovascular control, compared with peacekeepers with reference control. Mean heart rates did not show significant differences. Additional analyses revealed variables that discriminated reference and preabnormal types of autonomic cardiovascular control with HR as a stressogenic marker, namely, P_THM, P_RSA, and MS (Table III).

Discussion

Our study enabled the longitudinal psychophysiological assessment of stress responses and the HR screening of peacekeepers' health status in deployment phases. The results revealed that the autonomic control examined with HRV is affected by peacekeeping stressors. In the redeployment phase, compared with the predeployment phase, we observed a decrease in the mean values of P_RSA and STV, assumed to reflect RSA and P_THM, related to baroreceptor modulation of heart rhythm. These results indicate a reduction of parasympathetic function and baroreceptor modulation of heart rhythm in the redeployment phase. The control group was used for comparison in the second experimental period, because significant changes in the control group cannot occur in this period of time.

Assessment of deployment phases and their comparison provide useful information for further studies. Research on the predeployment phase might provide reference data before exposure to peacekeeping stress, and study of the redeployment

### TABLE I

<table>
<thead>
<tr>
<th>Variable</th>
<th>Predeployment Phase 1</th>
<th>Predeployment Phase 2</th>
<th>Control Group 3</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats per minute)</td>
<td>76.5 ± 11.22</td>
<td>75.30 ± 9.32</td>
<td>72.31 ± 10.35</td>
<td>NS</td>
</tr>
<tr>
<td>Time-domain HRV measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean RR interval (milliseconds)</td>
<td>800.53 ± 118.13</td>
<td>769.89 ± 111.78</td>
<td>846.18 ± 121.87</td>
<td>NS</td>
</tr>
<tr>
<td>STV (milliseconds)</td>
<td>68.03 ± 7.66</td>
<td>52.81 ± 6.50</td>
<td>67.03 ± 6.38</td>
<td>0.01</td>
</tr>
<tr>
<td>LTV (milliseconds)</td>
<td>48.39 ± 7.56</td>
<td>43.53 ± 7.34</td>
<td>45.21 ± 7.34</td>
<td>NS</td>
</tr>
<tr>
<td>Frequency-domain HRV measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_T (milliseconds²)</td>
<td>9.80 ± 1.00</td>
<td>8.13 ± 1.64</td>
<td>10.15 ± 1.82</td>
<td>NS</td>
</tr>
<tr>
<td>P_THM (milliseconds²)</td>
<td>12.63 ± 1.84</td>
<td>9.42 ± 1.33</td>
<td>12.00 ± 1.55</td>
<td>0.007</td>
</tr>
<tr>
<td>P_RSA (milliseconds²)</td>
<td>11.80 ± 1.65</td>
<td>6.58 ± 1.56</td>
<td>12.86 ± 1.38</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>HRV-derived indices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR (%)</td>
<td>23.94 ± 6.15</td>
<td>50.78 ± 7.73</td>
<td>25.03 ± 6.76</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PS</td>
<td>-0.34 ± 0.06</td>
<td>0.92 ± 0.05</td>
<td>-0.12 ± 0.03</td>
<td>0.007</td>
</tr>
<tr>
<td>MS</td>
<td>0.40 ± 0.09</td>
<td>1.03 ± 0.09</td>
<td>0.26 ± 0.05</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Values are mean ± SD. NS, not significant.
Wright et al. 

valvally mediated and how the individual might change the situation and accomplish his mission. This result is consistent with the results of social and psychological stressors and the cumulative effect of peacekeeping stress. In our opinion, most peacekeepers returned from the mission with subjectively experienced stress.

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. Heart rate did not increase and the sympathetically mediated HRV measures did not change as a function of stress. In this respect, 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, the role of psychophysiological assessment in stress investigation, and stress that might be a risk factor for cardiovascular disease.

Table II: MEANS AND p VALUES OF TIME- AND FREQUENCY-DOMAIN HRV MEASURES AND HEART RATE FOR PEACEKEEPER GROUPS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type of Autonomic Cardiovascular Control</th>
<th>Reference (1)</th>
<th>Preabnormal (2)</th>
<th>p, 1-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats per minute)</td>
<td>Reference (1)</td>
<td>74.15 ± 10.71</td>
<td>77.10 ± 11.49</td>
<td>NS</td>
</tr>
<tr>
<td>Time-domain HRV measures</td>
<td>Mean RR interval (milliseconds)</td>
<td>789.36 ± 110.15</td>
<td>749.53 ± 105.09</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>STV (milliseconds)</td>
<td>56.73 ± 6.04</td>
<td>48.23 ± 5.18</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>LTV (milliseconds)</td>
<td>48.93 ± 7.04</td>
<td>37.33 ± 6.71</td>
<td>0.01</td>
</tr>
<tr>
<td>Frequency-domain HRV measures</td>
<td>P₁ (milliseconds)</td>
<td>8.97 ± 1.04</td>
<td>7.85 ± 0.86</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>P₁min (milliseconds)</td>
<td>10.31 ± 1.41</td>
<td>8.45 ± 1.05</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>P₁RS (milliseconds)</td>
<td>7.85 ± 1.63</td>
<td>5.32 ± 1.47</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Values are mean ± SD. NS, not significant.

Table III: DISCRIMINANT FUNCTION ANALYSIS

<table>
<thead>
<tr>
<th>Group</th>
<th>Discriminant Function</th>
<th>Correct Classification (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR of &lt;25%</td>
<td>HR = -77.31 + 0.12 \cdot P₁RS + 0.34 \cdot P₁ + 0.76 \cdot MS</td>
<td>92.7</td>
</tr>
<tr>
<td>HR of 25-65%</td>
<td>HR = -112.3 + 0.19 \cdot P₁RS + 1.23 \cdot P₁ + 0.95 \cdot MS</td>
<td>87.6</td>
</tr>
</tbody>
</table>

phase might provide functional data indicating the effects of cumulative stress. This result is consistent with the findings of Wright et al.8

The observed changes indicate the cumulative effects of peacekeeping stressors on cognition and health. The decrease of vagally mediated P₁RS and STV and the decrease of baroreceptor modulation of heart rhythm in the redeployment phase might be affected by cognitive processes. Involved in these processes is a complex interaction between personal evaluation of a situation and how the individual might change the situation and accomplish his mission. This result is consistent with the results of Shapiro and Katkin33 and Wilson,34 indicating that cognitive processes have an influence on physiological functioning. Cognitive appraisal in the process of interaction between person and environment is a mechanism of peacekeeping stress.5,35

In addition to the psychophysiological assessment of stress, the HRV diagnostic system enables the longitudinal implementation of screening of HR. In our study, the pattern of autonomic changes was associated with increased HR. Although the increase of HR in the redeployment phase was 50% and did not reach the critical value of 65% for development of cardiovascular disease,31 this change indicates a risk of the premorbid state. As a response to the level of stress in the redeployment phase, reference and preabnormal types of autonomic control were differentiated. HRV measures decreased significantly with preabnormal autonomic control, compared with reference autonomic control. Preabnormal autonomic control might be associated with suspected premorbid states. The variables P₁RS, P₁RM, P₁MM, and MS discriminated the pattern of autonomic function significantly.

These changes indicate the effects of simultaneous exposure to risk of terrorist attacks, traumatic combat stressors, and social and psychological stressors and the cumulative effect of peacekeeping stress. We thank Professor David Shapiro (Department of Psychiatry and Biobehavioral Sciences, University of California, Los Angeles, California) and LTC Corina van de Pol, USA (U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama) for their help.

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