Psychiatr. Pol. 2018; 52(3): 511–524
PL ISSN 0033-2674 (PRINT), ISSN 2391-5854 (ONLINE)
www.psychiatriapolska.pl
DOI: https://doi.org/10.12740/PP/79217

Coping with stress, control of emotions and biochemical markers as a common protective element in the inflammatory response to stress

Maria Filip*, Marian Macander*, Piotr Gałecki, Monika Talarowska, Krzysztof Zboralski, Janusz Szemraj, Agata Orzechowska

Department of adult psychiatry, Medical University of Lodz

Summary

Aim. Based on a comprehensive approach to the problem of stress, we have decided to evaluate all components of a stress response – immunological (IL-1, IL-2, IL-6, IL-10, CRP, TNF-alpha) and hormonal one (CRH, ACTH), as well as to evaluate the psychological indicators of stress, coping with stress, and controlling emotional reactions as psychological markers that predispose to the most beneficial adaption in relation to stressors affecting flight personnel taking part in peace missions abroad.

Material and method. The research studies being the subject matter of the project were conducted among 113 antiterrorists and 123 representatives of aircrew (236 respondents in total) who participated in peace missions outside Poland. The study was conducted both before departure and during the missions. The study included a biochemical evaluation (IL-1, IL-2, IL-6, IL-10, CRP, TNF-alpha, CRH, ACTH) as well as a psychological assessment based on the Perceived Stress Scale by S. Cohen (PSS-10) and the Courtauld Emotional Control Scale (CECS) by M. Watson and S. Greer, and the COPE Inventory by J. Carver.

Results. Based on a statistical analysis of the variables, a relationship between the level of perceived stress and the methods of coping with it as well as between the selected methods of emotion control and inflammatory response indicators, was found.

Conclusions. In difficult situations, accompanied by an increase in the variables responsible for the biochemical inflammatory response of an organism, the effective model of coping with difficult situations and emotion control increases, while the subjective level of perceived stress drops.

Key words: stress coping styles, emotion control, inflammatory response, immune system, endocrine system

* both authors contributed equally to this work

This study was supported by grant No. ON402 312138

Introduction

Until now, it has not been possible to work out a single universal model of responding to stress [1, 2]. The development of psychoimmunology and psychoneuroendocrinology has enabled a broad analysis of the interrelations between the biological and psychological factors which play a key role in the etiology of endogenous diseases. By impacting neurotransmission within the central nervous system (CNS), the emotional state of a single person leads to the activation of immune and neuroendocrine mechanisms [3]. As a consequence, excessive sensitivity to certain stress-related situations develops, including the conditioning of predispositions which make it possible for mental disorders to develop, even in distant time [4]. In a holistic approach, stress is a reaction which involves three most important information and integration systems, i.e., neuronal, endocrine and immune one [5]. The synergy of these three systems modulates temporarily or permanently behavioral responses and decides about the intensity of a stress reaction. Additionally, personality traits have an influence on the process of expression at the behavioral level. It is appropriate to mention that these traits can have both a favorable and negative impact, i.e., they may help in the coping with stress and promote the desired forms of behavior, as well as may play a harmful and destabilizing role, resulting in the disadaptation of the organism.

Activation of the hypothalamic–pituitary–adrenal axis (HPA axis), referred to by some scientists as the "stress axis", plays the central role in a response to the action of stressors. Key elements associated with the hypothalamic–pituitary–adrenal axis include: interleukins (mainly IL-1, IL-2, IL-6, IL-10), C-reactive protein (CRP), tumor necrosis factor α (TNF-alpha), CREB (cAMP response element-binding protein), and the following hormones: corticotropin-releasing hormone (CRH) and adrenocorticotropic hormone (ACTH). The existence of the phenomenon involving activation of a stress situation in the hypothalamic–pituitary–adrenal axis does not raise doubt any longer. Hypercortisolism, on the other hand, leads to neuronal damage, affects synthesis and reuptake of neurotransmitters, hence reduces the sensitivity of receptors [6]. In recent years, besides the fundamental role of natural adaptive capabilities of an organism and genetic factors, inflammatory process has been considered increasingly more important in the processes of coping with stress. The presented paper illustrates selected aspects linked with the significance of the inflammatory process with reference to the level of stress and the styles of coping with it among pilots and flight personnel during missions overseas.

The selection of the group of participants (pilots on missions outside Poland) underlines the significance of the whole project. In the scope of biochemical and psychological variables, the obtained results may have a significant impact on the preselection of pilots who are sent on such missions, and on the process of stress level monitoring. Moreover, getting to know the mechanisms responsible for stress and the psychological components which determine more effective coping in stressful situations, as well as faster reduction of a stress response, enables to work out more effective methods of psychological support, the application of which before, during and after a mission may substantially improve pilots' efficiency while performing specific tasks, and reduce the short – and long-term consequences of exposure to stressors. This directly affects personnel safety during missions and improves the effectiveness of their actions.

Aim

Based on a comprehensive approach to the problem of stress, we have decided to evaluate all components of a stress response – immunological (IL-1, IL-2, IL-6, IL-10, CRP, TNF-alpha), hormonal one (CRH, ACTH), as well as to evaluate the psychological exponents of stress and coping with stress, and controlling emotional reactions as psychological markers that predispose to the most beneficial adaption in relation to stressors affecting flight personnel taking part in peace missions abroad. The exposure to stress factors associated with a life-threatening state during such missions in the selected group was sufficiently intense to enable evaluation of the organism's response to stress of moderate and high intensity. Owing to regular periodic examinations, selecting this group ensured a high level of somatic health state, which allowed excluding influences of chronic diseases on the assessed biochemical and psychological parameters. This guaranteed high credibility and reliability of the obtained results.

Detailed research objectives:

1. Evaluation of mRNA concentration for pro-inflammatory interleukins: IL-1, IL-2, IL-6, IL-10, CRP, CRH, ACTH, TNF-alpha.
2. Assessment of the relationship between selected biochemical markers taking part in an inflammatory reaction and the psychological aspects of a response to a stressful situation (level of perceived stress and strategies of coping with stress, as well as control over emotional reactions).

Material and method

During the three-year period of the project (2010–2013), studies and examinations were conducted in 123 (52.12% of the study group) representatives of flight personnel and in 113 (47.88% of the study group) antiterrorists, which gives a total of 236 respondents participating in missions outside Poland. All the participants were qualified for the study after a verification conducted at the Institute of Aviation Medicine in Warsaw, Poland, and expressed their written consent to take part in the study (approval by the Commission of Bioethics issued on 13 December 20011 – RNN/882/11/KB).

The study was conducted in two stages:

Stage I: an assessment analysis of biochemical factors (based on blood test results) and psychological indicators of a stress response (using the methods of psychological diagnosis described below) was conducted during routine examinations (before departure on a mission). Moreover, the level of perceived stress was determined (using S. Cohen's Perceived Stress Scale PSS-10 within a period of about a month before examination).

Stage II: during a mission, a medical personnel representative (medical doctor, psychologist, nurse) evaluated the level of perceived stress in each participant (based on S. Cohen's Perceived Stress Scale PSS-10).

Blood samples were collected from the participants. Blood was required to perform the biochemical evaluation of stress indicators which are the subject matter of this paper. Additionally, psychological tests were conducted based on the application of planned tests. The blood samples were collected and the tests were performed during routine examinations before soldiers' departure on a mission as well as during the very mission (only the level of perceived stress was assessed then). An analysis of the results of the last stage of the project will be presented in a separate publication.

The biochemical evaluation of stress indicators was carried out at the Department of Medical Biochemistry of the Medical University of Lodz, Poland.

The biochemical parameters were analyzed on the basis of the blood collected from the study participants. Mononuclear blood cells served as study material. Total RNA was isolated using the TRIzol Reagent method [7]. After reverse transcription, specific cDNA was determined using the QPCR method based on the application of specific TaqMan probes [8]. The level of ACTH and CRH was determined using the radioimmunological method and based on the commercially available kits [9].

Psychological methods used in the study

- S. Cohen's Perceived Stress Scale (PSS-10) (adapted by Z. Juczyński) – makes it possible to determine the level of perceived stress within a month before examination. Results in the questionnaire oscillate between 0 and 40 points. The higher the score, the greater the level of perceived stress – first and second stage of the research.
- Courtauld Emotional Control Scale (CECS) by M. Watson and S. Greer, adapted by Z. Juczyński – is composed of three subscales; each subscale includes seven statements regarding the manner of occurrence of anger, depression and anxiety. The scale is used to measure subjective control over anger, anxiety and depression in difficult situations – first stage of the research.
- COPE Inventory by Charles S. Carver, Michael F. Scheier, Jagdish K. Weintraub, adapted by Z. Juczyński and Nina Ogińska-Bulik – used to measure the strategies of coping with stress. It consists of 60 items. It enables to evaluate 15 strategies of reacting in stress situations, which form four more general styles of coping with stress, including: problem-focused, avoidance-oriented, socially-supported, and emotion-focused coping strategies.

Results

Mean age of all the examined individuals ($N = 236$) was: $M = 32.43$ years, standard deviation (SD) = 6.82; minimum age – 22 years, maximum age – 67 years.

Selected methods of descriptive statistics and methods of statistical reasoning were used in the statistical analysis of the collected material. During a statistical verification of the hypotheses, a two-tailed critical area was assumed.

Appropriate structural indicators, i.e., prevalence of a given trait expressed in percentage terms, were applied in the description of qualitative features in the examined group of affected patients and the control group. Arithmetic mean (*M*) and median (*Me*) were calculated for the description of the value of average quantitative markers. The scope of values (with the minimum and maximum value determined) as well as standard deviation (*SD*) were assumed as measures of dispersion.

The nature of the distribution of variables was examined with the Shapiro-Wilk test. In relation to variables which did not meet normal distribution, the following non-parametric tests were applied in statistical comparisons between the examined groups: Pearson's chi-squared test, Mann-Whitney *U* test in case of two independent groups, Wilcoxon signed-rank test in case of two dependent groups, Kruskal-Wallis ANOVA for several independent groups. Spearman's rank correlation coefficient was used to evaluate the correlations between the analyzed variables. Moreover, a procedure of factor analysis was performed. The significance level for all the applied statistical methods was set at $p < 0.05$.

All statistical calculations were conducted using STATISTICA PL software, version 10. Mean values and basic data of descriptive statistics obtained by the researches in the psychological tests are presented in Tables 1–3.

Table 1. **Descriptive statistics – S. Cohen's Perceived Stress Scale (PSS-10)**

Scale name	N	M	SD	Minimum	Maximum
PSS – 10 – Stage I	236	10.33	5.00	0	24
PSS – 10 – Stage II	189	8.87	5.05	0	33

PSS-10 – Perceived Stress Scale (Stage I and II); *N* – number of respondents; *M* – mean; *SD* – standard deviation

Mean value of perceived stress intensification measured with the PSS-10 Scale turned out to be slightly higher in case of measurements conducted in a period preceding departure on a mission (stage I). In order to indicate whether soldiers differed between one another in terms of perceived stress intensity in the specified periods, the Wilcoxon signed-rank test was used. The test value totaling 5.198 turned out to be statistically significant at the level of $p < 0.001$.

Table 2. **Descriptive statistics – Courtauld Emotional Control Scale (CECS) by M. Watson and S. Greer**

Scale name	N	M	SD	Min.	Max.
Anger	236	17.44	4.16	4	28
Depression		16.07	3.75	1	28
Anxiety		18.53	4.26	1	28
Emotion control index		51.93	10.22	6	81

N – number of respondents; *M* – mean; *SD* – standard deviation

Table 2 presents mean values and standard deviation for the Courtauld Emotional Control Scale (CECS) used to measure subjective anger, anxiety and depression control in difficult situations. Table 3 presents basic results of the COPE Inventory used in the measurement of strategies of coping with stress.

Table 3. **Descriptive statistics – COPE Inventory**

Scale name	N	M	SD	Min.	Max.
Active coping	236	11.21	2.32	4	16
Planning		12.08	2.93	4	28
Seeking of instrumental social support		10.51	2.45	4	16
Seeking of emotional social support		8.83	2.63	4	16
Suppression of competing activities		10.49	2.33	4	16
Turning to religion		7.25	2.89	0	16
Positive reinterpretation and development		11.22	2.34	5	16
Refraining from taking actions		10.20	2.11	4	16
Acceptance		9.95	2.68	4	16
Focus on and venting of emotions		7.81	1.81	4	14
Denial		6.09	1.98	3	13
Distraction		7.27	1.94	2	13
Discontinuation of actions		6.27	1.96	4	11
Alcohol/drugs use		5.13	2.06	1	13
Sense of humor		7.03	2.52	3	16

N – number of respondents, *M* – mean, *SD* – standard deviation

Based on the results obtained by the examined soldiers, it is possible to conclude that higher mean values were obtained in the scale which generally indicate preference of rational strategies in the process of solving stress situations. Among these results, the following scales are considered most important: Activity, Positive reinterpretation and development, and Active coping.

Table 4 presents a comparison of the analyzed biochemical indicators in the examined group considering a division into types of service.

Table 4. **Descriptive statistics of analysed biochemical variables**

Variable	N	M	Minimum	Maximum	SD
IL-1	236	0.54	0.36	0.88	0.12
IL-2	236	0.63	0.33	1.28	0.22
IL-6	236	0.41	0.20	0.79	0.14
IL-10	236	0.29	0.10	0.60	0.10
CRP	236	0.19	0.10	0.30	0.06
TNF-alpha	236	0.30	0.05	0.68	0.14

table continued on the next page

CRH	236	0.19	0.09	0.31	0.05
ACTH	236	11.75	5.19	18.72	3.00

N – Number of respondents; IL-1 – Interleukin 1; IL-2 – Interleukin 2; IL-6 – Interleukin 6; IL-10 – Interleukin 10; CRP – C-reactive protein; TNF-alpha – Tumor necrosis factor; CRH – Corticotropin-releasing hormone; ACTH – Adrenocorticotropic hormone; *M* – Mean; *SD* – Standard deviation

The Spearman's rank correlation test was performed to verify whether there is a relationship between the analyzed variables – whether the level of perceived stress and strategies of coping with stress, and the type of applied emotion control, co-occur with the measured indicators of an inflammatory state. The majority of the correlations recorded statistically significant values. An increase in the level of the biochemical variables serving as markers of an inflammatory response accompanied an increase in the beneficial strategies of coping with stress and a drop in the level of perceived stress, as well as a decrease in irrational styles of coping with stress. Table 5 includes results of a correlation matrix for the selected variables.

Table 5. **Correlation matrix after variables elimination**

Variables	IL-1	IL-2	IL-6	IL-10	CRP	TNF-alpha	CRH	PSS-10(I)	CECS G	CECS D	CECS L	CECS KE	Denial	Discontinuation of actions
IL-1	1.00	0.88	0.86	0.84	0.65	0.84	0.69	-0.67	0.06	-0.00	0.09	0.05	-0.19	-0.24
IL-2	0.88	1.00	0.88	0.84	0.70	0.85	0.71	-0.66	-0.06	-0.06	0.04	-0.03	-0.17	-0.19
IL-6	0.86	0.88	1.00	0.80	0.69	0.84	0.67	-0.70	0.03	-0.09	0.05	0.01	-0.23	-0.24
IL-10	0.84	0.84	0.80	1.00	0.56	0.78	0.60	-0.60	0.04	0.01	0.07	0.05	-0.15	-0.16
CRP	0.65	0.70	0.69	0.56	1.00	0.66	0.60	-0.54	0.01	-0.09	0.05	-0.00	-0.18	-0.19
TNF-alpha	0.84	0.85	0.84	0.78	0.66	1.00	0.65	-0.62	0.00	-0.10	0.04	-0.02	-0.12	-0.17
CRH	0.69	0.71	0.67	0.60	0.60	0.65	1.00	-0.55	-0.01	-0.08	0.08	-0.00	-0.18	-0.12
PSS-10 (I)	-0.67	-0.66	-0.70	-0.60	-0.54	-0.62	-0.55	1.00	-0.17	0.13	-0.12	-0.06	0.39	0.41
CECS G	0.06	-0.06	0.03	0.04	0.01	0.00	-0.01	-0.17	1.00	0.47	0.48	0.78	-0.02	-0.18
CECS D	-0.00	-0.06	-0.09	0.01	-0.09	-0.10	-0.08	0.13	0.47	1.00	0.66	0.83	0.20	0.14
CECS L	0.09	0.04	0.05	0.07	0.05	0.04	0.08	-0.12	0.48	0.66	1.00	0.86	-0.04	-0.02
CECS KE	0.05	-0.03	0.01	0.05	-0.00	-0.02	-0.00	-0.06	0.78	0.83	0.86	1.00	0.03	-0.04
Denial	-0.19	-0.17	-0.23	-0.15	-0.18	-0.12	-0.18	0.39	-0.02	0.20	-0.04	0.03	1.00	0.55
Discontinuation of actions	-0.24	-0.19	-0.24	-0.16	-0.19	-0.17	-0.12	0.41	-0.18	0.14	-0.02	-0.04	0.55	1.00

IL-1 – Interleukin 1; IL-2 – Interleukin 2; IL-6 – Interleukin 6; IL-10 – Interleukin 10; CRP – C-reactive protein; TNF-alpha – Tumor necrosis factor ; CRH – Corticotropin-releasing hormone; PSS-10 (I) – Intensification of perceived stress (stage I); CECS Courtauld Emotional Control Scale: CECS G – anger, CECS D – depression, CECS L – anxiety, CECS KE – emotion index

A factor analysis was performed in order to reduce the data and detect a structure in the correlations between the variables. All biochemical variables and psychological examination variables were initially applied in the factor analysis. Only the cases where no missing data was confirmed were selected. As a result of the analysis of the correlation matrix, 14 variables were selected for the factor analysis presented in Table 5.

The factor analysis was performed based on the method of main components and the below-presented factor loadings were obtained. Three factors were distinguished after the analysis:

1. In terms of factor 1, high factor loadings were recorded for the following variables: IL-1, IL-2, IL-6, IL-10, CRP, TNF-alpha, CRH, and the stress intensity scale (PSS-10).
2. In terms of factor 2, high factor loadings were recorded only for the psychological variables associated with emotion control, i.e., CECS-G, CECS-D, CECS-L, CECS-KE.
3. In terms of factor 3, high factor loadings were recorded for two COPE test variables: Denial and Discontinuation of actions.

Table 6 presents the factor loadings after the application of rotation based on the Varimax method.

Table 6. **Factor loadings**

Factor loadings (Varimax sur)			
Specification	Factor 1	Factor 2	Factor 3
IL-1	0.928	0.054	0.099
IL-2	0.951	-0.038	0.051
IL-6	0.921	-0.003	0.150
IL-10	0.870	0.048	0.033
CRP	0.765	-0.017	0.113
TNF-alpha	0.913	-0.029	0.032
CRH	0.786	-0.011	0.057
PSS-10 (I)	-0.701	-0.062	-0.461
CECS G	-0.010	0.774	0.218
CECS D	-0.049	0.852	-0.250
CECS L	0.068	0.864	0.026
CECS KE	0.006	0.994	0.020
Denial	-0.118	0.058	-0.843
Discontinuation of actions	-0.131	-0.027	-0.856
Output value	5.952	3.076	1.819
Share	0.425	0.220	0.130

IL-1 – Interleukin 1; IL-2 – Interleukin 2; IL-6 – Interleukin 6; IL-10 – Interleukin 10; CRP – C-reactive protein; TNF-alpha – Tumor necrosis factor ; CRH – Corticotropin-releasing hormone; PSS-10 (I) – Intensification of perceived stress (stage I); CECS Courtauld Emotional Control Scale: CECS G – anger, CECS D – depression, CECS L – anxiety, CECS KE – emotion index

Based on the Table 6, it is possible to draw conclusions that the first factor explains approx. 86% of the IL-1 variable, 91% of the IL-2 variable, 85% of the IL-6 variable, 77% of the IL-10 variable, 58% of the CRP variable, 83% of the TNF-alpha variable, 62% of the CRH variable, and 49% of the PSS-10 (I) variable.

On the other hand, factor 2 explains 60% of the CECS-G variable, 73% of the CECS-D variable, 75% of the CECS-L variable, and 99% of the CECS-KE variable.

Factor 3 explains approx. 40% of the denial variable and 39% of the discontinuation of actions variable.

Table 7. **Communality**

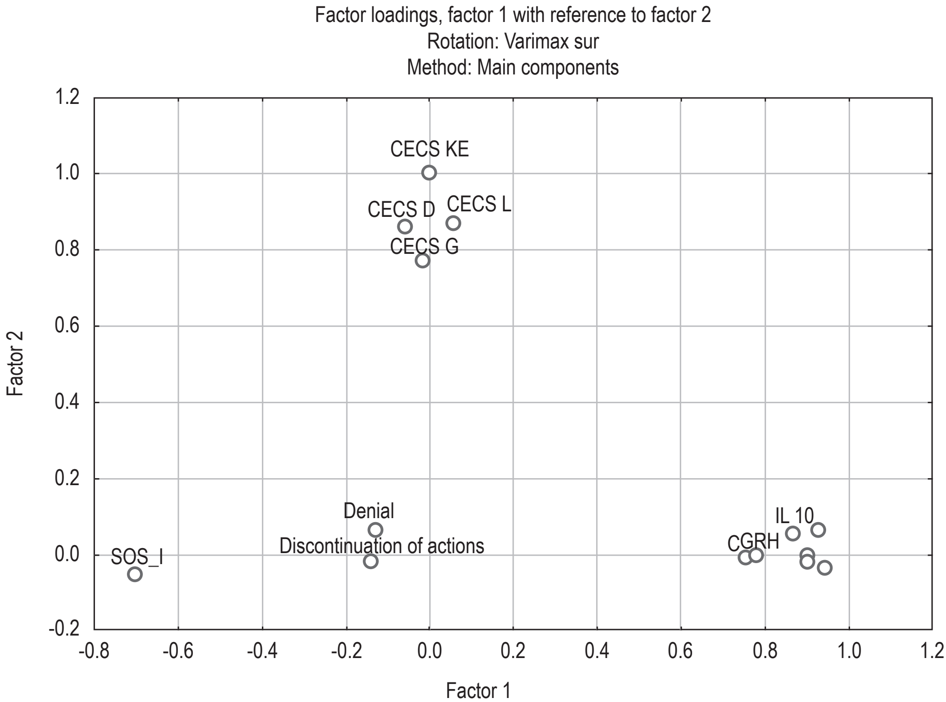
	Communality: Main components		Rotation: Varimax sur	
Specification	Factor 1	Factor 2	Factor 3	Multiple – R-square
IL-1	0.862	0.865	0.875	0.858
IL-2	0.905	0.907	0.909	0.889
IL-6	0.848	0.848	0.870	0.841
IL-10	0.773	0.775	0.776	0.768
CRP	0.585	0.585	0.598	0.550
TNF alpha	0.833	0.834	0.835	0.795
CRH	0.618	0.618	0.621	0.562
PSS-10 (I)	0.491	0.495	0.707	0.629
Denial	0.014	0.017	0.728	0.403
Discontinuation of actions	0.017	0.018	0.751	0.393
CECS G	0.000	0.599	0.647	0.909
CECS D	0.003	0.728	0.791	0.888
CECS L	0.005	0.751	0.752	0.915
CECS KE	0.000	0.988	0.989	0.981

IL-1 – Interleukin 1; IL-2 – Interleukin 2; IL-6 – Interleukin 6; IL-10 – Interleukin 10; CRP – C-reactive protein; TNF-alpha – Tumor necrosis factor ; CRH – Corticotropin-releasing hormone; PSS-10 (I) – Intensification of perceived stress (stage I); CECS Courtauld Emotional Control Scale: CECS G – anger, CECS D – depression, CECS L – anxiety, CECS KE – emotion index

The two graphs below present the dispersion of factor loadings in 2D and 3D version.

Three factors were distinguished as a result of the factor analysis of the biochemical and psychological variables.

1. The first factor included the following biochemical and genetic variables: IL-1, IL-2, IL-6, IL-10, CRP, TNF-alpha, CRH, as well as stress intensification PSS-10 (I) among the psychological variables.
2. The second factor – associated with emotion control – included the Courtauld Emotional Control Scale (CECS) variables such as anger, depression and anxiety, as well as the general emotion indicator.

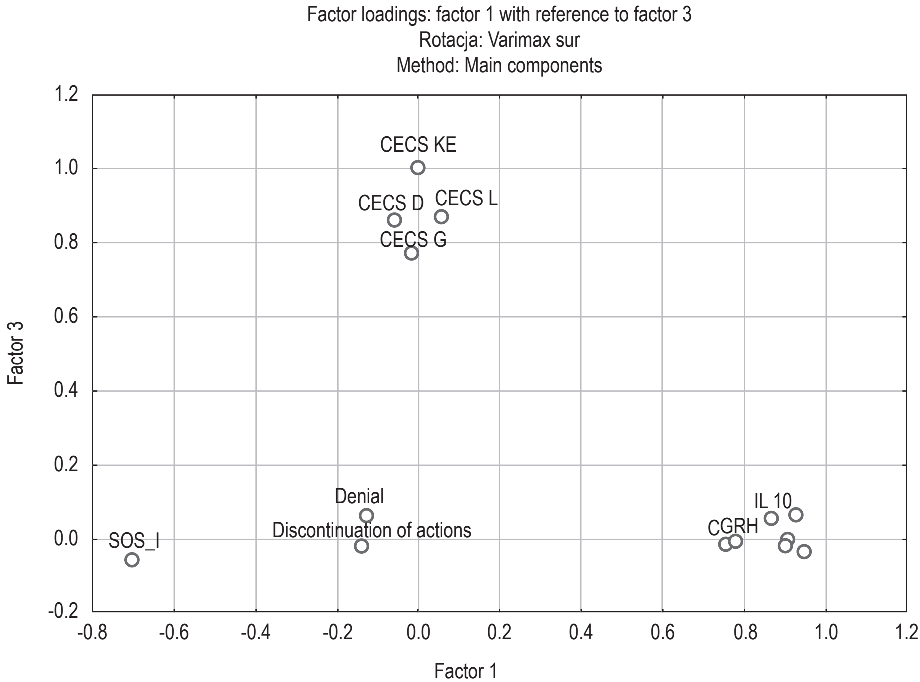


Graph 1. **Dispersion of loadings in relation to the first two factors (1 and 2)**

3. The third factor – regarding the mechanisms of coping in difficult situations – consisted of two variables from the COPE Inventory, i.e., Denial and Discontinuation of actions as forms of coping with a difficult situation.

Discussion

The main objective of this paper was to indicate the interrelations between the biochemical and psychological markers of a stress response in the personnel taking part in peace missions abroad. It is worth noticing that due to the specificity of the profession and performed tasks, the examined population is characterized by a high level of mental health and demonstrates adequate mental predispositions for the job which is associated with exposure to high stress levels. It could seem that the level of cytokines in a population exposed to the a stressor may be higher than in an unexposed population. However, the level of cytokines does not change immediately; it is affected most of all by the duration of action of a stress factor and the profile of a given profession. Additionally, observations indicate that soldiers with certain specific personality predispositions use rational strategies in difficult and stressful situations, as well as are characterized by a lower level of perceived stress.



Graph 2. **Dispersion of loadings in relation to factors 1 and 3**

Stress is one of the elements that have an impact on the risk of developing somatic and mental illnesses and disorders. Practically all diseases experienced by a human being are to a larger or smaller extent associated with stress. Both acute and chronic stress, linked with exposure to negative experiences, may lead to a release of a wide range of somatic and mental illnesses. Unskillful coping with stress linked with an inability to react effectively to tension, control emotional responses and function efficiently brings about the feeling of anxiety associated with a threat, accompanied by both physiological and mental symptoms characteristic for stress [10].

The relationship between stress and depression, its role in the development of successive stages of the illness, and the factors which mediate in the stress–depression relations are more often a subject of studies in psychiatry and psychology. Presently, depression is perceived as a disorder of multifactorial etiology. Genetic, biological and psychosocial factors are taken into account in the pathogenesis of this illness. In the people with a genetically determined predisposition to a specific mental disorder, the illness may occur only under the influence of stressful life events [11]. The said predisposition includes cognitive constructs developed as a result of social learning and acquired ways of coping in difficult situations. Life events are defined as events, especially linked with a loss or overloading, which – depending on the personality traits of a given person – may cause depression or have an impact on its clinical picture [12, 13].

The studies on an animal model [14] and on humans conducted so far suggest that both acute and chronic stress may have a direct influence on the level of cytokines [15]. The balance between pro-inflammatory cytokines (e.g., IL-1B, IL-6, TNF-alpha) and anti-inflammatory cytokines (e.g., IL-1, IL-4, IL-10) plays a key role in a neuroimmunological and neuroinflammatory response [16]. It is, however, important to notice that the number of conducted studies is insignificant and still insufficient. The studies conducted so far suggest different cytokine concentrations depending on the level of perceived stress, its duration or population exposed to stress.

In a paper which analyzed a population of rats, Brenberg et al. examined the correlation between the impact of acute (forcing to swim), chronic or complete absence of stress and the level of cytokines such as IL-2, IL-4, IL-6, IL-10, IL-22, and TNF-alpha. They demonstrated an interrelation between increased concentration of IL-2 in the rats subjected to acute stress as compared to the group not affected by a stressor or subjected to chronic stress. The level of IL-4, IL-6, IL-10, and TNF-alpha was, on the other hand, higher both in the population affected by acute and chronic stress in comparison with the group not subjected to any stress [17].

In other studies conducted on mice [17], rats [18] and humans [19–21] it was possible to demonstrate that stressful situations have a direct influence on an increase in the concentration of IL-6. A few subsequent studies revealed an increased level of TNF-alpha in rats [22, 23], mice [24] and humans [25] with reference to the action of stress. The available literature provides a diverse picture for other cytokines such as IL-2, IL-4 and IL-6. Stress results in both an increase [26] and a drop in the level of IL-2. Meanwhile, the level of IL-4, remains unchanged [27] or even drops [28]. In two examined animal models subjected to stress [29] and in humans after an operation [30] an increase in the concentration level of IL-10 was indicated. Similarly as in our studies, Aloe et al. juxtaposed information which confirmed that stress associated with parachute jumping did not alter the concentration of IL-1B and TNF-alpha both before as well as 20 minutes after landing [31]. A different study demonstrated that the concentration of TNF-alpha among parachute jumpers was significantly greater as compared to a group of individuals who did not jump [32]. When analyzing the results presented above, we are allowed to claim that a response of cytokines in a stressful situation is not immediate.

Conclusions

The conducted study enabled to formulate the following conclusions:

- The examined soldiers differed between one another during individual stages of a mission in terms of the level of perceived stress.
- A statistically significant relationship was confirmed between the analyzed biochemical markers and the variables which described the mental functioning of the subjects.
- In the examined group the following aspects affect the process of adaptation in relation to stressors:

a) biochemical variables and level of perceived stress;

b) features making up emotional control;
c) selected strategies of coping with stress.

References

1. Strelau J. *Temperament a stres: temperament jako czynnik moderujący stresory, stan i skutki stresu oraz radzenie sobie ze stresem*. In: Heszen-Niejodek I, Ratajczak Z. ed. *Człowiek w sytuacji stresu*. Katowice: Publishing House of University of Silesia; 2000. P. 88–132.
2. Bishop GD. *Psychologia zdrowia*. Wroclaw: ASTRUM; 2000.
3. Heim C, Nemeroff CB. *The Role of Childhood trauma in the neurobiology of mood and anxiety disorders: Preclinical and clinical studies*. Biol. Psychiatry 2001; 49: 10.
4. Ogińska-Bulik N, Juczyński Z. *Osobowość. Stres a zdrowie*. Warszawa: Difin; 2008.
5. Espinosa E, Bermúdez-Rattoni F. *Behavior-immunity relationship: The role of cytokines*. Rev. Invest. Clin. 2001; 53(3): 240–253.
6. Luthar S, Brown P. *Maximizing resilience through diverse levels of inquiry: Prevailing paradigms, possibilities, and priorities for the future*. Dev. Psychopathol. 2007; 19(3): 931–955.
7. Chomczynski P, Sacchi N. *Single-step method of RNA isolation by acid guanidinium thiocyanatephenol-chloroform extraction*. Anal. Biochem.; 1987; 162(1): 156–159.
8. Bobińska K, Gałecka E, Szemraj J, Gałecki P, Talarowska M. *Is there a link between TNF gene expression and cognitive deficits in depression?* Acta Biochim. Pol. 2017; 64(1): 65–73.
9. Huang G, Liu Z, He M, Wang X. *Reduced plasma corticotropin-releasing hormone levels during late gestation in patients with intrahepatic cholestasis of pregnancy*. Gynecol. Obstet. Invest. 2014; 78(3): 168–172.
10. Orzechowska A, Zajączkowska M, Talarowska M, Gałecki P. *Depression and ways of coping with stress: A preliminary study*. Med. Sci. Monit. 2013; 19: 1050–1056.
11. Dantzer R, O'Connor JC, Freund GG, Johnson RW, Kelley KW. *From inflammation to sickness and depression: When the immune system subjugates the brain*. Nat. Rev. Neurosci. 2008; 9(1): 46–56.
12. Benedysiuk E, Tartas M. *Coping mechanisms in depression*. Annales Academiae Medicae Gedanensis. 2006; 36: 9–19.
13. Sariusz-Skąpska M, Czabała JC, Dudek D, Zięba A. *Ocena stresujących wydarzeń życiowych i poczucie koherencji u pacjentów z chorobą afektywną jedno – i dwubiegunową*. Psychiatr. Pol. 2003; 37(5): 863.
14. Himmerich H, Fischer J, Bauer K, Kirkby KC, Sack U, Krügel U. *Stress-induced cytokine changes in rats*. Eur. Cytokine Netw. 2013; 24(2): 97–103.
15. Yang PC, Jury J, Söderholm JD, Sherman PM, McKay DM, Perdue MH. *Chronic psychological stress in rats induces intestinal sensitization to luminal antigens*. Am. J. Pathol. 2006; 168(1): 104–114.
16. Plata-Salaman C, Turrin N. *Cytokine interactions and cytokine balance in the brain: Relevance to neurology and psychiatry*. Mol. Psychiatry 1999; 4: 302–306.
17. Bernberg E, Ulleryd MA, Johansson ME, Bergström GM. *Social disruption stress increases IL-6 levels and accelerates atherosclerosis in ApoE-/– mice*. Atherosclerosis. 2012; 221(2): 359–365.
18. Okada S, Hori N, Kimoto K, Onozuka M, Sato S, Sasaguri K. *Effects of biting on elevation of blood pressure and other physiological responses to stress in rats: Biting may reduce allostatic load*. Brain Res. 2007; 1185: 189–194.

19. Rohleder N, Aringer M, Boentert M. *Role of interleukin-6 in stress, sleep, and fatigue*. Ann. NY Acad. Sci. 2012; 1261: 88–96.

20. Lutgendorf SK, Garand L, Buckwalter KC, Reimer TT, Hong SY, Lubaroff DM. *Life stress, mood disturbance, and elevated interleukin-6 in healthy older women*. J. Gerontol. A. Biol. Sci. Med. Sci. 1999; 54(9): M434–439.

21. Maes M, Lin AH, Delmeire L, Van Gastel A, Kenis G, De Jongh R, Bosmans E. *Elevatedserum-interleukin-6 (IL-6) and IL-6 receptor concentrations in posttraumatic stress disorder following accidental man-made traumatic events*. Biol. Psychiatry 1999; 45(7): 833–839.

22. Liu YL, Bi H, Fan R, Li YH, Wang YM, Chen YM et al. *Effect of compound nutrients on acute immobilization and cold water-immersion stress-induced changes of Th1/Th2 cytokines*. Xi Bao Yu Fen Zi Mian Yi Xue Za Zhi. Chinese Journal of cellular and molecular immunology 2012; 28(6): 601–603.

23. Binker MG, Binker-Cosen AA, Richards D, Gaisano HY, Cosen de RH, Cosen-Binker LI. *Chronic stress sensitizes rats to pancreatitis induced by cerulein: Role of TNF-alpha*. World J. Gastroenterol. 2010; 16(44): 5565–5581.

24. Chida Y, Sudo N, Motomura Y, Kubo C. *Electric foot-shock stress drives TNF-alpha production in the liver of IL-6-deficient mice*. Neuroimmunomodulation 2004; 11(6): 419–424.

25. Grossi G, Perski A, Evengård B, Blomkvist V, Orth-Gomér K. *Physiological correlates of burnout among women*. J. Psychosom. Res. 2003; 55(4): 309–316.

26. Chuian OM, Temur'iants NA, Makhonina MM, Zaiachnikova TV. *Effect of hypokinetic stress and low intensity electromagnetic field of extremely high frequency on changes of cytokine concentration in rat blood*. Fiziol. Zh. 2005; 51: 70–78.

27. Murakami M, Sato N, Sato N, Nakamura T, Masunaga H. *Changes in lymphocyte phenotypes and cytokine production by surgical stress in a rat small intestinal resection model*. J. Clin. Biochem. Nutr. 2007; 40(3): 216–220.

28. Sotnikov SV, Stepaniuk VL, Umriukhin AE. *Influence of exposure to immobilisation stress on blood concentration of TNF-alpha and IL-4 in rats active and passive in the open field test*. Zh. Vyssh. Nerv. Deiat. Im I P Pavlova. 2009; 59(6): 736–742.

29. Curtin NM, Boyle NT, Mills KH, Connor TJ. *Psychological stress suppresses innate IFN-gamma production via glucocorticoid receptor activation: Reversal by the anxiolytic chlordiazepoxide*. Brain Behav. Immun. 2009; 23(4): 535–547.

30. Servis D, Busic Z, Stipancic I, Patrlj L, Gagro A. *Serum cytokine changes after gastric resection or gastrectomy for gastric cancer*. Hepatogastroenterology 2008; 55(86–87): 1868–1872.

31. Aloe L, Bracci-Laudiero L, Alleva E, Lambiase A, Micera A, Tirassa P. *Emotional stress induced by parachute jumping enhances blood nerve growth factor levels and the distribution of nerve growth factor receptors in lymphocytes*. Proc. Natl. Acad. Sci. USA. 1994; 91(10): 440–444.

32. Wu TC, Xiong YL, Chen S, Leng ST, Hai T, Tanguay RM. *Biochemical changes of plasma in paratroops after parachuting: A preliminary investigation*. Space Med. Med. Eng. (Beijing) 1999; 12(4): 235–239.

Address: Maria Filip
Department of adult psychiatry, Medical University of Lodz
91-229 Łódź, Aleksandrowska Street 159
e-mail: mariafilip@interia.pl