Int J Clin Exp Med 2016;9(4):7314-7321
www.ijcem.com /ISSN:1940-5901/IJCEM0020472

Original Article

Psychological and physiological effects of long voyage on female seamen in China

Song-Yun Xia[1], Kun Zhang[2], Wei Shang[1], Mei Xing[1], Lei Chen[1]

[1]Department of Obstetrics and Gynecology, Navy General Hospital, Beijing, China; [2]Department of Obstetrics and Gynecology, Xi'an No. 4 Hospital, Shanxi, China

Received November 24, 2015; Accepted February 13, 2016; Epub April 15, 2016; Published April 30, 2016

Abstract: We examined the psychological and physiological effects on female seamen before, during, and after long navigation in China. Our research explored chronic psychological stress during a long voyage on the health of female seamen. Seventy-one female seamen participated in a psychological evaluation before and after navigation. We also examined neuroendocrine hormone levels, body fluid immunological index changes, and menstruation conditions and menstruation diseases. We found SCL-90 psychological evaluation of somatization, anxiety, paranoia, and other factors scored significantly higher following navigation than before the long voyage. We also found serum COR levels significantly increased while FT3 levels decreased. We also found PRL increased whereas FSH, LH, and E2 decreased. Our results also revealed an abnormal menstrual cycle and a significant increase in menstruation diseases. Finally, IgG and complement C3 significantly decreased following a long voyage. Female seamen experience chronic psychological stress that may influence their neuro-endocrine and immunological functions during a long voyage. Therefore, it is very important to strengthen the health care of female seamen.

Keywords: Psychological stress, voyage, seaman, neuroendocrine, immunity

Introduction

Long voyages expose seafarers to special living conditions in which their mental and physical health is greatly influenced by being far away from land, family members, and friends as well as facing severe weather and stressful working conditions. Long voyages can result in severe health impairment that may cause changes in the endocrine and immune system.

During a long voyage, waves cause the ship to rock and the stimulation of such abnormal movement results in conflicts within the central nervous system. This conflict causes many functional imbalances in the central nervous system and may lead to endocrine functional disorder and the cerebral cortex function disorder. Further, this leads to a brain stem malfunction and causes vestibular sensory abnormalities, plant nerve function disorder, and hemodynamic changes. The dual pressures of the mental and physical stress lead to negative cognitive emotional disorders, and lead to changes in the endocrine and immunology system [1]. Chrousos et al. [2] hypothesize that when a stressor is applied continuously, the self-steady state will become imbalanced. The nervous system, endocrine system, and the medium secretion of immune system will be abnormal, and causes physiological and mental diseases. Therefore, the stressor is unpredictable and uncontrollable. Studies of Stanley et al. [3] show that soldiers sustain dual loads of physiological and mental pressures in the face of military deployment tasks, which causes physical and mental functional disorders, such as post-traumatic stress disorder, mood irritancy, anxiety, and other psychological and physiological diseases. Stress may affect women more than men causing increases in depression and anxiety [4]. The animal experiments conducted by Guilloux JP [5] and other researchers show that male and female rats have distinctive differences in the response to external stimulation, which indicates that stress has a relevance to gender. A study on 20 baboons showed that chronic stress may lead to abnormal menstrual cycle, shorten the follicular phase period, and cause contracting of the overall cycle [6]. Literature reports show that

Table 1. Before voyage and before return from voyage, SCL-90 Questionnaire Test (N=71, X±SD)

Factors	One week before navigation	Navigation after three months	t Value	*P* Value
Somatization	1.41±0.27	2.01±0.74**	4.3756	P=0.0000
Obsessive-compulsive symptom	1.64±0.33	1.87±0.60	1.9295	P=0.0581
Interpersonal relationship sensitivity	1.40±0.23	1.67±0.49	2.8654	P=0.0056
Depression	1.43±0.57	1.72±0.71	1.8297	P=0.0720
Anxiety	1.03±0.21	1.50±0.56**	4.5144	P=0.0000
Hostility	1.33±0.42	1.53±0.61	1.5513	P=0.1258
Terror	1.22±0.21	1.33±0.45	1.2725	P=0.2078
Paranoia	1.28±0.27	1.66±0.64*	3.1426	P=0.0025
Psychoticism	1.26±0.17	1.37±0.40	1.4539	P=0.1509
Others	1.28±0.31	2.36±0.82**	7.0772	P=0.0000
Total scores	1.32±0.21	1.75±0.45**	4.9743	P=0.0000

*P < 0.05, **P < 0.01; Note: Others refer to the factor reflecting the sleep and diet status.

Table 2. Serum COR, TSH, FT3 and FT4 of female seamen were affected during long navigation (N=71, X±SD)

	One month before navigation	Navigation after three months	t Value	*P* Value
COR (ug/dl)	17.10±4.59	20.39±5.56*	2.5656	P=0.0127
TSH (mIU/L)	1.99±0.89	2.15±0.76	0.7854	P=0.4351
FT3 (pmol/L)	4.48±0.31	4.30±0.39*	2.0755	P=0.0420
FT4 (pmol/L)	11.89±1.24	11.49±0.95	1.4710	P=0.1462

*P < 0.05.

female naval soldiers have higher rate of mental disorders [7].

In the past, research was centred on male seamen, and it was rare to report on female seamen [8, 9]. This investigation is the first targeted research of multiple samples of female seamen. This voyage was the first time for female seamen to go to sea that lasted for 4 months.

Materials and methods

Participants

The study recruited 90 Chinese female seamen that went out to sea with a hospital ship during July through October 2013. We selected 71 female crewmembers in compliance with the standards of the study subjects. Participants were between 20 and 42 years-old (32.1±5.2) and lacked any endocrine disease, and did not they have pregnancy, abortion, contraception by drugs or genital organ lesion. They also did not have any applied hormone treatment nor received endocrine therapy in at least 1 year.

SCL-90 questionnaire test before voyage and return from voyage

Self-rating SCL-90 symptom scale is composed of 90 questions, including 10 sub-scales such as somatization, obsessive-compulsive symptom, depression and paranoia, with a 1-5 grade scoring system. Any score greater than 2 is considered abnormal. A centralized test was conducted to all female seamen 1 week before voyage and 1 month before return. The psychological health workers who were specially trained declared the instructions, and self-assessments were conducted on site.

Hormone determination

Venous blood was collected from participants on an empty stomach 3 days before their menstrual period and within 1 month before their voyage as well as 3 months following their voyage, and centrifuged for preparation of serum in order to test levels of cortisol (COR), thyrotropic hormone (TSH), Free T3 (FT3), Free T4 (FT4), serum immunoglobulin (IgA, IgG, IgM), and complement C3 and C4. The blood was preserved under -80°C.

Investigating menstruation change conditions during voyage

Investigation of menstruation conditions was conducted by way of combination of personal on-schedule record and questionnaire, which recorded menstruation conditions 1 month

Table 3. Serum PRL, FSH, LH, T and E2 of female seamen wereaffected during long navigation (N=71, X±SD)

	One month before navigation	The third month during the navigation	Three months after the navigation
PRL (ng/mL)	17.62±5.02	19.93±4.07*	17.87±4.99
FSH (mIU/mL)	6.18±1.71	4.67±1.00**	6.74±2.02
LH (mIU/mL)	4.64±1.28	3.31±1.21**	4.75±1.39
E2 (pg/mL)	47.47±10.23	40.01±13.12*	49.95±11.01
T (ng/dL)	31.20±5.90	34.32±11.99	34.90±14.80

*P < 0.05, **P < 0.01; Note: Compared prior to long endurance.

Table 4. Menstrual abnormalities were compared before and during long voyage, and 3 months after returning to harbour

	Before the navigation	During the navigation	After the navigation
Abnormal menstrual cycle	13 (18.5%)	28 (39.4%)**	16 (22.5%)
Menstrual cycle Reduced	6 (8.4%)	16 (22.5%)**	8 (11.2%)
Menstrual cycle Extended	4 (5.6%)	7 (9.8%)	3 (4.2%)
Menstrual cycle disorder	3 (4.2%)	5 (7.0%)	5 (7.0%)
Menstrual period Abnormal	6 (8.4%)	10 (14.8%)	8 (11.2%)
Dysmenorrhea	6 (8.4%)	11 (15.4%)	5 (7.0%)

**P < 0.01; Note: Compared before long endurance.

before the long voyage, 1 month before the return of the long voyage, and 3 months after voyage. Uniform questionnaires recorded menstrual cycle, duration, volume changes, reaction and abnormality conditions of the subjects, which are delimited according to the standard set by obstetrics and gynaecology.

Statistical analysis

The data were analysed with SPSS 18.0 software (SPSS Inc., Chicago). SCL-90 Questionnaire test and sexual hormone determination were expressed as mean ± SD and continuous variables were compared between groups by a Student t-test. Menstruation changes during voyage between groups were detected using a chi-square test (categorical variables) where P < 0.05 was considered statistically significant.

Results

Mental health assessment

There were 71 female seamen, with an average age of (32.1±5.2) years old. We detected no psychological diseases, and participants had no medical history of immune system and endocrine disorders before the voyage. SCL-90 (**Table 1**) was applied in the evaluation of mental health conditions and the evaluation of the mental behavioural disorder type and severity degree of the subjects. This research demonstrated that at the mental behavioural disorder of the seamen increased significantly after the long voyage than before (P < 0.01). Mental behavioural disorders expressed as somatization, anxiety, paranoia, and other factors demonstrated there was evident influence of long voyage on the mental health of seamen.

Thyroid hormone and cortisol of female seamen were affected during long navigation

We measured cortisol COR, thyrotropichormone TSH, FT3, and FT4 of venous blood within 1 month before voyage and within 1 month before returning to harbour. Results show FT3 levels after the long voyage was significantly lower than before long voyage (P < 0.01), and COR levels was significantly higher (P < 0. 01). The female seamen on the voyage also had slight, but not significant decrease in TSH (**Table 2**).

Serum PRL, FSH, LH, T, and E2 of female seamen were affected during long navigation

Table 3 shows that during a long navigation, FSH, LH, E2 decreased significantly compared to before a long navigation (P < 0.01). FSH, LH, E2 levels 3 months after returning to the harbour compared to that of before long navigation is slightly, but not significantly, higher (P > 0.05). However, PRL was significantly higher (P < 0.05). The current research demonstrated a decrease in the gonadotropin and oestrogen levels and an increase in the prolactin level after 3 months of a long voyage. These hormone level changes indicated there had been influences on reproductive endocrinology function.

Menstruation of female seamen was impacted during long voyage

The menstrual cycle refers to the period from the first day of the menstruation to the day

Table 5. Comparison of menstrual quantity of female seamen during and before long voyage (N=71)

	Before navigation case number (%)	During long voyage case number (%)	*P* Value
Menstrual quantity increased	5 (7.0%)	9 (12.7%)	0.26
Menstrual quantity decreased	6 (8.4%)	15 (12.6%)*	0.03
Change the number of people	8 (11.2%)	25 (21.1%)**	0.00

*P < 0.05, **P < 0.01.

Table 6. Effects of long voyage on female crew's serum IgA, IgG, IgM, complement C3, and complement C4 (X±SD, N=71)

	One month before the navigation	The third month during the navigation	*P* Value
IgA (g/L)	2.63±0.78	2.74±0.85	0.5858
IgG (g/L)	16.52±10.09	11.25±2.65**	0.0051
IgM (g/L)	1.13±0.68	1.04±0.28	0.4846
Complement C3 (g/L)	0.96±0.29	0.66±0.11**	0.0000
Complement C4 (g/L)	0.31±0.13	0.32±0.11	0.7370

**P < 0.01.

before the next menstruation. The menstruation period refers to the bleeding days in the menstruation. Abnormal menstrual cycle included reduced menstrual cycle, extended-menstrual cycle, and menstrual cycle disorder. **Table 4** shows personal self-reflection of menstrual disorder menstrual disorder increased significantly following the long voyage than before long voyage where 39.4% of women experienced abnormal menstrual cycle. The rate of abnormal menstruation period increased 11.8%. Menstrual status 3 months following long voyage approached that of before long voyage. Participants with abnormal menstrual cycle period during long voyage significantly increased than those before long voyage (P=0.01). Reduced menstrual cycle during long voyage significantly increased compared to before long voyage are obvious (P=0.02).

We compared menstrual quantity of female seamen before and during their long voyage. Results show that female menstrual quantity is significantly greater during long voyage than before long voyage. During long voyage, women's menstrual quantity change account for 21.1%, 12.6% of women menstrual quantity decreases (**Table 5**).

The immune system is affected due to the long voyage

Chronic stress has negative effects on immune function. The effect on a long voyage on female crew's serum IgA, IgG, IgM, Complement C3, and Complement C4 levels is shown in **Table 6**. Female crews after the long voyage had significantly reduced IgG and complement C3 levels compared to before the voyage (P < 0.05, P < 0.01, respectively).

Discussion

Impact of long voyage on psychology on female seamen

During long-term navigation at sea, the sailors, undergo tremendous mental load generally because of their special working environment and tense task. The cholinergic system in female's central nervous system has stronger stress reaction than males. Therefore, they are more liable to psychological stress under such special weather and environmental conditions at sea [10]. When responding to stress stimulation, females tend to show more intense anxiety and depression than males. According to the literature, female mariners suffer from higher mental disorder incidence than their male counterparts [7]. SCL-90 has been widely applied in the evaluation of the mental health conditions of various groups as well as in the evaluation of recent mental health conditions of subjects, and the mental behavioural disorder type and severity in subjects. Its reliability and validity are generally recognized. Consistent with the previous reports [11], our research demonstrates that the mental behavioural disorders of mariners are mainly expressed as somatization, anxiety, paranoia, and other factors, and that long voyages influence their mental health. Such adverse psychological stress poses multiple influences to body functions. Literature shows that the long voyage affects the mental health of seamen within 2 to 3 months after their navigation [12]. This shows that our investigation period during this long voyage is the exact high-incidence season when mental issues appear.

Impact of long voyage on physiology of female seamen

Stress is a kind of psychosomatic tension caused by an imbalance between the organism and their environment following intense stimulation to the organism. Research has discovered that the pathological characteristics of stress is oxidative stress, especially considering the mental impact [13]. Two essential neuro-endocrine channels in the neuro-endocrine network, which mainly trigger stress reactions, are activated by a stressor. One channel is the blue spot-norepinephrine neurons (LC-NE) axis, enabling the rapid increase in plasma catecholamine substances concentration. The second is the hypothalamus-pituitary-adrenal cortex (HPA) axis where activation can result in the increase of the secretion of adrenal cortical glucocorticoids inside the downstream target organs. Glucocorticoids are able to withstand harmful stimulation, and provide wide protection function for the organism. Some scholars discovered that the HPA axis function is increased in mentally stressed animals However, it occurs relatively slowly and persistent, which may be related to increases in mRNA expression of the CRH paraventricular nucleus of the hypothalamus [14]. Our research discovers that after long voyage, cortisol levels increases significantly ($P < 0.01$).

The thyroid gland is a very important endocrine organ that secretes multiple hormones and plays a very important role in regulating the growth and development of the organism, as well as in organ differentiation, basic metabolism, and genetic expression. In research such as Helmreich's, mental stress is imposed on mice through unavoidable electrical stimulation on their feet. It was discovered that plasma T3 and T4 levels decrease significantly after 15 days [15]. The female seamen in our study had slight decreases in TSH. However, these results lacked statistical significance. TSH is a major regulator of thyroid gland function. A decrease in TSH may be caused by glucocorticoids enhancing the hypothalamus and somatostatin and dopaminergic nerves prohibit TRH. This results in the decrease in TSH's reactivity to TRH. There are 3 possible reasons for T3 decrease. First, stress enhances glucocorticoids, which is a major responsive hormone in HPA, and can inhibit the secretion of TRH and TSH, as well as hinder the transformation from T4 to T3. This is closely related to the reduction of thyroid hormones, and T3 in particular is caused by long-term stress. Second, stress may result in the reduction of thyroid peroxidase and oxidase, especially the inhibition of 5'deiodinase, which makes TT3 and FT3 significantly lower than the normal physiological conditions [16].

The hypothalamic-pituitary-ovarian axis (HPO) is the neuro-endocrine system regulating the reproductive functions of females, and the hypothalamus secretes gonadotrophin-releasing hormone (GnRH), which regulates ovary function by adjusting the secretion of gonadotropin. In some research, animal models of psychological stress are established with constraint as the stressor to determine antimullerian hormone levels (AMH) in mice serum. It has been shown that psychological stress can result in the reduction of ovarian reserve function [17]. One study found that 89 cases of chronic psychological stress in women was harmful to ovarian reserve function [18]. Our current research demonstrates the decreases in gonadotropin and oestrogen levels, and increases in prolactin level following a three-month-voyage indicate there had been influences to reproductive endocrinology function. The major reason for the damages caused by the psychological stress to the reproductive endocrinology functions may lie in its influence on HPA hyperfunction. While HPA hyperfunction further inhibits the activity of the HPO axis, especially in the reduction of GnRH pulse onset of the central nervous system and the secretion of LH and FSH resulting in ovulation disorder and a series of endocrine disorders.

The loss of hypothalamus GnRH pulse secretion function is the most significant. This is because secretion activity of GnRH neurons is inhibited by very high endorphin and dopamine levels [19]. In addition, corticotrophin releasing hormone (CRH) does not only inhibit the secretion of gonadotropin, but also directly inhibits the synthesis of oestrogen in the ovaries. Stress conditions activate the PRL promotion system that increases PRL levels and is considered related to the regulation of 5-hydroxytryptamine. PRL is mainly synthesized and secreted by PRL cells in the pituitary gland, where an increase has inhibitory effect on the hypothalamic-hypophyseal-ovarian axis function. An increase in PRL can affect the neurons secretion rate of dopamine in the hypothalamus through shortcut feedback, thus, inhibiting the synthesis and release of GnRH [20].

Menstruation changes during long navigation

This study investigated the changes in menstruation before and after the long voyage. As shown in our results, many female seamen undergo menstruation changes during navigation, which is mainly expressed in the reduction of menstruation volume and shortened menstrual cycles. Compared with the psychological scale, it was found that the female seamen whose menstruation changes are positively correlated to abnormality in mental scales [21]. Menstruation disorder mechanism is relatively complicated, and psychological and mental stresses affect the regulation function of the HPO axis resulting in the reduction of sexual hormones or secretion rhythm disorder, which may lead to the menstruation disorder. Alloswoah [22] carried out research on healthy married women and found that the shortening of menstrual cycles for females with high intensity work were twice than that of females with low intensity work, and may shorten the menstrual cycle by 1 day on average. Stress also results in the increase in incidence of dysmenorrhea. This research measured hormone level of female seamen 3 months after their voyage. We discovered that they were restored to normal and that their menstruation conditions had were also restored to normal. It is indicated that such HPO suppression states can be recovered after removal of stressor. This indicates the influence of vessel environment to reproductive endocrinology on female seamen is functional changes instead of physical damage.

The immune system is affected during long voyage

Mental stress may affect the immune system. During stress, neuroendocrine-immune reaction is the result of organism regulation, and there is close relationship between the immune system and the neuroendocrine system. They not only generate large volumes of informational molecules, but also regulate or execute functions through close interaction with these molecules. We discovered IgG and complement C3 had decreased in different degrees. Immunoglobulin is the globulin protein with immune function, capable of specific integration with antigen secreted by B cells after they are stimulated by antigens. Immunoglobulin is an important product for humoral immune response mediated by B cells and the concentration of immunoglobulin is one of the important indexes suggesting humoral immunity status. According to psychoneuroimmunology research, psychological stress can change the immune capacity of an organism by influencing the central nervous system and endocrine system [23]. Chronic stress has retardant effects on immune function; long term mental health disorder and negative emotion experience have a larger influence to immune function of organism [24]. Research by Maattanen show that sIgA secretion increases under low working pressure conditions, and decreases after strong working pressure. sIgA level is related to disease resistance, and lower sIgA may lead to health damages [25]. Gao's [26] study found that stress affects humoral immunity and concludes that stress intensity may lead to a decrease in humoral immunity response capacity. The mechanism wherein stress influences antibody reaction is very complicated, and research indicates that stress is negatively correlated with antibody reaction. Earlier research regard that the mechanism may be related to the HPA axis and sympathetic nervous system [27]. Other scholars also discovered that Prolactin have influences to B cell function. Saha's research concluded that sustained increased in serum prolactin level can interfere with B cells immune tolerance, mainly through damages to BCR (B cell receptor) mediated cloning deletion to eliminate the receptor. This reduces the activation threshold of B cells without activity, and promotes their autoreaction [28]. As to the mechanism of C3 reduction, it is not clear yet. Some research indicates that emotions may affect changes of immune response. Chronic stress may suppress immune function, and social support may buffer this effect. Some psychological social intervention may improve immune functions [29].

Conclusions

This investigation discovered that a long voyage has certain influence to the neuro-endocrine and humoral immunity system of female seamen. As the navy develops, the demands for female seamen are increasing. Therefore, the mental health of female seamen under special working environments is important so that they are able to perform better.

Acknowledgements

This study was supported by Army Logistics Scientific Research Projects in China (No: CHJ11J015).

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Lei Chen, Department of Obstetrics and Gynecology, Navy General Hospital, 6 Fucheng Road, Haidian District, Beijing 100048, China. Tel: 86-10-66958114; Fax: 86-10-66958114; E-mail: chenleinavy@sina.com

References

[1] Yadav AP, Chaturvedi S, Mishra KP, Pal S, Ganju L, Singh SB. Evidence for altered metabolic pathways during environmental stress: (1) H-NMR spectroscopy based metabolomics and clinical studies on subjects of sea-voyage and Antarctic-stay. Physiol Behav 2014; 135: 81-90.

[2] Chrousos GP, Gold PW. The concepts of stress and stress system disorders. Overview of physical and behavioral homeostasis. JAMA 1992; 267: 1244-1252.

[3] Lawrence-Brown M, Stanley BM, Sun Z, Semmens JB, Liffman K. Stress and strain behaviour modelling of the carotid bifurcation. ANZ J Surg 2011; 81: 810-816.

[4] Chaplin TM, Hong K, Bergquist K, Sinha R. Gender differences in response to emotional stress: an assessment across subjective, behavioral, and physiological domains and relations to alcohol craving. Alcohol Clin Exp Res 2008; 32: 1242-1250.

[5] Guilloux JP, Seney M, Edgar N, Sibille E. Integrated behavioral z-scoring increases the sensitivity and reliability of behavioral phenotyping in mice: relevance to emotionality and sex. J Neurosci Methods 2011; 197: 21-31.

[6] O'Connor KA, Brindle E, Shofer J, Trumble BC, Aranda JD, Rice K, Tatar M. The effects of a long-term psychosocial stress on reproductive indicators in the baboon. Am J Phys Anthropol 2011; 145: 629-638.

[7] Freeman MD, Woodruff SI. Incidence and predictors of mental health hospitalizations in a cohort of young U.S. Navy women. Mil Med 2011; 176: 524-530.

[8] Hjarnoe L, Leppin A. Health promotion in the Danish maritime setting: challenges and possibilities for changing lifestyle behavior and health among seafarers. BMC Public Health 2013; 13: 1165.

[9] Kingdom SE, Smith AP. Combined effects of work-related stress in Her Majesty's Coastguard (HMCG). Int Marit Health 2012; 63: 63-70.

[10] Nielsen MB, Bergheim K, Eid J. Relationships between work environment factors and workers' well-being in the maritime industry. Int Marit Health 2013; 64: 80-88.

[11] Carotenuto A, Fasanaro AM, Molino I, Sibilio F, Saturnino A, Traini E, Amenta F. The Psychological General Well-Being Index (PGWBI) for assessing stress of seafarers on board merchant ships. Int Marit Health 2013; 64: 215-220.

[12] Lu Y, Gao Y, Cao Z, Cui J, Dong Z, Tian Y, Xu Y. A study of health effects of long-distance ocean voyages on seamen using a data classification approach. BMC Med Inform Decis Mak 2010; 10: 13.

[13] Kovacic P, Thurn LA. Cardiovascular toxicity from the perspective of oxidative stress, electron transfer, and prevention by antioxidants. Curr Vasc Pharmacol 2005; 3: 107-117.

[14] Samad N, Perveen T, Haider S, Haleem M, Haleem DJ. Inhibition of restraint-induced neuroendocrine and serotonergic responses by buspirone in rats. Pharmacol Rep 2006; 58: 636-642.

[15] Helmreich DL, Parfitt DB, Lu XY, Akil H, Watson SJ. Relation between the hypothalamic-pituitary-thyroid (HPT) axis and the hypothalamic-pituitary-adrenal (HPA) axis during repeated stress. Neuroendocrinology 2005; 1: 183-192.

[16] Koyu A, Cesur G, Ozguner F, Akdogan M, Mollaoglu H, Ozen S. Effects of 900 MHz electromagnetic field on TSH and thyroid hormones in rats. Toxicol Lett 2005; 157: 257-262.

[17] Yao Y, Yao QQ, Pan XL, Xu LQ, Zheng YH. Correlation between Psychological stress and decrease in ovarian store. Acta Academiae Medicinae Jiangxi 2012; 52: 11-16.

[18] Pal L, Bevilacqua K, Santoro NF. Chronic psychosocial stressors are detrimental to ovarian reserve: a study of infertile women. J Psychosom Obstet Gynaecol 2010; 31: 130-139.

[19] Roelfsema F, Veldhuis JD. Thyrotropin secretion patterns in health and disease. Endocr Rev 2013; 34: 619-657.

[20] Whirledge S, Cidlowski JA. Glucocorticoids, stress, and fertility. Minerva Endocrinol 2010; 35: 109-125.

[21] Myznikov IL, Askerko NV, Ustimenko LI, Miloshevich IuR, Volkova LV, Sadchenko SN, Matochkina AA. Health status of female soldiers serving in the Northern Fleet. Voen Med Zh 2013; 334: 59-64.

[22] Allsworth JE, Clarke J, Peipert JF, Hebert MR, Cooper A, Boardman LA. The influence of stress on the menstrual cycle among newly in-

carcerated women. Womens Health Issues 2007; 17: 202-209.
[23] Cocco C, Brancia C, D'Amato F, Noli B. Pituitary gonadotropins and autoimmunity. Mol Cell Endocrinol 2014; 385: 97-104.
[24] Jeckel CM, Lopes RP, Berleze MC, Luz C, Feix L, Argimon II, Stein LM, Bauer ME. Neuroendocrine and immunological correlates of chronic stress in 'strictly healthy' populations. Neuroimmunomodulation 2010; 17: 9-18.
[25] Määttänen I, Keltikangas-Järvinen L, Swan H, Toivonen L, Kontula K, Hintsanen M, Alatupa S, Hintsa T. Stress proneness in molecularly defined long QT syndrome: a study using temperament assessment by behavioural inhibition system scale. Stress Health 2013; 29: 150-155.
[26] Gao YH, Yu QL, Tian YP, Dong ZN, Hu JC, Wen XY, Gao B, You CB, Yu QJ. Effects different work environment on the immune function of naval personnel. Med J Chin PLA 2008; 33: 226-228.
[27] Tsartsali L, Papadopoulos M, Lagona E, Papadimitriou A, Kanaka-Gantenbein C, Louizou E, Kastania A, Priftis KN, Chrousos G. Association of hypothalamic-pituitary-adrenal axis-related polymorphisms with stress in asthmatic children on inhaled corticosteroids. Neuroimmunomodulation 2012; 19: 88-95.
[28] Saha S, Gonzalez J, Rosenfeld G, Keiser H, Peeva E. Prolactin alters the mechanisms of B cell tolerance induction. Arthritis Rheum 2009; 60: 1743-1752.
[29] Costa-Pinto FA, Palermo-Neto J. Neuroimmune interactions in stress. Neuroimmunomodulation 2010; 17: 196-199.