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Original Article

Sex-related differences in heart rate variability and static body stability in military personnel under stressful conditions

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Abstract.
The study focused on examining sex-related differences in the functioning of the autonomic nervous system and static balance performance in operational-level military personnel under stressful conditions. A total of 63 participants were involved, including 33 men (mean age 33.6 ± 1.8 years) and 30 women (mean age 33.1 ± 2.2 years). The objective was to identify and characterize sex differences in the autonomic nervous system's response to stress and muscle tone in military personnel. Methods: A systematic review of scientific publications performed, using heart rate variability analysis, computerized stabilography, and nonparametric statistical techniques. Results: The HRV analysis revealed statistically significant differences ($p \leq 0.05$) between men and women. It was found that 66.7 % of men and 63.3 % of women exhibited a high stress index, significantly exceeding physiological norms. Additionally, the median stress index value for women was statistically significantly higher ($p < 0.05$). A comparative analysis of spectral variability parameters revealed notable sex differences. Men showed higher overall power ($p < 0.01$), greater power in the low-frequency ranges, and an increased mean interval between heartbeats ($p < 0.05$). The analysis of the stress index revealed that 36.4% of servicemen had a low level of stress, while among servicewomen this figure was much lower and amounted to only 23.3 %. Women were more likely to demonstrate high (43.4 %) and moderate levels of stress (23.3 %). Despite the fact that women showed higher levels of stress index based on HRV, there was a paradoxical tendency for women to perform better in static balance tests and no negative impact on coordination abilities. Our results indicate a potential sex specificity of stress response, which is manifested in the ability of women to more effectively compensate for the physiological effects of stress through neuroplastic and other adaptive mechanisms. This is confirmed by statistically significant differences ($p < 0.05$; $p < 0.01$) in several parameters, such as COP length, mean velocity of the COP, sway angle variation, and 95 % confidence ellipse area. Women also demonstrated better stability in maintaining a static body position, as evidenced by a decreased COP length. Although not all parameters showed statistically significant differences, the general trend indicates a higher quality of balance function in women, in particular, more adequate compensation for balance disturbances. Conclusion. It was found that men and women demonstrate different physiological responses to stress that are evidenced from the HRV parameters and static balance performance.
Keywords: autonomic nervous system, coordination abilities, stress, officers.

Introduction.

Resistance to stress, speed of decision-making, ability to act flexibly in critical situations, leadership skills, special practical skills such as medical care, firearms training, and survival in extreme conditions are essential for successfully completing military tasks (Shynkaruk, et al.) In the context of modern military conflicts, there is a growing trend of increased stress levels among military personnel, which significantly impacts their physiological and psychological resilience and their ability to perform combat missions (Johnson, 2021; Smith et al., 2019). Despite extensive research on the physical preparedness of military personnel (Yarmak et al., 2023-2024), the comprehensive study of the physical and psychological aspects of stress in a military environment remains under-researched.

The study of heart rate variability (HRV) as an indicator of the body's adaptive capacity is an important tool for assessing stress resistance and overall health in military personnel. Although it is known that there are specific physiological differences between men and women (Apykhtin et al., 2023), research on specific aspects of HRV in military personnel under stressful conditions remains underdeveloped. The studies (Yarmak et al., 2024) involving operational-level officers of both sexes have shown that both servicemen and servicewomen under martial law have a more pronounced sympathetic activation, which is reflected in a decrease in HRV parameters, but a comparative analysis of sex differences in the autonomic nervous system's response to stress was not conducted. Although there is a substantial body of research on the stress response in military personnel,

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sex-specific differences remain understudied. In order to optimize physical training programs, it is crucial to consider sex-based variations in HRV, given its strong association with static balance, which is a key aspect of physical fitness. HRV reflects the interplay between the sympathetic and parasympathetic nervous systems, directly impacting muscle tone and balance. Existing research suggests that HRV can differ between sexes. Several studies (Bakusov, 1998; Ramaekers, 1998; Yabluchanskyi, 2004) have highlighted these disparities. One study (Yabluchanskyi, 2004) specifically noted qualitative differences between sexes in HRV and systemic arterial pressure. Another study (Ramaekers, 1998) introduced sex differences in HRV as a new finding, suggesting that the lower sympathetic tone observed in women may be an adaptive response to reduce the risk of arrhythmias. Analysis of data from several non-invasive HRV studies revealed that women exhibit predominantly high-frequency heart rate modulation. In contrast, men exhibit predominantly low-frequency heart rate modulation during resting conditions (Kuch et al., 2001). Shvets' (2020) findings corroborate the hypothesis that there are sex-specific differences in the physiological mechanisms underlying stress responses. Women exhibit heightened sensitivity to stress, as evidenced by increased HRV, suggesting new avenues for exploring the neurobiological underpinnings of stress. The studies (Yarmak et al., 2024) have shown that static balance is an important indicator of the physical fitness of military personnel and can be significantly altered by various factors, particularly stress, especially in individuals with different autonomic regulations. As noted by the authors (Kounalakis et al., 2024), the physiological ability to maintain a static balance is crucial for military and law enforcement personnel. It directly affects shooting accuracy and the overall performance of official duties, increasing the chances of survival in extreme situations. The results reported by Nourizadeh et al. (2019) provide important information about the relationship between static balance, endurance of the core muscles, and shooting performance. Thus, the above data emphasize the relevance of the chosen research topic and indicate the importance of understanding the physiological mechanisms underlying the body's adaptation to stressful conditions in different sex groups of military personnel. Our study will expand the knowledge of sex differences in stress response based on HRV and static balance indicators. The results will help to improve military personnel's training, increase the effectiveness of recovery, and develop programs for preventing the adverse effects of stress under battlefield conditions. An individual approach to military personnel based on sex-related characteristics will optimize the training process and ensure maximum special (military) physical training effectiveness.

Materials and methods

Study participants. The study involved 63 Ukrainian Land Forces officers aged 30÷35 years (mean age: 33.4 ± 2.1 years). Participants were selected randomly from operational-level officers and met the following inclusion criteria: at least 10 years of military service, absence of chronic cardiovascular diseases, acute respiratory and infectious diseases, and informed consent. The sample comprised 33 men (mean age: 33.6 ± 1.8 years) and 30 women (mean age: 33.1 ± 2.2 years).

Study Design. HRV analysis was employed to assess the functional state of the autonomic nervous system in both male and female military personnel. Non-invasive electrocardiogram recordings followed by mathematical analysis of RR intervals allowed for a quantitative evaluation of the balance between sympathetic and parasympathetic activation. By examining HRV metrics, we can better understand the body's stress response and adaptive mechanisms. The 5-minute electrocardiographic recordings were obtained using a multifunctional MPFI Rhythmograph-1 device and EasyHRV software by international standards. The research protocols derived from the male and female subjects are shown in Figures 1 and 2.

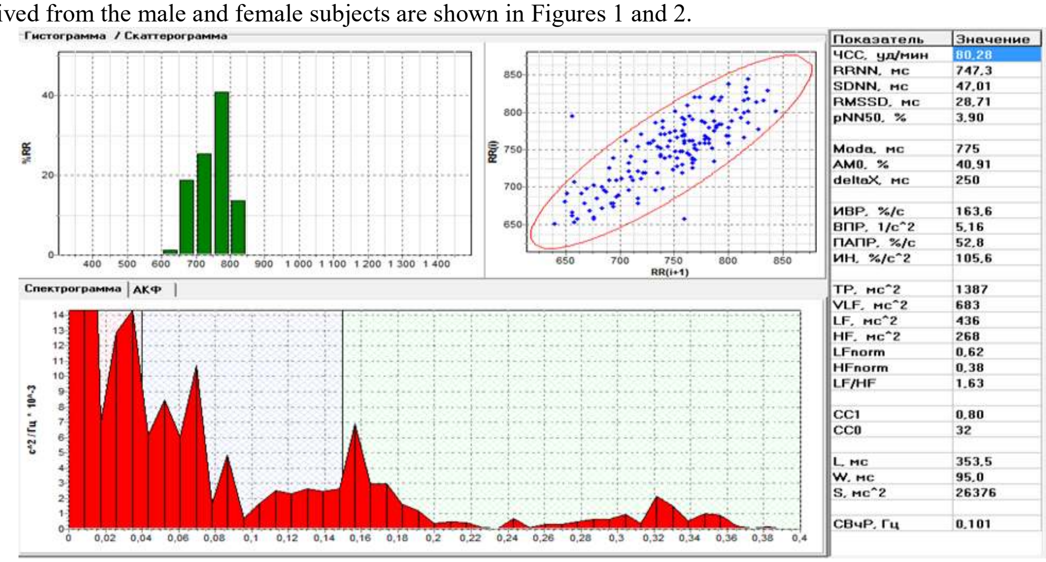

Fig. 1. Study Protocol of Heart Rate Variability in Female Military Personnel

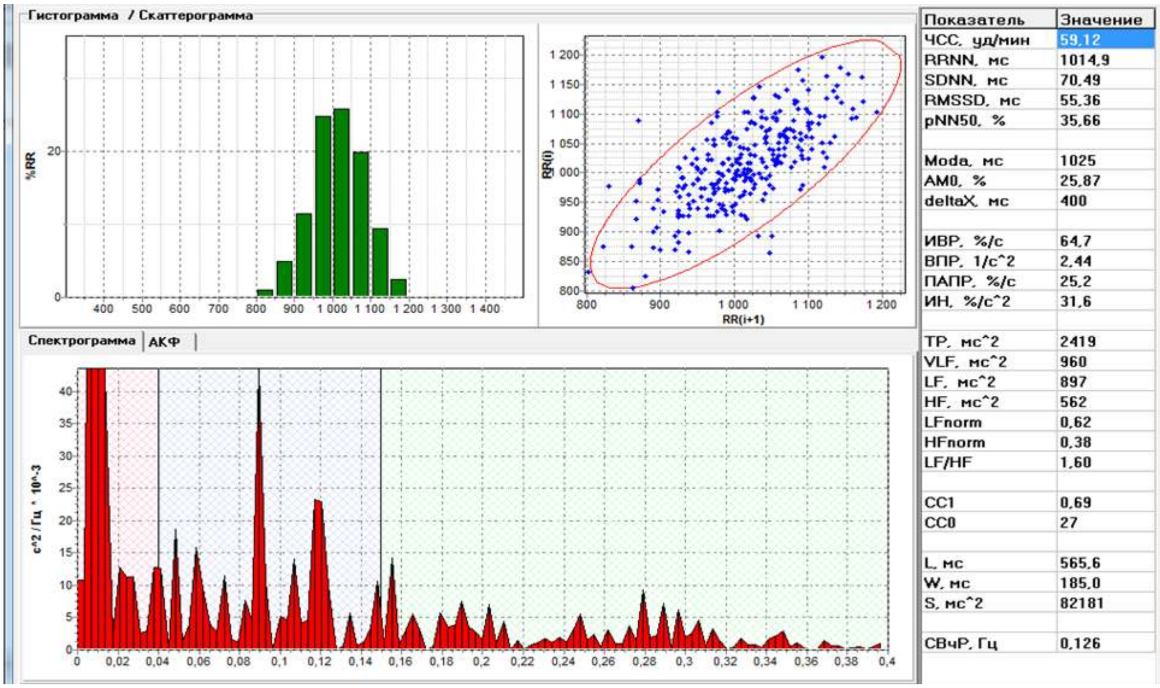

Fig. 2. Study Protocol of Heart Rate Variability in Male Military Personnel

In order to ensure standardized conditions for the study, the participants were placed in a quiet room with an air temperature of +22÷24°C. During the ECG recording, participants were sitting with their backs and legs supported to minimize the impact of physical activity on the measurements. The HRV study was performed in the morning from 9:00 to 12:00 am.

For a comprehensive assessment of the autonomic regulation of the cardiovascular system, the temporal and spectral analysis of HRV was conducted. The following parameters were calculated: the mean heart rate (HR), standard deviation of RR intervals (SDNN), root mean square of successive RR interval differences (RMSSD), percentage of successive intervals differing by more than 50 ms (pNN50), mode of RR intervals (Mo), mode amplitude (AMo), variation range (VR), stress index (SI), autonomic balance index (ABI), autonomic rhythm index (ARI), index of adequacy of regulation processes (IARP), and total power of spectral analysis. Spectral analysis was performed in very low, low, and high frequency ranges to assess the activity of different parts of the autonomic nervous system.

Based on HRV parameters, the stress index (arb. un.) was calculated by the formula:

Stress index = AMo × Mo / 2 × MxDMn,

where: Mo (ms) is the most frequent RR interval; AMo (%) is the mode amplitude in percent; and MxDMn (ms) is the variation scope reflecting degree of RR interval variability. The evaluation of the results was conducted using a categorical scale. A low level was defined as values of 56.36 arbitrary units or below, while values between 56.37 and 64.79 arbitrary units indicated a level below moderate. 64.80-81.64 arbitrary units characterized the moderate level. Values from 81.65 to 90.06 arbitrary units were classified as above moderate, and the high level corresponded to values exceeding 90.06 arbitrary units.

We used the Stabilis software hardware complex to assess the static balance manufactured by Aster-ITI LLC, Kharkiv, Ukraine. This diagnostic complex allows us to automatically record and analyze body movements during balance tests in a standing position with feet together with eyes open or closed. This method, developed on principles described by Kochina M. and Kaminsky A., ensured the high accuracy of the data obtained. According to the obtained protocol for the study of static spatial balance of military personnel, we analyzed the following: total motor activity during the balance test; ability to maintain static balance; degree of instability and variability of body movements; presence of cyclic components in movements; main frequencies characterizing the movements of the center of pressure (COP). The static postural stability test protocols for male and female subjects are illustrated in Figures 3 and 4.

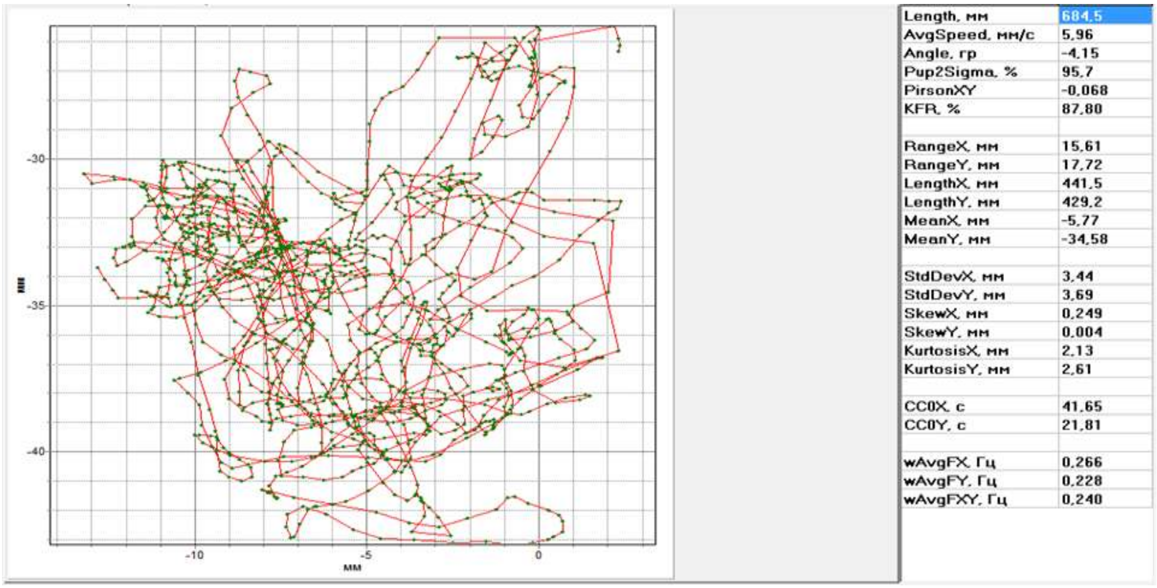

Fig. 3. Protocol for the Assessment of Static Postural Stability with Eyes Closed in Female Military Personnel

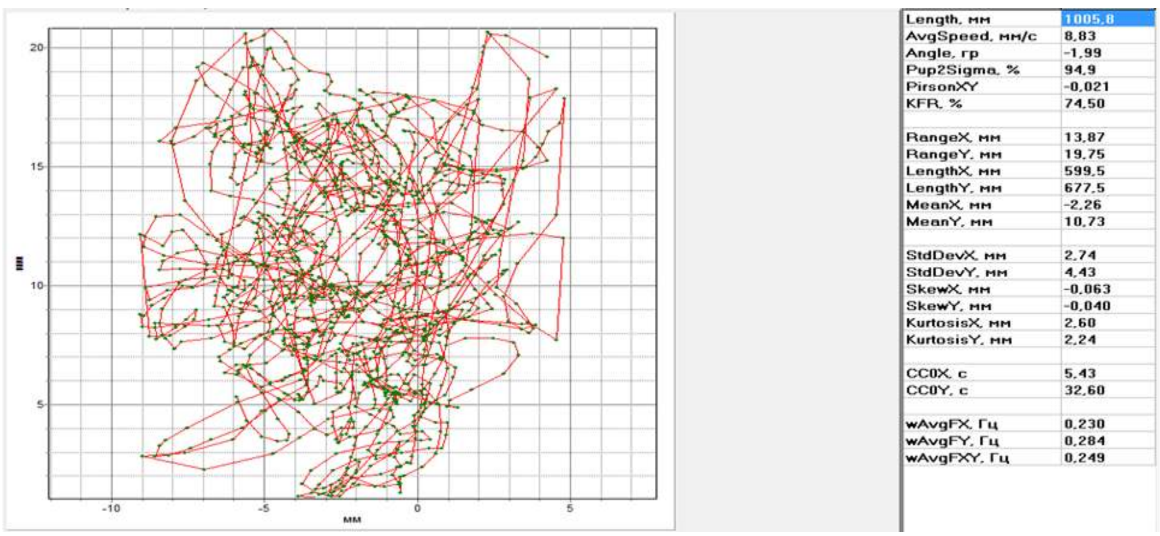

Fig. 4. Protocol for the Assessment of Static Postural Stability with Eyes Closed in Male Military Personnel

Data Analysis. Data analysis was conducted using Statistica 10.0 software. The Shapiro-Wilk test was applied to assess the normality of the data distribution. Given the non-normal distribution of the data, the non-parametric Mann-Whitney U-test was employed to compare independent groups. Multivariate analysis of variance (MANOVA) was utilized to evaluate the simultaneous impact of multiple factors on the dependent variable. Statistical significance was set at the conventional $\alpha = 0.05$ level. The results were reported as median and interquartile range to accommodate the non-normal distribution, which are robust measures of central tendency and variability for non-normally distributed data.

Results

The study was undertaken to analyze HRV parameters to explore sex-based differences (n=63). The results are summarized in Table 1.

The HRV analysis uncovered statistically significant gender disparities ($p < 0.05$). Specifically, women exhibited lower median values for the SDNN parameter than men, suggesting a reduced overall HRV in women, potentially indicating decreased adaptability of the cardiovascular system to various stressors and environmental changes.

Table 1. Results of the temporal analysis of heart rate variability in military personnel (n = 63)

Parameters	Men (n=33)			Women (n=30)			p
	Statistics						
	Me	25 %	75 %	Me	25 %	75 %	
Heart rate (bpm)	76.4	69.0	85.7	73.7	71.7	82.6	1.00
RRNN (ms)	785.4	700.2	869.8	814.5	726.3	836.5	0.79
SDNN (ms)	38.6	30.6	67.3	35.8*	28.3	42.2	0.02
RMSSD (ms)	24.9	16.8	36.7	26.5	17.6	35.3	0.12
pNN50 (%)	4.8	0.9	16.9	3.6	0.6	12.9	0.15
Moda (ms)	750.0	675.0	875.0	825.0	725.0	825.0	0.64
AMo (%)	46.2	29.5	52.5	47.4*	42.7	59.9	0.04
deltaX (ms)	250.0	200.0	350.0	200.0	200.0	250.0	0.10
ABI (%)	207.0	79.6	257.4	237.1	170.9	299.2	0.42
ARI (s^{-2})	5.0	3.5	7.4	6.1	4.9	7.4	0.95
IARP (%)	57.6	35.8	72.3	60.0	51.8	80.2	0.21
SI (arb.un.)	125.1	53.3	180.8	150.0*	103.6	206.4	0.05
WMFr (Hz)	0.11	0.09	0.13	0.11	0.09	0.14	0.89

Note. Statistically significant differences between males and females in the time-domain parameters of heart rate variability were identified using the Mann-Whitney U test for independent samples (*$p < 0.05$).

Statistically significant differences ($p<0.05$) between men and women were observed in the mode amplitude (AMo) and indicate that in women, most cardiac cycles have the same duration, which is typical for situations where the sympathetic nervous system dominates the parasympathetic one. It is worth noting that in women, heart rate is less affected by the processes of relaxation and recovery.

It is important to note that not all parameters exhibited statistically significant sex differences. Notably, no significant difference was observed in median heart rate (HR) between male and female participants, suggesting similar levels of sympathetic nervous system activation across groups.

There were also no statistically significant differences ($p>0.05$) between the sex groups in such parameters as RRNN, RMSSD, pNN50, mode of RR intervals, deltaX, ABI, ARI, IARP, and weighted mean frequency of rhythmogram (WMFr). These indicators provide a comprehensive assessment of HRV, encompassing overall cardiac activity as well as short- and long-term fluctuations linked to the functioning of the sympathetic and parasympathetic divisions of the autonomic nervous system. A comparative analysis of time-domain parameters revealed no statistically significant differences in most variables between male and female participants, suggesting a comparable level of HRV in both groups. Despite observed gender-specific variations, the fundamental regulatory mechanisms of heart rate in military personnel demonstrated consistency across both sexes. In our study, we paid special attention to the stress index (SI), which is quite informative for assessing autonomic balance, since it reflects the degree of influence of the sympathetic nervous system on the heart rate. It is well known that the higher the value of the stress index, the greater the influence of the sympathetic nervous system and, accordingly, the higher the level of physiological stress.

Figure 5 shows the distribution of individual values of stress index in military personnel.

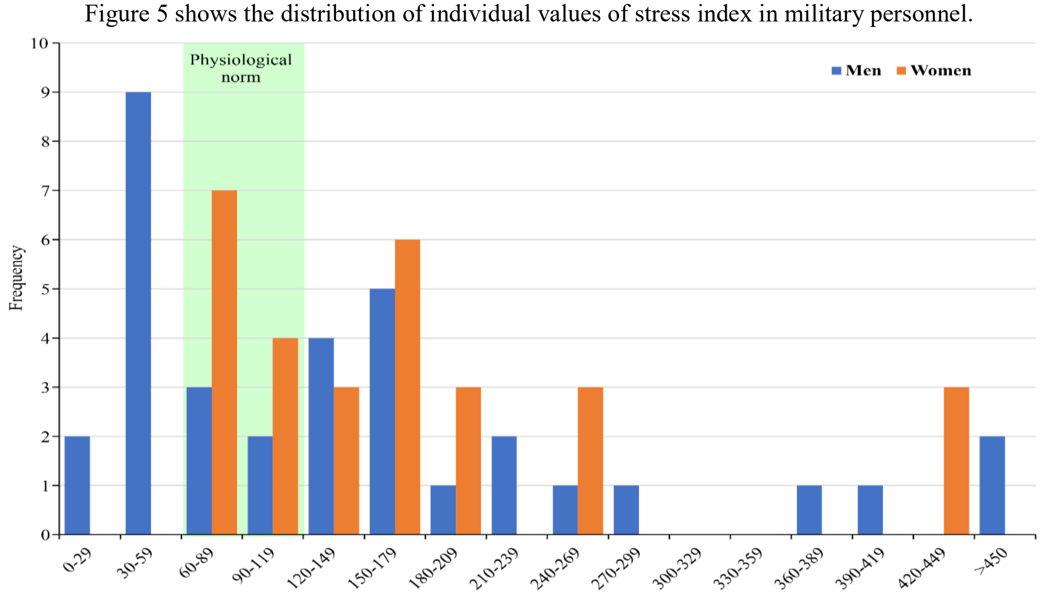

Fig. 5. The distribution of individual values of stress index in military personnel

The analysis of SI values revealed a significant excess of physiological norms (60-120 arb. un.) in both sex groups, moreover, this parameter was statistically significantly ($p<0.05$) higher in women. We also found a significant variation in individual SI values, especially in men, where the maximum value of the stress index reached 701.8 arb. units, and the minimum was 13.2 arb. units. However, the analysis results also demonstrated an increased level of stress in women, for them the range of SI values was somewhat narrower compared to men and ranged from 67.7 arb. units to 430.3 arb. units.

When comparing the individual SI values of service persons with the physiological norms, we found the following distribution. Among male participants, 18.1% exhibited moderate stress levels within the physiological range (60-120 arbitrary units), 15.2% displayed low stress levels (below 60 arbitrary units), and 66.7% demonstrated high stress levels (130-701 arbitrary units). In contrast, female participants showed a different distribution, with 36.7% exhibiting moderate stress levels and 63.3% displaying high stress levels.

When comparing the HRV spectral parameters presented in Table 2, a large number of statistically significant differences ($p<0.05$; $p<0.01$) were found between the sex groups.

Table 2. Results of spectral analysis of heart rate variability in military personnel (n = 63)

Parameter	Men (n=33)			Women (n=30)			p
	Statistics						
	Me	25 %	75 %	Me	25 %	75 %	
TP (ms^{-2})	910.0	628.0	2509.0	777.0**	398.0	1067.0	0.01
VLF (ms^{-2})	419.0	239.0	819.0	349.0*	186.0	555.0	0.02
LF (ms^{-2})	342.0	248.0	775.0	256.0*	108.0	472.0	0.04
HF (ms^{-2})	157.5	88.0	441.0	135.0*	79.0	192.0	0.03
LFnorm (arb.un.)	0.67	0.60	0.78	0.66	0.57	0.83	0.86
HFnorm (arb.un.)	0.34	0.22	0.40	0.34	0.17	0.43	0.86
LF/HF	2.02	1.53	3.50	1.92	1.33	4.91	0.67
L (ms)	353.5	282.8	494.9	282.8*	252.8	331.5	0.05
W (ms)	105.0	75.0	155.0	85.0*	65.0	125.0	0.05

Note. Significant differences between men and women by the non-parametric Mann-Whitney test for independent samples based on the results of spectral parameters of HRV *$p<0.05$; **$p<0.01$

A comparative analysis of the data demonstrated that men statistically significantly differ from women in several HRV indicators (Table 2). Men exhibited higher values of total power (TP) ($p<0.01$), power in the VLF and LF ranges ($p<0.05$), as well as a longer mean interval between heartbeats (L) and a broader spectral peak (W) ($p<0.05$).

The findings reveal statistically significant gender differences ($p < 0.05$, $p < 0.01$) in autonomic nervous system regulation. Specifically, men exhibited significantly higher LF values than women, suggesting a more pronounced physiological response to various stimuli.

However, the increased HF in the group of men is associated with the activation of the parasympathetic nervous system, which is responsible for the body's recovery and maintaining homeostasis. Our findings indicate a predominance of sympathetic activity in men, as evidenced by higher low-frequency HRV (LF) levels. Conversely, an elevated high-frequency (HF) component in men might suggest an atypical stress response. It is essential to acknowledge that individual physiological responses can vary significantly due to factors such as genetics, lifestyle, and health status.

We did not observe statistically significant gender differences in normalized low-frequency power (LFnorm), normalized high-frequency power (HFnorm), or the LF/HF ratio ($p > 0.05$). This suggests that the balance between the sympathetic and parasympathetic nervous systems may not differ significantly between men and women in our study group, at least based on these specific parameters. However, the observed predominance of sympathetic activity in women, as reflected by higher LF values, indicates a potential state of increased stress.

Military personnel are frequently exposed to high-stress levels, which can negatively impact overall health and job performance, particularly among operational-level officers. Studying the level of stress in different sex groups of military personnel provides important data for developing effective psychological support programs. Therefore, in our study, we calculated the stress index based on the temporal parameters of HRV, and the results are graphically presented in Figure 6.

In the studied group of service persons, statistically significant differences ($p<0.05$) between the men and women were observed in the stress index values. Women demonstrated higher stress index values, particularly in high and moderate levels, while the same number of men, i.e., 36.4%, fell into the low and high levels category.

These results may be related to various factors, including physiological characteristics of the female body, the combination of military service, and family responsibilities.

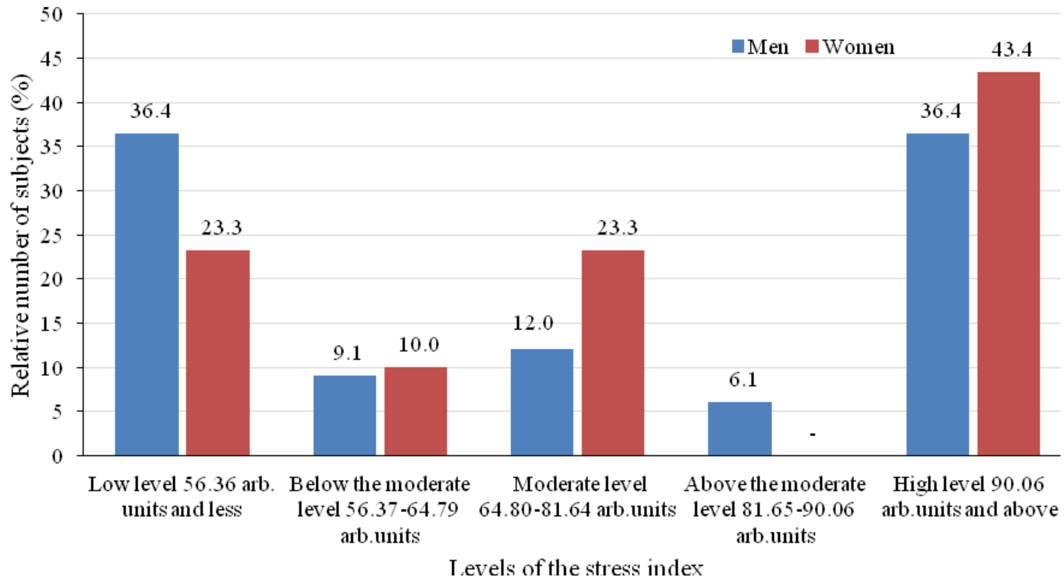

Fig. 6. Distribution of military personnel of both genders by stress index levels

The next step was to study the static body balance of service persons; the results of the eyes open balance test are presented in Table 3.

It is worth noting that sex-related differences in static balance are a rather complex issue that has not yet been thoroughly studied. This issue is especially relevant to military personnel, particularly operational-level officers, whose vocational activity is associated with a significant impact of stress factors. This parameter is critically important for military personnel, especially those who perform tasks under extreme conditions.

Table 3. Results of the eyes open static balance test for military personnel (n=63)

Parameter	Men (n=33)			Women (n=30)			p
	Statistics						
	Me	25 %	75 %	Me	25 %	75 %	
Length (mm)	701.8	639.6	825.7	684.0	561.7	739.6	0.13
AvgSpeed ($mm \cdot s^{-1}$)	6.4	5.7	7.3	5.4	5.0	7.1	0.12
Angle (degree)	4.3	-1.9	13.1	-6.1*	-23.5	15.3	0.02
Pup2Sigma (%)	94.3	92.8	95.1	93.6	93.4	95.8	0.68
RangeX (mm)	13.7	11.9	15.6	10.8	10.0	13.7	0.04
RangeY (mm)	19.8	13.8	19.7	15.4*	15.2	23.0	0.02
LengthX (mm)	472.8	388.6	552.0	392.2	332.2	424.0	0.23
LengthY (mm)	449.7	411.1	502.7	396.7	356.2	446.2	0.18
SkewX (mm)	0.01	-0.06	0.17	0.08	-0.09	0.17	0.39
SkewY (mm)	0.06	-0.20	0.18	0.11	-0.09	0.52	0.11
KurtosisX (mm)	2.4	2.2	2.7	2.5	2.2	2.6	0.34
KurtosisY (mm)	2.5	2.3	2.7	2.4	2.3	2.8	0.35
wAvgFX (Hz)	0.27	0.230	0.322	0.274	0.235	0.297	0.42
wAvgFY (Hz)	0.230	0.200	0.254	0.220	0.16	0.235	0.19
wAvgFXY (Hz)	0.242	0.221	0.284	0.221	0.203	0.252	0.09
KFR, %	85.9	81.0	88.6	90.1	82.0	91.9	0.21

Note. Significant differences between men and women by non-parametric criterion for independent samples of Mann-Whitney tests based on the results of eyes open static balance tests, * $p < 0.05$

An analysis of the data presented in Table 3 reveals a lack of statistically significant differences between men and women across most measured parameters. Consequently, the hypothesis proposing significant sex-related disparities in static balance performance within service members, particularly those at the operational level, can be dismissed. However, it is worth noting that our results can only indicate that under standard testing conditions, without any external influences, men and women have stable statokinetic balance.

Our next step was to compare the static body balance in men and women in a balance test with the eyes closed. The stress associated with performing the task with the eyes closed may affect men and women differently, as reflected in the results presented in Table 4.

Table 4. Results of the eyes closed static balance test for service persons (n=63)

Parameter	Men (n=33)			Women (n=30)			p
	Statistics						
	Me	25 %	75 %	Me	25 %	75 %	
Length (mm)	1247.7	1048.5	1640.4	1037.2**	812.8	1336.8	0.01
AvgSpeed (mm·s^{-1})	11.3	9.5	15.0	9.3*	7.4	11.6	0.05
Angle (degree)	0.7	-9.6	8.9	2.9*	-9.8	22.5	0.05
Pup2Sigma (%)	92.8	92.1	93.4	93.5*	92.1	94.6	0.05
RangeX (mm)	18.0	15.8	21.4	14.9*	11.8	17.9	0.02
RangeY (mm)	19.9	17.9	23.9	20.8	15.9	23.8	0.35
LengthX (mm)	768.4	531.7	986.9	604.6**	381.1	824.3	0.01
LengthY (mm)	859.7	695.6	1152.5	705.3**	641.3	753.2	0.01
SkewX (mm)	-0.016	-0.133	0.094	-0.059*	-0.232	0.050	0.05
SkewY (mm)	-0.010	-0.071	0.080	0.040*	-0.135	0.087	0.02
KurtosisX (mm)	2.5	2.4	2.7	2.6	2.5	2.7	0.37
KurtosisY (mm)	2.4	2.3	2.7	2.6	2.5	2.7	0.41
wAvgFX (Hz)	0.299	0.257	0.327	0.292	0.247	0.313	0.15
wAvgFY (Hz)	0.276	0.255	0.335	0.268*	0.237	0.290	0.05
wAvgFXY (Hz)	0.284	0.263	0.318	0.277	0.247	0.302	0.95
KFR, %	61.8	48.0	69.7	71.4*	62.4	80.5	0.05

Note. Significant differences between men and women by non-parametric criterion for independent samples of Mann-Whitney based on the results of balance tests with eyes closed, *p< 0.05; **p< 0.01

According to the authors (Shvets, et al., 2020), the exclusion of visual control during computer-based stabilometry, which plays a significant role in maintaining balance, allows for the acquisition of the most reliable indicators for diagnosing dysfunctions of the autonomic nervous system.

However, not for all the parameters the difference is statistically significant; in general, women demonstrate less asymmetry of COP trajectory. Furthermore, by Kurtosis Y. parameter, women demonstrate a higher mean frequency of COP displacements along the Y-axis, which may indicate a more active compensation for balance disturbance. Analysis of KFR revealed that women exhibited significantly better balance function (p < 0.05) than men. This suggests that women's mechanisms for maintaining upright posture are more efficient.

Our findings highlight the crucial role of visual input in balance control. Additionally, the observed significant differences (p < 0.05; p < 0.01) in various balance parameters indicate that men may be more susceptible to balance impairments under stress compared to women.

Discussion

The study of sex-related characteristics of the HRV status and static balance performance under stressful conditions in military personnel is extremely relevant in modern conditions, especially given the increasing number of women in the armed forces. This trend indicates the need for a more detailed study on the physiological characteristics of women and men in the military environment. An analysis of HRV enables the identification of delicate alterations in autonomic nervous system functioning that arise as a result of exposure to stressors (Dantas, et al., 2010; Draghici, 2016; Dantas, et al., 2018; Thomas et al., 2019; Geovanini, et al., 2020).

Our study has a number of methodological characteristics that should be taken into account when interpreting the results. The sample of subjects was formed from among operational-level officers, which allows us to generalize the results obtained for this particular category of military personnel.

Our results indicate the presence of sex differences in autonomic regulation in military persons, with most of them being statistically significant (p<0.05; p<0.01). Women demonstrate a reduced overall HRV and a greater dominance of the sympathetic nervous system compared to men, which may indicate an increased level of baseline stress in women or specifics of their adaptation to stressful conditions. Our results are consistent with the findings of Koenig et al. (2016) and Geovanini et al. (2020), who also found higher HRV in men. Research has indicated that stress can significantly influence HRV (Kim, 2018). Notably, periods of heightened stress are frequently linked to diminished parasympathetic nervous system activity, leading to reduced high-frequency HRV and increased low-frequency HRV. Neuroimaging research suggests that brain regions involved in stress appraisal, such as the ventromedial prefrontal cortex, may influence fluctuations in HRV. HRV is a complex physiological phenomenon shaped by a multitude of factors, including medical conditions, physical health, mental state, environmental influences, lifestyle habits, and genetic predispositions (Tiwari, 2021).

It is known that the static body balance performance in both sexes is influenced by many factors, including anatomical characteristics, hormonal background, physical fitness, age, stress, sleep disorders, and more (Chraif, Anitei, 2013; Sell, Lovalekar, 2018; Ołpinska-Lischka, 2021). Some studies involving military personnel indicate that static body balance is also negatively affected by wearing personal protective equipment (Sell, Pederson, 2013). The maintenance of postural equilibrium is predominantly regulated by tonic musculature. To prevent falls, these muscles exhibit a 'mosaic-like' redistribution of tension across various muscle groups, optimizing metabolism for energy efficiency (Sarabon, 2012). When considering factors influencing human stability, experts, despite having access to diverse information, have generally agreed that age, sex, height, and weight do not significantly affect bodily stability (Gamaliy, 2004; Boloban, et al. 2012). Rather, it is more dependent on the functional state of the nervous system.

The question of whether sex differences exist in static balance performance among military personnel remains inconclusive. While some studies, such as Sell and Lovalekar (2018), suggest that women may exhibit superior static balance, the majority of research (Mocanu & Murariu, 2022; Atceken, 2024; Taskuyu et al., 2024) indicates no significant sex differences in coordination abilities across various age groups and occupations. This discrepancy may be attributed to numerous factors, including methodological variations and individual differences. When performing the static balance test with eyes closed, women demonstrated statistically significantly ($p<0.05$; $p<0.01$) better results than men, which may be due to the specifics of neurophysiological regulation, as well as to women's greater ability to concentrate and compensate for balance disturbances.

The results of our research are in line with the majority of modern studies (Mocanu and Murariu, 2022; Atceken, 2024; Taskuyu et al., 2024), which also found insignificant sex differences in static balance performance under standard testing conditions.

For the first time, we found that servicewomen of the operational level demonstrate higher static balance performance compared to men under visual deprivation conditions. This fact confirms the significant role of the visual analyzer in maintaining static balance and indicates possible sex differences in the neurophysiological mechanisms of compensation for balance disturbances.

Conclusions

Comparative analysis revealed gender-based differences in autonomic nervous system regulation among military personnel, specifically, lower heart rate variability in females.

The results also indicate that servicewomen have a better static balance performance under conditions of limited sensory input. This fact may be due to the specifics of the neural networks responsible for controlling the body's spatial position or a more effective strategy for using sensory information.

The theoretical significance of the results obtained is that they expand the knowledge of the physiological mechanisms underlying the maintenance of static balance and regulation of the autonomic nervous system, as well as sex-related differences in these processes.

The practical significance of this work is that the results obtained can be used to optimize the process of special (military) physical training of operational level military personnel and to develop programs taking into account sex-related characteristics of autonomic regulation and static balance of the body.

Conflict of Interest - The authors declare that there is no conflict of interest.

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