RESEARCH ARTICLE

F.U. Med.J.Health.Sci.
2021; 35 (3): 152 - 159
http://www.fusabil.org

Autonomic Nervous System Activity and Stress Perception in Male Healthcare Personnel

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Objective: Shift work and work stress have been associated with multiple negative effects on health and have been regarded as important stress factors that activate the autonomic nervous system. The aim of the present research was to compare self-reported stress and autonomic nervous system activity in male shift staff (doctor, health officer, patient caregiver) working in hospital.

Materials and Methods: Doctors (n=30), health officers (30) and patient caregivers (30) working at the hospital were included in the study. Autonomous nersvous system (ANS) activity was determined by heart rate variability (HRV) and self-reported stress was assessed by State and Trait Anxiety Inventory (STAI-II). HRV is derived from short-term electrocardiogram recordings, carried out both at day- and night -shifts, and included standard deviation of NN intervals (SDNN (ms); low frequency (LF); total power (TP) parameters.

Results: SDNN value (42±3) was found to be higher in the doctors than the caregivers group (32±2, p=0.014). LF was higher in the doctors group compared to the patient caregivers group (805±102, 555±97 respectively, p=0.046). TP [1651 (1129-2903), p=0.065) was not different in the doctors group compared to the health officers group [1466 (764-2313)] and the patient caregivers group [786 (508-1821)]. STAI-II was higher in-patient caregivers group [45(42-48) points] than the doctors group [40(35-45) points, P=0.002].

Conclusion: It has been observed that job status has different impacts on heart rate variability even under same working environment. Moreover, although the doctors work longer hours per week, the data suggest that they have better autonomic nervous system activity and stress perception.

Key Words: *Autonomic nervous system, stress, heart rate variability, male, health care*

Erkek Sağlık Personelinde Otonom Sinir Sistemi Aktivitesi ve Stres Algısı

Amaç: Vardiyalı çalışma ve iş stresi, sağlık üzerinde birçok olumsuz etki ile ilişkilendirilmiş ve otonom sinir sistemini harekete geçiren önemli stres faktörleri olarak görülmüştür. Bu araştırmanın amacı, erkek hastane çalışanlarında (doktor, sağlık görevlisi, hasta bakıcısı) stres algısı ve otonom sinir sistemi aktivitesini karşılaştırmaktır.

Gereç ve Yöntem: Hastanede çalışan doktorlar (n = 30), sağlık görevlileri (30) ve hasta bakıcılar (30) çalışmaya dahil edildi. Otonom sinir sistemi (OSS) aktivitesi, kalp atış hızı değişkenliği (KHD) ile belirlendi ve kişilerin stress algıları, Durum ve Süreklilik Kaygı Envanteri (STAI-II) ile değerlendirildi. KHD, hem gündüz hem de gece vardiyalarında gerçekleştirilen kısa süreli elektrokardiyogram kayıtlarından elde edildi ve NN aralıklarının standart sapması, SDNN (ms); düşük frekans, LF; toplam güç, TP (ms²) gibi parametreleri içerdi.

Bulgular: SDNN değeri, doktorlarda (42±3) hasta bakıcı grubuna göre (32±2) daha yüksek bulundu (p=0.014). LF, hasta bakıcı grubuna göre doktorlarda daha yüksekti [sırasıyla (805±102, 555±97 p=0.046]. TP, doktorlarda [1651 (1129-2903)], ofis görevlileri grubuna [1466 (764-2313)] ve hasta bakıcı grubuna [786 (508-1821)] göre farklı değildi (p=0.065). STAI-II hasta bakıcılarda [45 (42-48) puan] doktorlardan [40 (35-45) puan, p=0.002] daha yüksekti.

Sonuç: Aynı ortamda fakat farklı işlerde çalışmanın, kalp hızı değişkenliği üzerine farklı etkiler oluşturabileceği gözlenmiştir. Ayrıca, doktorlar, daha çok çalışmalarına rağmen, ede edilen bulgular, otonom sinir sistemi aktivitesinin ve stres algısının daha iyi olduğunu göstermektedir.

Anahtar Kelimeler: *Otonom sinir sistemi, stres, kalp hızı değişkenliği, erkek*

Received : 12.12.2020
Accepted : 28.07.2021

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Introduction

Shift work is common in modern societies (1). Although shift work provides economic advantages, it is a situation that should be considered critically as it may cause circadian rhythm disorder, decreased sleep time and quality, increased fatigue (2). Shift work is associated with numerous negative effects on health (3). The most obvious reason for these negative effects is impaired sleep (3). People who work at night shifts have difficulty falling asleep because the internal circadian rhythm cannot adapt to the sleep-wake program in the shift work schedule. Therefore, the circadian rhythm is often disrupted (4) and this causes an imbalance in the activity of the autonomic nervous system, leading to shift-related cardiovascular diseases (5). Studies in shift workers have shown an increase in cardiovascular morbidity and mortality rates (6). Some studies have emphasized that working in the night shift may be an independent risk factor for hypertension (7).

Social hierarchical factors such as low status and occupational factors pose a threat to cardiovascular diseases (CVD) (8, 9). In addition to social factors, low socioeconomic status increases the risk of disease in healthy people. Socioeconomic status influences the risk of multiple diseases, frailty, and disability. The reason for these seems to be more social inequality. Strong evidence suggests that social inequalities exist in multiple diseases, frailty and disability; all three conditions were associated with a greater risk of mortality (10). The relationship between socioeconomic status and cardiac outcomes can be related to education, income or profession (11). Low socioeconomic status creates mental stress and increases the risk of cardiovascular disease (12). In studies, it was emphasized that negative physical and psychosocial work environments, working conditions (such as shift work, overwork load) are related to CVD (13). Shift work is linked to a variety of health problems, including harmful effects on the cardiovascular system (14). Studies support that psychosocial stressor at work have negative effects on CVD, including high blood pressure, CVD incidence, and CVD recurrence (15). One of the systems activated in response to stress is the autonomic nervous system (ANS) (16). The autonomic nervous system activates the sympathetic nervous system while suppressing the parasympathetic nervous system (PSS) in excessive or prolonged stress (17,18). Reduced parasympathetic modulation is associated with increased risk of cardiovascular diseases (19). Heart rate variability (HRV) is a noninvasive method used to evaluate ANS status and its regulation on the heart (20). HRV can be used to evaluate autonomic imbalances, diseases and mortality (18). Work stress has been associated with reduced HRV (21). There are studies showing a positive relationship between low HRV and mortality (18).

Shift work has been associated with numerous negative effects on health and is one of the most important stress factors activating the autonomic nervous system.

The aim of this study was to determine the effects of occupational status (doctor, health officer, patient caregiver) on stress perception and autonomic nervous system activity in hospital staff. Additionally, as these parameters likely to be affected by menstrual cycle, we studied only on male personnel.

Materials and Methods

Research and Publication Ethics: The study was carried out in accordance with the ethical guidelines of the 1964 Declaration of Helsinki following ethical approval from the local ethics committee (Malatya Clinical Ethics Committee, no: 2019/22).

MINTAB statistical package (PA, USA) was used for power analysis. It was calculated that 16 individuals should be included in the paired t-test in order to obtain a difference of 1 standard deviation difference when standard deviation was 22.5 for SDNN and the alpha value was 0.05. The male volunteer participants were informed about the study and written consent was obtained from them. Doctors (n=30), health officers (30) and patient caregivers (30) working at the hospital were included in the study. The inclusion criteria were; being healthy, being in the 18-45 age range and and not using any medication. Doctors were working between 08:00 a.m. and 05:00 p.m. However, in case of night shifts, they continued to work for 32 hours continuously. Health officers and patient caregivers work with a similar variable shift system. Rotating-shift system consisted of daytime shifts between 08:00 a.m. and 04:00 p.m. and night shifts between 04:00 pm and 08:00 a.m. Rotating-shift system employees were given at least 16 hours to rest after the day and night shifts. The locations of the day and night shifts were constantly changing, with work schedules arranged at two-week intervals. Data on total working hours and monthly income of the participants are added to Table 1. Demographic characteristics of the study population are represented in Table 1. Body mass indexes [BMI; (weight in kilograms/height in meter^2)] of the subjects are also calculated.

The State-Trait Anxiety Inventory (STAI): The State-Trait Anxiety Inventory (STAI) was used in this study. STAI was developed in 1970 by Speilberger et al. (22) the adaptation of the scale to Turkish, validity and reliability studies were carried out by Öner and Le Compte (23) in 1983. The STAI is a self-assessment questionnaire that is used to find out how participants felt at a particular time or under a specific condition. It has two subscales, the State Anxiety Scale (S-Anxiety) and the Trait Anxiety Scale (T-Anxiety). We used the Trait Anxiety Scale (T-Anxiety) in our study. The STAI helps professionals differentiate between feelings of anxiety and depression by making a clear distinction between the transient state of anxiety and the more general and prolonged persistent anxiety (24).

Heart Rate Variability and Arterial Blood Pressure: All participants were asked not to consume stimulant beverages such as tea and coffee for approximately 2 hours before the heart rate variability (HRV) measurement. In order to determine HRV, electrocardiogram (ECG) recording in volunteer participants were taken for 5 minutes in supine positions with eyes open. ECG recordings were taken once between 4:00 pm and 10:00 pm. Poly-Spectrum 8-E (Neurosoft, Ivanovo, Russia) was used for ECG record and HRV analysis was made with the HRV software program of the same device (Neurosoft, Ivanovo, Russia). HRV is used in the non-invasive evaluation of the autonomic nervous system activity (25). All inter-beat intervals were visually checked to ensure that the program recognized all of them accurately. Time domain parameters (HR, SDNN, RMSSD and pNN50) and frequency domain parameters (TP, LF, HF and LF/HF) were evaluated. Time domain parameters: Heart rate, HR (bpm); standard deviation of NN intervals, SDNN (ms); root mean square of successive RR interval differences, RMSSD (ms); percentage of successive RR intervals that differ by more than 50 ms, pNN50 (%) and total power, TP (ms^2) (26). High-frequency, HF (ms^2) (synchronous with respiration, generally in the band 0.2–

0.45 Hz); low-frequency, LF (ms²) (band 0.03–0.15 Hz); and ratio of LF-to-HF power, LF/HF (27). Arterial blood pressure was measured indirectly using an automated digital blood pressure monitor (Omron, M6 comfort, China).

Statistical Analyses: Statistical analyses were carried out using statistical software (Minitab 19 USA). Distribution of the data was checked by the Anderson-Darling test and non-normally distributed data was transformed into log 10 data for normal distribution. Following this transformation, normally distributed data were analyzed by One-way ANOVA test. Data with non-normal distribution despite the log 10 transformation were analyzed by the Kruskal-Wallis test. Diastolic and systolic blood pressure, heart rate (HR), SDNN and LF had normal distribution whereas the other data did not. Bonferroni correction Mann-Whitney test was used as post hoc analysis after Kruskal-Wallis. Tukey's t test was used as post hoc analysis after one-way ANOVA. Data are presented as median (interquartile range as Q1-Q3) for non-normally distributed data whereas mean ± SEM was used for normally distributed data. $p<0.05$ was considered as level of significance.

Results

Arterial Blood Pressure

Blood Pressure: Mean systolic blood pressure was not different in the doctor group (115±1 mm Hg, p=0.987) compared to the health officers group (114±2 mm Hg) and the patient caregivers group (116±2 mm Hg). Mean diastolic blood pressure was not different in the doctors group (77±1 mmHg, p=0.719) compared to the health officers group (77±2 mm Hg) and the patient caregivers groups (77±1 mm Hg) (Table 2).

Trait Anxiety Scale (T-Anxiety): STAI was higher in-patient caregivers [45 (42-48) points] than doctors [40(35-45) points, p=0.002].

Time Domain Parameters of HRV: HR (80±2, p=0.556) was not different in the doctors group compared to the health officers group (81±2, P=0.556) and the patient caregivers group (78±2 mm Hg). SDNN was higher in the doctors group compared to the patient caregivers group (42±3, 32±2 respectively, p=0.014) (Figure 1). Time domain parameters of the HRV are shown in Table 2.

HRV Frequency Domain Parameters: TP [1651(1129-2903), p=0.065] was not different in the doctors group compared to the health officers group [1466 (764-2313)] and patient caregivers group [786 (508-1821)] (Figure 2). LF/HF [3.42 (1.42-6.52), p=0.293] was not different in the doctors group compared to the health officers group [3.53 (1.24-5.07)] and the patient caregivers group [2.46 (1.22-3.71)] (Figure 2). LF was higher in the doctors group compared to the patient caregivers group (805±102, 555±97 respectively, p=0.046) (Figure 1). HF [222 (120-459), p=0.065] was not different in the doctors group compared to the health officers group [217 (88-396)] and the patient caregivers group [160 (63-344)]. Frequency domain parameters of the HRV are shown in Table 2.

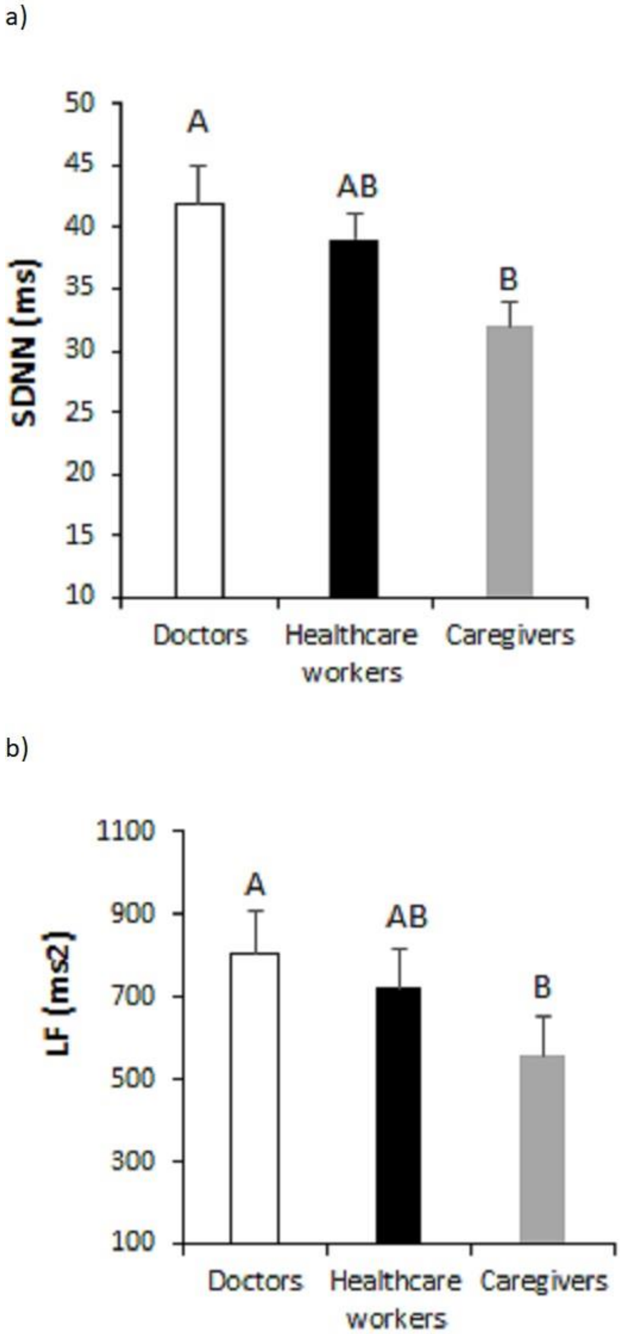
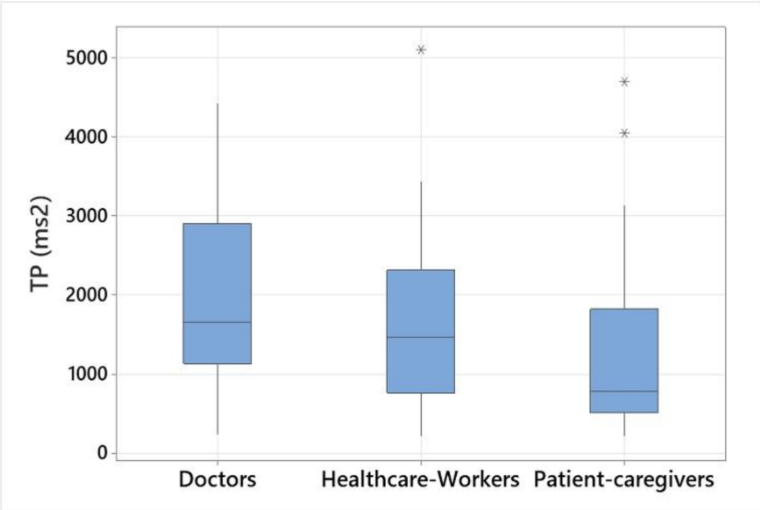


Figure 1. SDNN (a) and LF (b) values in men working in different professions in the health sector. The data are expressed as mean ± standard error for SDNN and LF. Different letters represent the differences between groups. $p<0.05$ was considered as level of significance.

a)



b)

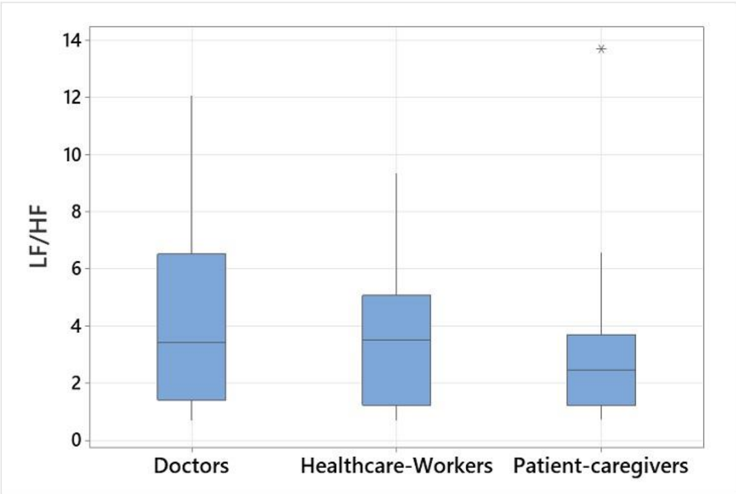


Figure 2. TP (a) and LF/HF (b) values in men working in different professions in the health sector. Box-plot graph is shown for TP and LF/HF. There was no difference between the groups for TP and LF/HF. p<0.05 was considered as level of significance.

Table 1. Demographics of the study population. Data presented as the interquartile range [median(Q1-Q3)]. p<0.05 was considered as level of significance.

Subject characteristic	**Doctors** (n=30)	**Health officers** (n=30)	**Patient caregivers** (n=30)	**P value**
Age (years)	28(26-30)	29(28-31)	33(30-39)	0.001
BMI (kg/m^2)	27(24-29)	25(23-30)	25(24-26)	0.260
Working year	3(2-5)	6(4-8)	9(4-12)	0.001
Weekly working hours (in total)	~ 56-72	~ 40-48	~ 40-45	
Monthly income (TL)	~ 9000-10.000	~ 6000-7000	~ 3000-3.500	

*__BMI:__ Body mass index

Table 2. Heart rate variability index results in men working in different professions in the health sector. Data presented as the interquartile range [median(Q1-Q3)] or mean±SEM. p<0.05 was considered as level of significance.

Variable	Doctors (n=30)	Health officers (n=30)	Patient caregivers (n=30)	P value
Blood pressure indicates				
Systole (mm/Hg)	115±1	114±2	116±2	0.987
Diastole (mm/Hg)	77±1	77±2	77±1	0.719
Time domain parameters				
HR (bpm)	80±2	81±2	78±2	0.556
SDNN (ms)	42±3	39±2	32±2	0.014
RMSSD (ms)	26(19-34)	23(16-32)	24(14-31)	0.664
pNN50 (%)	5.35(2.15-11.15)	3.15(0.42-11.00)	3.20(0.20-9.50)	0.340
TP (ms²)	1651(1129-2903)	1466(764-2313)	786(508-1821)	0.065
Frequency domain parameters				
VLF (ms²)	522(354-701)	561(342-791)	319(206-589)	0.101
LF (ms²)	805±102	719±97	555±97	0.046
HF (ms²)	222(120-459)	217(88-396)	160(63-344)	0.065
LF/HF (ms²)	3.42(1.42-6.52)	3.53(1.24-5.07)	2.46(1.22-3.71)	0.293
%VLF	35(30-46)	36(29-48)	39(32-54)	0.410
%LF	46(34-58)	44(36-55)	42(34-48)	0.409
%HF	13(8-26)	15(10-24)	18(10-25)	0.706

HR, heart rate; **SDNN**, standard deviation of NN intervals; **RMSSD**, root mean square of successive RR interval differences; **pNN50**, percentage of successive RR intervals that differ by more than 50 ms; **TP**, total power; **VLF**, absolute power of the very-low-frequency band; **LF**, absolute power of the low-frequency band; **HF**, absolute power of the high-frequency band; **LF/HF**, ratio of LF-to-HF power (Shaffer and Ginsberg, 2017). **p*<0.05 Tukey test

Discussion

Due to the sympathetic and vagal parasympathetic innervations of the heart, HRV is widely used as a marker of the ANS and its two branches (28). HRV is considered one of the most accurate markers of sympathovagal balance in autonomic activity (29). HRV may be used as a tool to predict autonomic imbalances, disease, and mortality (18). In this study, we evaluated time and frequency dependent HRV parameters in male shift staff (doctor, health officer, patient caregiver) working in hospital. In the study, SDNN and LF values were found to be higher in doctors compared to the caregiver group (Figure 1). However, the STAI-2 score was found to be higher in-patient caregiver compared to doctors.

Systolic and diastolic pressures were not statistically significant between the doctor, health officer and patient caregiver groups. In addition, systolic and diastolic pressures were within normal limits in all groups. ANS affects blood pressure through adjustments in parasympathetic and sympathetic activity (30). There is an increasing amount of studies that work stress may be associated with cardiovascular diseases (31). In addition, shift work is a risk factor for cardiovascular disease and hypertension (32). CVD is a leading cause of morbidity and mortality (18). It is known that socioeconomic status also has effects on CVD (33). Poverty has always been associated with poor health, but this may not be the case in modern societies (33). Although the specific contribution of genes and environment is not fully understood, environmental factors and lifestyle are thought to play a more dominant role in the development of CVD (33).

HR was not statistically significant between the doctor, health officer and patient patient caregiver groups. In addition, HR was within normal limits in all groups. HR is under the influence of ANS (34). HR assessment continues to be used as a health indicator from past to present (34). Researchers emphasize that status and work stress are associated with illnesses and poor health (18, 31). Studies have shown that high resting heart rate is associated with increased mortality (35). Researchers emphasized in their study that HR increased in acute stress situations, but HR decreased with chronic stress (36). Therefore, there may not have been a difference between the groups because they have been doing this job for years in all three groups.

In our study, SDNN value was found to be lower in the patient caregiver group compared to the doctor group (Figure 1). SDNN is a measure for the evaluation of total sympathetic and parasympathetic activity (37). A higher SDNN value is associated with a higher probability of survival (26). Weakness of ANS can lead to a weakened ability to adapt to difficulties and a decrease in the ability to cope with emotional / physical stress factors (5, 38). Low HRV has been associated with conditions such as psychopathology, including anxiety (39). The researchers emphasized in their studies that low SDNN values are associated with both morbidity and mortality (26). HRV time-domain measurements decrease with age (26). Hence, SDNN tends to decrease with advancing age (40). Therefore, the decrease in SDNN value may also be due to the age difference. However, the fact that 20-29 and 30-39 age groups are consecutive in the age groups classification and there is no difference between the groups in (41) terms of other HRV parameters also suggests the possibility that age has less effect on SDNN. Work stress has been associated with reduced HRV (18). Among men, job stress has been associated with low HRV due to recurrent ANS activation (8). In our study, the STAI-2 score was found to be higher in the patient caregiver group compared to the doctor group. Researchers emphasize that status and work stress are associated with illnesses and poor health (18, 31). The researchers emphasized in the studies that low HRV is also associated with low socioeconomic status (42). Although social class has an effect on the cardiovascular system, its mechanism of action is not yet understood (42). Studies have shown that reduced education (43), occupational status, and income (43), are all associated with mortality, morbidity, and poor functional status (42). TP was not different in the doctors group compared to the health officer group and the patient caregiver group (Figure 1). TP is a marker of autonomic nervous system activity (44). Higher TP is associated with better health (45).

In our study, there was no difference between the groups in terms of PNN50, RMSSD and HF values. Some of the parasympathetic components of HRV are PNN50, RMSSD and HF (38). Modulation of vagal tone is important for maintaining cardiovascular health (26). Although there are some differences between studies, the consensus is that lower values of vagal function indices are prospectively associated with death and disability (18). High vagal activity is considered cardioprotective and hence associated with better health (46). In our study, there were no difference between the groups in terms of VLF and LF/HF (Figure 1). Normal VLF value correlates with healthy state (26). LF/HF is an indicator of sympathovagal balance (26). An increase in LF/HF ratio indicates predominant sympathetic activity, while a decrease in LF/HF indicates parasympathetic dominance (47).

LF has long been considered a measure of sympathetic activity (47). The origin of LF power, however, has consistent controversy (47). Thomas et al. emphasized in their study that LF and VLF do not represent cardiac sympathetic modulation of the heart and these parameters may reflect vagal mediated baroreflex cardiac effects (47). In our study, the STAI-II score was found to be higher in the patient caregiver group compared to the doctors group. However, the LF value was found to be higher in the doctors group compared to the patient caregiver group. This situation seems to support the predictions of Thomas et al. However, the perception of physiological and psychological stress may be different (48). Although they are STAI and HRV stress parameters, it has been observed that they may give different results in some studies (49).

In our study, the STAI-II score was found to be higher in the patient caregiver group compared to the doctors group. STAI scores are commonly classified as no or low anxiety (20-37), moderate anxiety (38-44), and high anxiety (45-80) (50). While moderate anxiety was observed in the doctors group, there was a high level of anxiety in the patient caregiver group. Among men, work stress has been associated with low HRV due to recurrent ANS activation (8). Stress in the workplace is an important public health risk associated with cardiovascular morbidity (18). CVD is the leading cause of death and disability worldwide (18). Researchers emphasize that status and work stress are associated with illnesses and poor health (18, 31). Low socio-economic status (SES) is associated with steadily increasing rates of morbidity and mortality when measured by income, education, or other indicators (51).

As a result, shift work is an important component of the modern world, but has been linked to risk for diseases such as cardiovascular diseases (5). In addition, researchers highlight that job status and stress are also associated with illnesses and poor health (18, 30). In our study, SDNN value was found to be higher in the doctor group compared to the patient caregivers group. In addition, the STAI-II score was higher in the patient caregivers group than in the doctor group. These collectively show that, even the doctors work hard and have higher responsibilities; they appear to have better heart rate variability parameters and less stress perception. As a result, the data suggest that job status may have significant effects on health, even in individuals working in the same environment.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: There are no financial supports.

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