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RELATIONSHIP OF THE AUTONOMIC NERVOUS SYSTEM WITH SLEEP QUALITY, PHYSICAL ACTIVITY, AND DEPRESSION IN 18-25 YEARS OLD HEALTHY UNIVERSITY STUDENTS

ZWIĄZEK AUTONOMICZNEGO UKŁADU NERWOWEGO Z JAKOŚCIĄ SNU, AKTYWNOŚCIĄ FIZYCZNĄ I DEPRESJĄ U ZDROWYCH STUDENTÓW W WIEKU 18-25 LAT

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Summary

Background. The autonomic nervous system regulates cardiovascular response in animals and humans during physical activity. This study aimed to explore the relationship between the autonomic nervous system and factors such as sleep quality, physical activity, and depression in healthy young individuals aged 18 to 25.

Material and methods. Demographic data of the participants (age, height, body weight, education level, exercise, and smoking habits) were recorded in the demographic data form. The sleep quality of the participants was measured using the Pittsburgh Sleep Quality Index and their depression levels were determined through the Beck Depression Inventory. Evaluation of the autonomic nervous system of the participants was performed using the Elite HRV Corsense device, which is based on the observation of RR waves that are also present during the resting state.

Results. A moderately negative and statistically significant correlation was found between the LF/HF ratio and the total scores of the Beck Depression Inventory (r=-0.352; *p*=0.014). The correlation between the average heart rate sub-parameter and the total scores of the Beck

Depression Inventory was found to be moderately positive and statistically significant (r=0.362; *p*=0.011).

Conclusions. The study, along with the reviewed literature, highlights the relationship between depression and the autonomic nervous system at various levels. Depression causes alterations in the body's autonomic control mechanisms.

Keywords: heart rate variability, sleep quality, autonomic nervous system, physical activity, depression

Streszczenie

Wprowadzenie. Autonomiczny układ nerwowy reguluje reakcję układu sercowo-naczyniowego u zwierząt i ludzi podczas aktywności fizycznej. Niniejsze badania miały na celu określenie związku między autonomicznym układem nerwowym a czynnikami takimi jak jakość snu, aktywność fizyczna i depresja u zdrowych młodych osób w wieku od 18 do 25 lat.

Materiał i metody. Dane demograficzne uczestników (wiek, wzrost, masa ciała, poziom wykształcenia, aktywność fizyczna i nawyki związane z paleniem tytoniu) zostały zapisane w formularzu danych demograficznych. Jakość snu uczestników mierzono za pomocą kwestionariusza jakości snu Pittsburgh, a ich poziom depresji określono za pomocą skali depresji Becka. Ocenę autonomicznego układu nerwowego uczestników przeprowadzono za pomocą urządzenia Elite HRV Corsense, które opiera się na obserwacji fal RR, które są również obecne w stanie spoczynku.

Wyniki. Stwierdzono umiarkowanie ujemną i statystycznie istotną korelację między stosunkiem LF/HF a całkowitymi wynikami w skali depresji Becka (r=-0,352; *p*=0,014). Korelacja między średnim podparametrem tętna a całkowitymi wynikami w skali depresji Becka okazała się umiarkowanie dodatnia i istotna statystycznie (r=0,362; *p*=0,011).

Wnioski. Niniejsze badania, wraz z literaturą poddaną analizie, podkreślają związek między depresją a autonomicznym układem nerwowym na różnych poziomach. Depresja powoduje zmiany w autonomicznych mechanizmach kontroli organizmu.

Słowa kluczowe: zmienność rytmu serca, jakość snu, autonomiczny układ nerwowy, aktywność fizyczna, depresja

Introduction

The autonomic nervous system, also known as the visceral nervous system, is distinguished from the somatic nervous system by its involuntary function. Since it innervates the heart muscle, smooth muscles, and endocrine and exocrine glands, this nervous system structure regulates the activity of many tissues and organs. The visceral nervous system regulates homeostatic functions such as blood pressure, bladder contraction, gastrointestinal responses, and thermoregulation [1].

Afferent and efferent fibers enter and exit the central nervous system through spinal and cranial nerves synapse with intermediate neurons, which mediate autonomic reflexes in the spinal cord and brainstem [2].

The vagus nerve, part of the parasympathetic system, enables two-way communication between the brain and internal organs. Its afferent pathways transmit signals from interoceptors that track the body's physiological condition [3,4]. The autonomic nervous system is a key neural pathway activated by stress. At higher levels of the central nervous system, information from the afferent pathways of the vagus nerve contributes to mood regulation. In patients with depression, there is an increase in sympathetic nervous system activation and a decrease in parasympathetic activity [5,6].

Human beings need to meet many biological and psychological needs in order to survive. One of these needs is sleep [7]. Sleep allows both the brain and the body to rest [8]. The systems that govern sleep are anatomically and physiologically connected to the autonomic nervous system. This system also plays a role in regulating sleep duration, maintaining the sleep-wake balance, and managing events related to the circadian process during sleep [9].

The autonomic nervous system regulates cardiovascular response in animals and humans during physical activity. The amount of oxygen utilized during physical activity is defined by the product of heart rate, stroke volume (i.e. cardiac output), and the difference between arterial and mixed venous oxygen content, in accordance with Fick's principle. The degree to which each of these factors increases determines the maximum oxygen uptake. There is substantial evidence indicating that some protective and therapeutic benefits of physical activity are associated with its impact on the autonomic nervous system. Furthermore, enhancements in vascular function, blood volume expansion, cardiac remodeling, insulin resistance, and renal-adrenal function resulting from training may also contribute to the prevention and treatment of cardiovascular, metabolic, and autonomic disorders [10].

Aim of the work

This study aimed to explore the relationship between the autonomic nervous system and factors such as sleep quality, physical activity, and depression in healthy young individuals aged 18 to 25.

Material and methods

This study was conducted from May 1, 2024, to June 30, 2024, and included students enrolled in the Physiotherapy and Rehabilitation Department and the Vocational School of Physiotherapy program at Mudanya University, Faculty of Health Sciences (Türkiye). Based on the power analysis derived from this value in the reference study [11], which reported a moderate effect size (r=0.58), it was determined that a minimum of 34 participants would be required to achieve 80% power at a 95% confidence level. A total of 48 university students between 18 and 25 years of age who were free of any systemic disease, had no issues with cooperation, and voluntarily agreed to participate in the study were included. Exclusion criteria were pregnancy status, malignancy, presence of a pacemaker, use of sleeping pills, smoking 2 hours before the measurements, and drinking alcohol 24 hours before the measurements. In addition, no athletes or art students engaged in regular physical activity were among the participants in our study. All students participating in the study were briefed about its objectives, and their informed consent was secured. Evaluations were performed through in-person interviews. Demographic data of the participants (age, height, body weight, education level, exercise, and smoking habits) was recorded in the demographic data form.

The short form of the International Physical Activity Questionnaire (IPAQ) was utilized to evaluate the levels of physical activity. The IPAQ consists of 7 questions focusing on sitting, walking, moderately vigorous activities, and the time spent on vigorous activities. The overall score is calculated by adding the duration (in minutes) and frequency (in days) of walking, moderately vigorous, and vigorous activities. The sitting score is calculated separately. For all activities to be evaluated, each must be performed for at least 10 minutes. Minutes, days, and MET values are multiplied to obtain an MET/minute/week score. Based on the total physical activity score, physical activity levels are categorized as follows: “low (<600 MET/min/week), moderate (600-3000 MET/min/week), and high (>3000 MET/min/week)" [12]. Öztürk conducted the validity and reliability study of the questionnaire in 2005 [13].

The participants' sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI). The PSQI consists of 24 questions, 19 of which are completed by the individual and 5 of which are only used for clinical information, are not included in the scoring, and are completed by the individual's roommate. It assesses the individual's sleep quality over the last month, as well as the type and severity of any sleep disorders. The questions, which evaluate 7 sub-dimensions—subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction—are answered by the individuals and subsequently analyzed. However, the questions answered by the roommate are not included in this evaluation. Each item on the scale is scored from 0 (indicating no distress) to 3 (indicating severe distress). The sum of the scores from the 7 sub-dimensions yields the total PSQI score, which ranges from 0 to 21. A total score of 5 or higher is regarded as indicating "good sleep quality", while a score below 5 is classified as "poor sleep quality" [14].

The depression level of the individuals was evaluated with the Beck Depression Inventory (BDI). The BDI was developed by Beck et al. in 1961. It is a 21-item self-assessment scale. Each item is scored from 0 to 3, with a maximum total score of 63. This scale objectively assesses the extent of somatic, emotional, cognitive, and motivational symptoms associated with depression. It was adapted into Turkish by Hisli in 1988 [15].

The participants' autonomic nervous system assessments were performed using the Elite HRV Corsense device, which is based on the observation of RR waves that are also present during the resting state. The device has a finger sensor and an application compatible with the phone. The Elite HRV application is software that can synchronize with a personal monitor by collecting peak-to-peak intervals for instant analysis of pulse rate variability (PRV). Studies show that Elite HRV, a smartphone application, is a valid application platform for examining Root Mean Square of Successive Differences (RMSSD) [16-18]. The values measured by the device for 1 minute are [19]:

- RMSSD: provides a snapshot of the Parasympathetic branch of the Autonomic Nervous System and is the basis of the HRV score;
- low frequency (LF) power: refers to the frequency of activity within the range of 0.04 to 0.15 Hz. This frequency is directly proportional to the activity of the sympathetic nervous system and serves as an indicator of sympathetic activity;
- high frequency (HF) power: activity of the frequency between 0.15-0.40 Hz. The HF band reflects parasympathetic activity and is highly correlated with PNN50 and RMSSD time domain measurements;
- LF/HF ratio: ratio of low frequency power to high frequency power, commonly used as a measure of sympathovagal balance. Refers to the balance between opposing branches of the autonomic nervous system;
- mean heart rate.

Measurements for autonomic nervous system assessment were taken while the participants were in a sitting position and after resting for 5 minutes. In order to ensure standardization, all students' assessments were taken during lunch break (12:00-1:00 pm) at the university. All measurements took approximately 30 minutes for one person.

Data was analyzed using the SPSS 25.0 software package. Continuous variables are presented as mean ± standard deviation, while categorical variables are expressed as numbers and percentages. The connections between continuous variables were examined using Spearman or Pearson correlation analyses, and the variations among categorical variables were evaluated with Chi-square analysis. While the mean heart rate and RMSSD parameters were normally distributed, the data of LF, HF, LF/HF, IPAQ, PSQI, and BDI did not fit the normal

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distribution. Spearman correlation analysis was used to compare the normally distributed values in the table in which the comparisons were made since the values compared to the normally distributed values were not normally distributed, and the two values compared were not parameters that fit the normal distribution.

Results

Sociodemographic data

The study was completed with 48 participants, 32 women and 16 men. The mean age of the individuals was 19±0.92 years, the mean height was 1.70±0.11 m, and the mean body weight was 65.22±14.87 kg. When body mass indexes (BMI) were analyzed, the mean BMI of the individuals was 22.09±3.19 kg/m^2. Demographic characteristics of the subjects are summarized in Table 1.

Table 1. Sociodemographic data

Sociodemographic characteristics		**n (%)**	**X±SD**	**Min-Max**
Gender	**Female**	32 (66.7)	-	-
	Male	16 (33.3)	-	-
	Total	48 (100)	-	-
Age		-	19±0.92	18-21
Height (m)		-	1.70±0.11	1.56-1.99
Weight (kg)		-	65.22±14.87	42-105
BMI		-	22.09±3.19	16-29.32

Notes: *p*<0.05 statistically significant difference, n – number of cases, X – mean, SD – standard deviation, Min – minimum, Max – maximum.

Participants' autonomic nervous system, sleep quality, physical activity, and depression test scores, as well as RMSSD, HF, LF, LF/HF, and mean heart rate values, are given in Table

2. As a result, it was found that the participants exhibited a high level of weekly physical activity. It was observed that their sleep quality measured by PSQI was good, and their depression levels measured by the BDI were mild. At the same time, the participants' LF values were higher than the HF values because the sympathetic activities of the participants were higher than their parasympathetic activities. A higher LF/HF ratio indicates that sympathetic activation is superior. The participants also had LF and HF ratios higher than 1. In other words, it was observed that the sympathetic activities of the participants were more dominant.

Table 2. Autonomic nervous system, sleep quality, physical activity and depression test scores

Assessment scales	X±SD	Min-Max
IPAQ	4254.91±5352.13	0-32776
PSQI	6.813±2.97	2-13
BDI	11.292±7.35	0-34
RMSSD	69.37±29.38	8.9-132
LF	5472.70±4161.81	92.39-18485
HF	1867.72±1808.34	56.9-7301
LF/HF	4.91±5.10	0.1-29.9
Average Heart Rate	92.35±10.93	71-129

Notes: $p<0.05$, X – mean, SD – standard deviation, Min – minimum, Max: maximum, IPAQ – International Physical Activity Questionnaire, PSQI – Pittsburgh Sleep Quality Index, BDI – Beck Depression Inventory, RMSSD – square root of the mean sum of squares of the differences between normal heartbeats, LF – low frequency, HF – high frequency, LF/HF – ratio of low frequency to high frequency.

Table 3 displays the results of the Spearman correlation test conducted to assess the relationship between the autonomic nervous system, sleep quality, physical activity, and depression. A graphical visualization of these results is also shown in Figure 1. The strength of the relationship between the variables is categorized as weak if the correlation coefficient falls between 0 and 0.29, moderate if it is between 0.30 and 0.64, strong if it ranges from 0.65 to 0.84, and very strong if it is between 0.85 and 1 [20].

Table 3. Association of autonomic nervous system with sleep quality, physical activity, and depression

Autonomic measurements	X±SD	Min-max	Statistics	IPAQ	PSQI	BDI
RMSSD	69.37±29.38	8.9-132	**r**	0.231	0.144	-0.096
			p	0.118	0.328	0.515
LF	5472.7±4161.81	92.39-18485	**r**	0.016	0,118	-0.127
			p	0.916	0.424	0.390
HF	1867.72±1808.34	56.9-7301	**r**	0.059	0.102	0.192
			p	0.696	0.492	0.191
LF/HF	4.91±5.10	0.1-29.9	**r**	0.039	-0.015	-0.352*
			p	0.797	0.922	0.014*
Average Heart Rate	92.35±10.93	71-129	**r**	-0.067	-0.028	0.362*
			p	0.653	0.851	0.011*

Notes: * $p<0.05$, * r>0.30 – Spearman Correlation Analysis, X – mean, SD – standard deviation, Min – minimum, Max – Maximum, RMSSD – square root of the mean sum of squares of the differences between normal heartbeats, LF – low frequency, HF – high frequency, LF/HF – ratio of low frequency to high frequency.

In our study, no statistically significant correlation was found between RMSSD and the total scores of IPAQ (r=0.231; *p*=0.118), PDQI (r=0.144; *p*=0.328), BDI (r=-0.096; *p*=0.515). However, no statistically significant correlation was found between LF, another parameter used in the evaluation of the autonomic nervous system, and the total scores of IPAQ (r=0.016; *p*=0.916), PDQI (r=0.118; *p*=0.424), BDI (r=-0.127; *p*=0.390).

Another sub-parameter, HF, was not found to correlate statistically significantly with IPAQ (r=0.059; *p*=0.696), PDQI (r=0.102; *p*=0.492), or BDI (r=0.192; *p*=0.191) total scores.

No statistically significant correlations were identified between the LF/HF ratio and the total scores of the IPAQ (r=0.039; *p*=0.797) and PSQI (r=-0.015; *p*=0.922). However, a moderate negative correlation was observed between the LF/HF ratio and the total scores of the BDI (r=-0.352; *p*=0.014).

Discussion

In this study, the relationships between autonomic nervous system parameters and sleep quality, physical activity, and depression were examined. Although no statistically significant relationship was found in general, positive correlations were found between mean heart rate and depression levels, and negative and moderately significant correlations were found between the LF/HF ratio and depression levels.

In a study conducted by Sato et al. [21] involving 31 healthy adult Japanese women aged 20 to 40 years, the relationship between sleep quality and autonomic nerve functions was evaluated. The results indicated a positive correlation between heart rate variability measures (HF and LF/HF) and sleep duration, as assessed by PSQI. Our study found no significant correlation between autonomic nervous system parameters (HF and LF/HF) and sleep quality (PSQI). This difference is thought to be influenced by various factors, including age range, gender distribution, and cultural differences [21].

In a study by Oliver et al. [22], involving 141 undergraduate students without a medical diagnosis of sleep disorders such as narcolepsy, sleep apnea, or sleep terrors, the relationship between sleep and resting autonomic nervous system functioning was examined. They reported that sleep components evaluated using the PSQI were associated with resting autonomic nervous system activity (mean heart rate, VLF, LF, HF, LF/HF). Additionally, they found that better sleep efficiency correlated with reduced sympathetic activation. In contrast, our study did not identify a significant relationship between sleep quality and autonomic nervous system parameters. The differences in sample size and assessment methods between the two studies may influence the results [22].

In another study, Castro-Diehl et al. [23] examined the association between shorter sleep duration and poorer sleep quality with mean heart rate and HF autonomic tone markers and

Multi-Ethnic Study of Atherosclerosis Sleep Protocol in individuals aged 45 to 84 years without cardiovascular disease other than atherosclerosis. They observed that lower sleep efficiency and insomnia were associated with autonomic tone markers, indicating lower cardiac parasympathetic (vagal) tone levels and higher sympathetic tone levels. Our study observed no significant relationship between mean heart rate, HF parameters, and sleep quality. Considering that the participants' history of cardiovascular disease may affect the autonomic nervous system, this may cause the results to be different, and the findings can be evaluated within this framework [23].

In a study conducted by Pressman and Fry [24], researchers utilized the Stanford Insomnia Scale, the Multiple Sleep Latency Test, and pupillometry to examine how autonomic nervous system activity correlates with daytime sleepiness in patients with obstructive sleep apnea. Their results indicated a significant link between an increased frequency of apneas and hypopneas in these patients, along with a decrease in sympathetic activity and an increase in parasympathetic activity. These findings suggest that autonomic nervous system activity is associated with both daytime sleepiness and the quality of prior sleep. In contrast, our study did not find a significant correlation between autonomic tone parameters, which reflect parasympathetic and sympathetic activity, and sleep quality. These discrepancies may stem from the specific sleep disorder, such as sleep apnea, and variations in overall health status [24].

In a study conducted by Ertan et al. [25] assessing autonomic nervous system functions in patients with moderate to severe obstructive sleep apnea syndrome (OSAS), the electrophysiological examination of autonomic nervous system functions was evaluated. The Sympathetic Skin Response (SSR) was utilized to assess sympathetic nervous system activity, while RR Interval Variability (RRIV) was measured both at rest and after hyperventilation (HV) to evaluate parasympathetic nervous system function. It was reported that no significant autonomic dysfunction was found in OSAS patients in a study conducted with 29 moderate and severe patients and a control group consisting of 30 healthy individuals [25]. Likewise, our study failed to establish a significant connection between the parameters of the autonomic nervous system and the clinical outcomes pertaining to sleep quality. The fact that autonomic dysfunction was not found in the study group in both studies may have caused the results to be similar. In addition, the fact that no significant autonomic dysfunction is observed even in patients with a chronic health problem such as OSAS suggests that detecting such associations in healthy individuals may be difficult.

Research in literature indicates that the relationship between sleep quality and the autonomic nervous system may vary based on the demographic characteristics of the sample groups and the measurement methods employed. The discrepancies in findings could be due to the fact that autonomic nervous system dysfunction manifests differently in each individual and clinical scenario, demonstrating complex interactions. This suggests that the impact on the autonomic nervous system may differ from person to person and depend on the severity of the condition, with autonomic dysfunction not always being readily apparent. Our study emphasizes that the relationship between sleep quality and the autonomic nervous system should be investigated in more comprehensive and homogeneous groups.

In a study by Atılgan et al. [26] that included 30 healthy female volunteers aged 18 to 30 with no medical issues, the effects of yoga-based exercises on flexibility, quality of life, physical activity, and depression were examined. Quality of life was assessed using the short form 36 (SF-36), while physical activity levels were measured using the Physical Activity Index, and depression levels were evaluated with BDI. The results indicated that there were no changes in depression or physical activity levels in the post-exercise evaluations. Similarly, in our current study, no statistically significant relationship was found between the autonomic nervous system and sleep quality, physical activity, and depression in healthy individuals aged 18-25 years. Both studies suggest that the effects of exercise or lifestyle changes on psychological and physiological parameters may be limited in young and healthy individuals [26].

Iwasa et al. [27] explored the relationship between heart rate variability and physical activity in a sample of 29 children (17 boys and 12 girls) utilizing nighttime Holter ECG monitoring. Their results indicated a significant negative correlation between energy expenditure and the HF component ($r=-0.71$, $p<0.05$) [27]. A similar trend was reported by Chiang et al. [28] in a meta-analysis that investigated the effects of exercise on HRV during exercise and within one hour post-exercise. This analysis included 10 studies involving 292 adult participants and used various methods to assess autonomic nervous system activity, such as the LF/HF ratio and RMSSD. The meta-analysis revealed a marked decrease in parasympathetic activity during and after exercise compared to pre-exercise levels. In contrast, it showed an increase in sympathetic activity post-exercise, as indicated by the LF/HF ratio, relative to pre-exercise values [28]. These findings provide an essential perspective in understanding the relationship of autonomic nervous system activation with physical activity. On the other hand, in our current study, no statistically significant relationship was found between the autonomic nervous system and physical activity in healthy individuals aged 18-25 years, indicating that factors such as age group and health status may be influential in observing such changes. These results emphasize the need to examine more extensive and different demographic groups to understand the effects of exercise on the autonomic nervous system.

In a randomized controlled study conducted by Niemela et al. [29], the relationship between exercise and the recovery pattern of baroreflex sensitivity after exercise was tested in 12 healthy, non-smoking male volunteers, by measuring continuous blood pressure and R-R intervals. It was shown that baroreflex sensitivity after acute exercise was related to exercise intensity. Similarly, the present study's lack of a significant relationship between autonomic nervous system parameters and physical activity suggests that the effects of exercise intensity and individual characteristics on such parameters may exhibit a more complex dynamic. This makes it necessary to examine individuals in different age groups and health conditions to understand better the effects of exercise type and intensity on the autonomic nervous system [29].

The relationship between physical activity level and the autonomic nervous system presents a striking and complex situation in existing literature. Compared to other studies in literature, it is noteworthy that such relationships are not evident in young and healthy individuals, and our study contributed to this field. Age, health status, and exercise intensity are important factors shaping this relationship, and studies on larger and diverse populations are needed to fully understand the dynamic interaction between the autonomic nervous system and physical activity.

In a cross-sectional study conducted, Singla et al. [30] determined the effects of depression on HRV parameters by recording heart rate at rest, supine position, RR mode, and ECG monitoring on 50 depressed patients (medically diagnosed and antidepressant users) aged between 18-65 years and 50 healthy controls. They showed that mean heart rate (beats/min), LF, and LF/HF parameters were significant when the controls and cases were compared. However, the differences between LF peak (Hz), HF peak (Hz), HF power (ms2), LF power (%), HF power (%), HF power (nu), and LF power (nu) parameters were found to be statistically insignificant [30]. In a review study conducted by Paniccia et al. [31] in order to investigate the link between heart rate variability and depression and anxiety in young people (aged 10-24 years), it was reported that HRV was lower in populations with depression or anxiety compared to controls [31]. In a review of 54 articles by Vasudev et al. [32] that examined the interplay between autonomic function and major depressive disorder (MDD) in relation to lifelong cardiovascular health, it was found that autonomic dysfunction was consistently present in individuals showing depressive symptoms or those diagnosed with MDD. Additionally, this autonomic dysfunction was linked to an increased risk of developing cardiovascular disease (CVD). Autonomic dysfunction has been reported to be a marker of depression [32]. In our study, only healthy individuals were evaluated, and in support of literature, the mean heart rate increased, and the LF/HF ratio decreased as depression increased, which supports the effects of depression on the autonomic nervous system.

Wang et al. [33] conducted a study with 106 participants (53 in the experimental group and 53 in the control group) to assess cardiac autonomic function, cardiac arrhythmia, depression severity, and heart rate variability indices, including Standard Deviation of the Average NN intervals **(**SDANN), RMSSD, pNN50, and Standard Deviation of the NN intervals (SDNN). The researchers utilized the Hamilton Rating Scale for Depression (HAMD) alongside data collected over 24 hours from a multichannel electrocardiograph (ECG-92C) to explore the correlation between the LF/HF ratio and the prevalence of arrhythmias. Their results showed that the depression group exhibited significantly lower values for SDNN, SDANN, RMSSD, PNN50, and HF when compared to the control group. Additionally, the mean LF value was higher in the depression group, and the LF/HF ratio was also elevated compared to the control group. These findings imply a linear relationship between the severity of depression and HRV indices, suggesting that depression is linked to dysfunction of the cardiac autonomic nervous system and that the degree of depression is correlated with the extent of this dysfunction. We can say that this relationship emerged with limited parameters in the healthy and mildly depressed participants in our study. This indicates that the impact of depression severity on the autonomic nervous system may be more pronounced [33].

Conclusions

Our study and the literature we reviewed reveal the relationship between depression and the autonomic nervous system at different levels. Depression induces alterations in the body's autonomic control. In our study, HRV analysis also showed that this altered the autonomic balance in favor of an increased sympathetic tone. In agreement with literature, changes in the autonomic nervous system were not evident in individuals with low levels of depression; only in more severe cases of depression could autonomic dysfunction be clearly manifested. In our study, the HRV analysis indicated that this resulted in an autonomic imbalance favoring an increased sympathetic tone. While some associations were identified between depression severity and the LF/HF ratio, as well as mean heart rate, other parameters such as RMSSD, LF, and HF did not yield significant results. These findings suggest that as depression severity escalates, its impact on the autonomic nervous system becomes more pronounced, with autonomic dysfunction being more consistently observed in cases of severe depression. In conclusion, our study investigated the relationships between the autonomic nervous system, sleep quality, physical activity, and depression among healthy university students aged 18 to 25. The findings showed that the participants had high weekly physical activity levels and good sleep quality. At mild levels of depression, a moderate positive correlation was found between mean heart rate and BDI scores, whereas a moderate negative correlation was observed between the LF/HF ratio and the severity of depression. However, there was no statistically significant relationship identified between HRV parameters, including RMSSD, LF, and HF, and the variables of sleep quality and depression.

Limitations

The small sample size and the inclusion of only healthy university students in our study limit the generalizability of the findings. Another limitation is that PRV was measured instead of HRV, and measurements were taken for 1 minute. Long-term follow-up instead of short-term PRV measurements may allow for more comprehensive and reliable results; however, PRV was measured simultaneously and in the same position in all participants. This is likely to increase the accuracy of the measurement. In addition, since this is a single-center study, caution should be exercised in generalizing the results obtained to different demographic groups, and similar multicenter studies should support the results.

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