THE ANATOLIAN JOURNAL OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

The Relationship Between Sexual Activity and Heart Rate Variability in Menopausal Women

ABSTRACT

Background: Menopause is an important life stage for women, which can bring along sexual and cardiac problems. Increased heart rate variability is an indicator of parasympathetic activity and is associated with mental and physical health and life expectancy. This study aimed to evaluate the effect of sexual activity (only penile–vaginal intercourse but not masturbation or non-coital sex with a partner) on heart rate variability in healthy menopausal women.

Methods: We evaluated 130 menopausal patients aged 45-60 years, without chronic disease. The average weekly sexual activity numbers remembered in the last 1 year were questioned. The patients were divided into 2 groups according to the presence of sexual activity. The sexually active group was divided into subgroups as 1 per week and 2 or more per week. Menopause Rating Scale was applied for menopausal symptoms. Heart rate variability was analyzed from the 24-hour electrocardiography Holter recording.

Results: Heart rate variability parameters were higher in the sexually active group than in the sexually inactive group (mean of the standard deviations of all the NN intervals for each 5 min segment of a 24-hour heart rate variability recording: $P = .004$; root mean square of differences between adjacent normal RR intervals, expressed in ms: $P = .001$; number of NN intervals exceeding 50 milliseconds: $P = .011$; percentage of adjacent RR intervals with a difference of duration >50 ms: $P = .009$; low frequency: $P = .011$; high frequency: $P = .008$, low frequency/high frequency: $P = .018$). When assessed by multiple linear regression analysis by adjusting for age, body mass index, and menopause duration, the variables mean of the standard deviations of all the NN intervals for each 5 min segment of a 24-hour heart rate variability recording, root mean square of differences between adjacent normal RR intervals, expressed in ms, and low frequency were independently associated with the number of sexual activities per week ($B = 2.89 \pm 1.02$, 95% CI = 0.866-4.91, $P = .005$; $B = 4.57 \pm 1.83$, 95% CI = 0.94-8.2, $P = .014$; and $B = 1174.9 \pm 592.2$, 95% CI = 2.9-2346.9, $P = .049$, respectively).

Conclusion: In healthy menopausal women, continued sexual activity with penile–vaginal intercourse is associated with better health outcomes on cardiac autonomic function through higher heart rate variability, an index of parasympathetic activity.

Keywords: Menopause, penile-vaginal intercourse, heart rate variability, autonomic nervous system

INTRODUCTION

Menopause is a life period that begins with the decline in ovarian functions and the loss of reproductive ability in women of advancing age.[1] During menopause, which covers approximately one-third of women's lives, different psychological and physiological problems may occur.[2] Sexual dysfunction due to psychological and physiological reasons is observed at a high rate during menopause.[3] It is also associated with an increased cardiovascular risk due to decreased estrogen levels.

Heart rate variability (HRV) is a non-invasive measure used to evaluate the effect of the sympathetic and parasympathetic branches of the autonomic nervous system on cardiac function. It refers to the measurement of beat to beat changes in heart rate (HR).[4] The time and frequency domain components of HRV have been used to assess prognosis in patients with different types of heart disease. The decrease in HRV is associated with high triglyceride levels, insulin resistance,[5] and

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Received: October 18, 2021
Accepted: February 7, 2022
Available Online Date: May 10, 2022

Cite this article as: Tolunay H, Yıldırım E, Gökoğlan Y, et al. The Relationship Between Sexual Activity and Heart Rate Variability in Menopausal Women. *Anatol J Cardiol.* 2022;26(7):543-551.

DOI:10.5152/AnatolJCardiol.2022.1180

metabolic syndrome,[6] and has prognostic significance for cardiovascular diseases.[7] There are also studies evaluating HRV in healthy individuals. Certain foods, nutrients, and dietary styles have been found to affect HRV, for example, high intakes of saturated or trans fats and carbohydrates have been found to reduce HRV.[8] In the study conducted to evaluate the work stress of surgeons in outpatient clinic and operating room conditions, HRV parameters were compared by attaching rhythm Holter to physicians in both conditions. Heart rate variability parameters were found to be significantly lower in the operating room.[9]

Sexual activity is a fundamental element of quality of life. There are studies examining the link between a sexually active life and progressive aging.[10,11] In women in the menopause period, a decrease in sexual desire can be observed due to hormonal changes and related menopausal symptoms. However, the successful confrontation of women with the markers of aging, knowing, and further defining the beneficial effects of PVI in terms of heart health in healthy population may be an important element that increases the motivation of life of women in this period and supports a healthy life.

Although there are studies evaluating the relationship between PVI and HRV in sexually active young patients, the relationship between PVI and HRV has not been defined in menopausal women.[12,13]

The aim of this study is to compare sexually active (only PVI but not masturbation or non-coital sex with a partner) and sexually inactive natural postmenopausal women aged 45-60 years without chronic disease in terms of time and frequency domain parameters in 24-hour electrocardiography (ECG) Holter analysis.

METHODS

The study was designed as a prospective cohort study. Approval was obtained from the Clinical Research Ethics Committee dated June 25, 2020, and protocol number E1-20-815. Natural menopausal female patients aged 45-60 years, who did not have any pathology in their clinical and laboratory findings, did not have any concomitant chronic disease, and did not have pathology in the basal electrocardiogram and cardiac examination were examined. Patients with coronary artery disease, diabetes mellitus, hypertension, heart failure, chronic liver, kidney disease, and cancer diagnosis, those diagnosed with anemia, hypothyroidism, and hyperthyroidism, those using drugs effective on rhythm, those taking hormone replacement therapy, those with acute or chronic infection, patients who use alcohol and actively smoke, and patients with pathology other than rare extrasystole in rhythm Holter were excluded from the study.

Among those who met the inclusion criteria, 130 patients who agreed to participate in the study were included. Patients with pathology in echocardiography were excluded from the study. Female patients who exercise regularly were not included in the evaluation due to their very small number. Patients with simultaneous masturbation and non-coital sexual activity and patients with multiple partners were not included in the evaluation due to their small number. The patients included in the study were housewives with similar average daily sleep, nutrition, and activity levels according to their own statements.

Menopausal age, marital status, and number of children were questioned. Menopause Rating Scale (MRS) consisting of 11 questions was applied to all patients. At the same time, the average weekly PVI numbers remembered in the last 1 year were questioned. According to the weekly PVI number, the patients were divided into 2 groups as sexually inactive and sexually active patients. Afterward, sexually active patients were divided into subgroups as 1 day per week and 2 days or more per week. The clinical and laboratory data of the patients were recorded. Heart rate variability, time, and frequency domain parameters were evaluated with 24-hour ECG rhythm Holter analysis.

Biochemical Analysis

Demographic and clinical variables of the study population were recorded. Fasting blood glucose, blood urea nitrogen, serum creatinine, total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, triglyceride, white blood cell, and hemoglobin values were recorded from blood samples taken at admission to the hospital. Body mass index (BMI) was calculated using the formula: BMI = body weight/(height)^2.

Rhythm Holter Analysis

24-hour Holter electrocardiography data were evaluated using a 5-lead Holter device (DR181 Digital Recorder, 3-channel Holter, NorthEast Monitoring, Inc., USA) to assess HRV. Holter recordings of all cases for HRV analysis were manually evaluated to exclude artifacts. Heart rate variability time and frequency domain parameters were obtained from the existing Holter recordings of all patients by automatic analysis method. Heart rate variability time criteria, standard deviation of all NN intervals (SDNN), standardization of all NN intervals in 5-minute recordings (SDNN index), number of contiguous NN intervals with a difference of more than 50 ms during the entire recording (NN50), NN 50 number to the total number of NNs (% pNN50), and square root of the sum of squares differences of consecutive NN intervals

HIGHLIGHTS

- Menopause covers an important part of a woman's life in which the risk of cardiovascular disease increases with the decrease in estrogen protection. Sexual problems and a decrease in penile–vaginal intercourse (PVI) are common during menopause.
- Heart rate variability (HRV) is an important parameter that predicts the sympathetic and parasympathetic balance of the autonomic nervous system and has been shown to correlate with prognosis in many diseases.
- In healthy menopausal women, PVI is associated with increased HRV time and frequency domain parameters and better health outcomes on cardiac autonomic function.

(RMSSD) parameters were measured. Frequency domain parameters, high frequency (HF), and low frequency (LF), and LF/HF ratio were recorded.[14]

Menopause Rating Scale

The MRS Scale developed in 1992 by Schneider et al was developed to measure the severity of menopausal symptoms. In the scale, which consists of 11 items in total including menopausal complaints, there are options for each item: "0=None," "1=Mild," "2=Moderate," "3=Severe," and "4=Very Severe." The total score of the scale is calculated based on the scores given for each item. The lowest score that can be obtained from the scale is 0, and the highest score is 44. The increase in the total score obtained from the scale indicates the increase in the severity of the complaints.[15]

Statistical Analysis

Statistical analyses were done using International Business Machines (IBM) Statistical Package for the Social Sciences Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as numbers and percentages for categorical variables, mean ± standard deviation, and median [interquartile range (Q1-Q3)] for continuous variables. Normal distribution for continuous variables was assessed with visual (histograms and probability graphics) and analytic methods (Kolmogorov–Smirnov test). The Mann–Whitney *U* test was used for the comparison of datasets that were not normally distributed for the variables. Independent samples *t*-test was used for the comparison of datasets that were normally distributed for the variables. Spearman correlation was used to test the correlation between the number of weekly sexual activities and HRV parameters. The associations of HRV parameters with the number of weekly sexual activities were evaluated by multivariate linear regression analysis by adjusting for age, BMI, and menopause duration. The *B* coefficients, R^2, and partial correlation coefficients were calculated for each HRV parameter. Chi-square tests were used for the comparison of categorical variables between groups. $P < .05$ was considered statistically significant.

RESULTS

The mean age of 130 patients included in the study was 53.0 ± 4.5. The mean age at menopause was 47.4 ± 3.5 years, and the mean duration of menopause was 5.7 ± 3.8 years. The number of married patients was 110 (84.6%). The number of patients with PVI was 80 (61.5%). The number of patients with a PVI of 1 per week was 50 (38.5%), and the number of patients with a PVI of 2 or more was 30 (23.1%). Among women with PVI, 67 patients (83.7%) reported varying degrees of dyspareunia and 58 patients (72.5%) reported decreased sexual activity after menopause. In the group with PVI, the MRS median score was significantly lower [16 (12-19), $P < .001$], and the BMI median value was significantly higher [28.7 (25.8-33.3), $P = .041$]. Demographic and laboratory data according to the PVI status of the patients are summarized in Table 1.

Table 1. Evaluation of Demographic Characteristics and Laboratory Data According to Penile–Vaginal Intercourse Status

	All Patients (n=130)	PVI (–) (n=50)	PVI (+) (n=80)	*P*
Age, years (mean ± SD)	53.03 ± 4.5	53.9 ± 4.1	52.5 ± 4.7	.065*
Age of menopause, years (mean ± SD)	47.4 ± 3.5	47.5 ± 3.4	47.3 ± 3.6	.770*
Menopause duration, years (median (IQR))	5 (2-9)	5.5 (2-10)	4 (2-8)	.061**
Married, n (%)	110 (84.6)	31 (62.0)	79 (98.8)	**<.001*** **
Number of children, median (IQR)	2 (2-2)	2 (1-2.3)	2 (2-3)	**.004****
MSRS score, median (IQR)	17 (14-20)	19.5 (17-22)	16 (12-19)	**<.001****
BMI, kg/m^2, median (IQR)	28 (25.6-31.7)	27.4 (24.5-30)	28.7 (25.8-33.3)	**.041****
WBC, kg/m^2, median (IQR)	6.5 (5.7-7.5)	6.5 (5.6-7.3)	6.5 (5.9-7.9)	.200**
Hb, g/dL, median (IQR)	13.5 (12.8-14.4)	13.5 (12.8-14.4)	13.7 (12.8-14.4)	.994**
Fasting glucose, mg/dL, median (IQR)	94 (87-104)	95.5 (86-105)	93.5 (87.3-102)	.926**
BUN, mg/dL, median (IQR)	26 (23-31)	26 (23-33)	26 (22-31)	.285**
Creatinine, mg/dL, median (IQR)	0.78 (0.7-0.86)	0.79 (0.73-0.85)	0.78 (0.7-0.87)	.369**
TC, mg/dL, median (IQR)	218.5 (193.7-242)	221 (199.3-242)	217 (193-243.8)	.712**
LDL, mg/dL, median (IQR)	134 (113.8-151)	137.5 (120.8-151)	132.5 (107.8-150.8)	.256**
HDL, mg/dL, median (IQR)	54 (48-59)	54 (48-57.3)	54 (49-60)	.565**
Triglyceride, mg/dL, median (IQR)	144 (99-208.5)	125 (92.8-163.5)	153.5 (100-217.5)	.120**

*Independent samples *t* test; **Mann–Whitney *U* test;
***Chi-square test.
Continuous variables are expressed as either mean ± SD or the median (IQR): Q_1-Q_3. Statistically significant *P*-values are given in bold.
BMI, body mass index; BUN, blood urine nitrogene; HDL, high density lipoprotein; Hb, hemoglobin; LDL, low density lipoprotein; MSRS, Menopause Symptoms Assessment Scale; WBC, white blood cell; TC, total cholesterol; PVI, penile–vaginal intercourse; SD, standard deviation; IQR, interquartile range.

Heart rate variability parameters were higher in the group with PVI than in the group without PVI [SDNNI: 45.1 ± 9.8, 51.4 ± 12.7, *P* = .004; RMSSD: 20.1 (15.9-27.6), 27.6 (19.6-41.1), *P* = .001; NN50: 1765 (774.3-4978), 3208 (1677-7087), *P* = .011; pNN50: 1.8 (0.8-4.4), 3.6 (1.5-7.6), *P* = .009; LF: 1015 (641.3-1759.8), 1430 (950-2881), *P* = .011, HF: (376 (184-979.5), 570 (340-1620.8), *P* = .008, LF/HF: 2.7 (2.1-3.4), 2.4 (1.7-2.9), *P* = .018, respectively]. The relationship of HRV time and frequency domain parameters according to sexual activity status is summarized in Table 2.

When the relationship between weekly PVI number and HRV parameters was evaluated by correlation analysis, a positive and weak-moderate correlation (range, r = 0.207-0.331) was found between SDNNI, RMSSD, NN50, PNN50, LF, HF, and PVI number (Table 3). Scatter plots of the relationships between HRV parameters and weekly PVI number are shown in Figure 1.

Patients with PVI were divided into 2 groups as 1 PVI per week and ≥2 PVI per week. There was no statistically significant difference between the number of weekly PVI and HRV frequency domain parameters. Square root of the sum of squares differences of consecutive NN intervals and maximum HR were significantly higher in patients with ≥2 PVI per week than those with PVI once per week (*P* = .035 and *P* = .016, respectively) (Table 4). The relationship between weekly PVI number and HRV time and frequency domain parameters is shown in Figure 1.

A weak negative correlation was found between the duration of menopause and the number of sexual activities per week (r = −0.207, *P* = .018), SDNNI (r = −0.224, *P* = .010), and RMSSD (r = −0.190, *P* = .030) (Table 5). In terms of the association between HRV parameters and weekly PVI number, each HRV parameter was evaluated by multiple linear regression analysis by adjusting age, BMI, and menopause duration. When the *B* coefficients, R^2, and partial correlation coefficients in Table 6 were examined, it was determined that the SDNNI, RMSSD, and LF variables were independently associated with weekly number of PVI (*B* = 2.89 ± 1.02, 95% CI = 0.866-4.91, *P* = .005; *B* = 4.57 ± 1.83, 95% CI = 0.94-8.2, *P* = .014; and *B* = 1174.9 ± 592.2, 95% CI = 2.9-2346.9, *P* = .049, respectively).

DISCUSSION

In this study, it was shown that PVI may provide cardiac protection by causing an increase in HRV in menopausal healthy women aged 45-60 years. This effect was independent of age, duration of menopause, and BMI. The increased number of weekly PVIs in sexually active patients did not cause a further significant increase in parameters other than RMSSD in HRV.

Heart rate variability is a method used to evaluate regulation by the parasympathetic and sympathetic divisions of the autonomic nervous system. The LF is believed to reflect both sympathetic and vagal action and is associated with baroreflex sensitivity. Square root of the sum of squares differences of consecutive NN intervals, percentage of adjacent RR intervals with a difference of duration >50 ms, and high frequency are thought to represent parasympathetic activation. There are no HRV parameters that reflect sympathetic modulation alone. Sympatovagal balance is often defined by the LF/HF ratio.[4,16]

Age and gender are the main determinants of HRV. Frequency domain parameters decrease with aging and menopause, which can be explained by the decrease in the effect of estrogen on the autonomic nervous system.[17]

There are studies showing that increased HRV is an indicator of parasympathetic activity and is associated with mental and physical health and life expectancy.[14,18] It has been proven

Table 2. Time and Frequency Domain Parameters of Heart Rate Variability According to Penile–Vaginal Intercourse Status

	All Patients (n = 130)	PVI (−) (n = 50)	PVI (+) (n = 80)	*P*
SDNN, ms, mean ± SD	128.4 ± 31.2	128.2 ± 27.7	128.6 ± 33.4	.934*
SDNNI, ms, mean ± SD	48.9 ± 12.1	45.1 ± 9.8	51.4 ± 12.7	**.004***
RMSSD, ms, median (IQR)	24.5 (18.6-36.9)	20.1 (15.9-27.6)	27.6 (19.6-41.1)	**.001****
NN50, n, median (IQR)	2583 (1189-6325)	1765 (774.3-4978)	3208 (1677-7087)	**.011****
PNN50, %, median (IQR)	2.6 (1.02-6.3)	1.8 (0.8-4.4)	3.6 (1.5-7.6)	**.009****
LF, ms^2 ,median (IQR)	1309 (767.3-2317.5)	1015 (641.3-1759.8)	1430 (950-2881)	**.011****
HF, ms^2 ,median (IQR)	513 (288.5-1220.8)	376 (184-979.5)	570 (340-1620.8)	**.008****
LF/HF, %, median (IQR)	2.5 (1.7-3.04)	2.7 (2.1-3.4)	2.4 (1.7-2.9)	**.018****
Min. HR, mMean ± SD	51.2 ± 6.1	51.8 ± 6.2	50.9 ± 6	.364*
Max. HR, mean ± SD	131.1 ± 14.1	134.5 ± 15.7	130.5 ± 12.7	.123*
Mean HR, mean ± SD	77 ± 7.3	77.5 ± 7.4	76.7 ± 7.2	.566*

*Independent samples *t* test;**Mann–Whitney *U* test. Continuous variables are expressed as either mean ± SD or the median (IQR): Q_1-Q_3. Statistically significant *P*-values are given in bold.

HR, heart rate; HF, high frequency; LF, low frequency; min, minimum; max, maximum, pNN50, percentage of adjacent RR intervals with a difference of duration >50 ms; RMSSD, root mean square of differences between adjacent normal RR intervals, expressed in ms; SDNN, standard deviation of all normal RR intervals, expressed in milliseconds; SDNNI, mean of the standard deviations of all the NN intervals for each 5 minutes segment of a 24-hour HRV recording; PVI, penile–vaginal intercourse; SD, standard deviation; IQR, interquartile range.

Table 3. Correlation Coefficients Between Number of PVI and HRV Parameters

	Number of PVI	
	Spearman Correlation Coefficient	***P***
SDNN	0.032	.721
SDNNI	**0.246**	**.005**
RMSSD	**0.331**	**<.001**
NN50	**0.220**	**.012**
PNN50	**0.234**	**.007**
LF	**0.224**	**.010**
HF	**0.207**	**.018**
LF/HF	−0.167	.058
Min. HR	−0.067	.449
Max. HR	−0.031	.730
Mean HR	−0.041	.641

Statistically significant *P*-values are given in bold. HR, heart rate; HRV,heart rate variability; HF, high frequency; LF, low frequency; min, minimum; max, maximum; pNN50, percentage of adjacent RR intervals with a difference of duration >50 ms; RMSSD, root mean square of differences between adjacent normal RR intervals, expressed in ms; SDNN, standard deviation of all normal RR intervals, expressed in milliseconds; SDNNI, mean of the standard deviations of all the NN intervals for each 5 minutes segment of a 24-hour HRV recording; PVI, penile–vaginal intercourse.

that an increase in sympathetic activity and a decrease in parasympathetic activity and autonomic nervous system imbalance are associated with an increased risk of cardiac mortality.[19] It is also a prospective predictor of hypertension, diabetes, cardiovascular diseases, and cancer.[18,20] In the study evaluating the relationship between hyperlipidemia and sexual activity in perimenopausal women, HDL cholesterol and triglyceride levels were independently associated with the sexual function score.[21] In our study, no significant relationship was found between sexual activity status and lipid parameters during menopause.

The protective effect of regular physical exercise in terms of cardiovascular diseases is known.[11] Sex is a type of exercise with a stronger isometric aspect that includes body movements. Various studies show that sexual activity has psychological and physiological benefits that can even be compared to exercise in terms of health.[22] Sexual activity occurs with the coordination of sympathetic and parasympathetic activities, and cardiac functions are affected in this process.[23] During PVI, blood pressure and HR increase. It has been shown that the highest blood pressure level occurs at the beginning of the plateau phase, not at orgasm, and decreases rapidly. Sexual activity in adult men and women has been shown to provide moderate levels of physical stress comparable to stage 2 for men and stage 1 for women of the standard multi-stage Bruce treadmill protocol.[24] Sexual activity can provide multi-faceted protection in menopausal women by both affecting the sympathovagal balance and providing physical exercise.

In a study that examined the relationship between daily recorded PVI frequency and HRV and diastolic blood pressure in 120 healthy adults aged 19-38 years, higher HRV was associated with higher PVI but not with non-coital sexual activity and masturbation.[12,13] The parasympathetic nervous system transmits sensory information from the cervix and vagina to the brain via the vagus.[25] This is an important explanation for the increase in HRV due to increased parasympathetic activity with regular PVI. In these studies, HRV was grouped only as low and high, and time and frequency domain parameters were not evaluated. Also, it has been found that the use of condoms can reduce the benefits of PVI.[26] Since our patients were in the menopause period and were not at risk of sexually contagious diseases, there were no patients who used condoms.

In a study conducted to evaluate the features of cardiovascular autonomic control in pre- and post-menopausal women, no significant relationship was found between autonomic indices, which are also considered cardiovascular risk factors, and the characteristics of menopausal status. A weak correlation was found between autonomic indices and duration of menopause, similar to our study data.[27] In addition, in our study, in terms of the relationship between HRV parameters and the number of weekly PVI, each HRV parameter was evaluated by multiple linear regression analysis by adjusting age, BMI, and menopause time. Standard deviation of all NN intervals, square root of the sum of squares differences of consecutive NN intervals, and less frequency variables were found to be independently associated with the number of weekly PVIs. Available data minimize the role of other confounding factors in the effect of continued sexual activity at menopause on HRV.

Although studies have shown that the frequency of sexual intercourse is associated with cardiovascular health,[15,16] the possibility that decreased sexual activity may also be associated with underlying cardiovascular disease makes it difficult to interpret the results. For this reason, patients who do not have chronic diseases during menopause and who do not have additional confounding risk factors that may affect HRV parameters such as smoking and alcohol were evaluated in our study.

Cardiac and metabolic activation during sexual intercourse will vary according to the type of sexual activity.[28] In our study, all our patients were monogamous. In addition, all patients stated that they were in a passive position in PVI. As stated in previous studies, PVI is an activity where sympathetic and parasympathetic activation are combined and may require effort between isometric exercise and maximum exercise levels depending on the passive and active position.[29,30] In our study, although the participants declared that they were in the passive position, there was an isometric exercise that continued in the passive position. The duration and intensity of isometric contractions can be related to orgasm duration regardless of position. The presence of PVI during

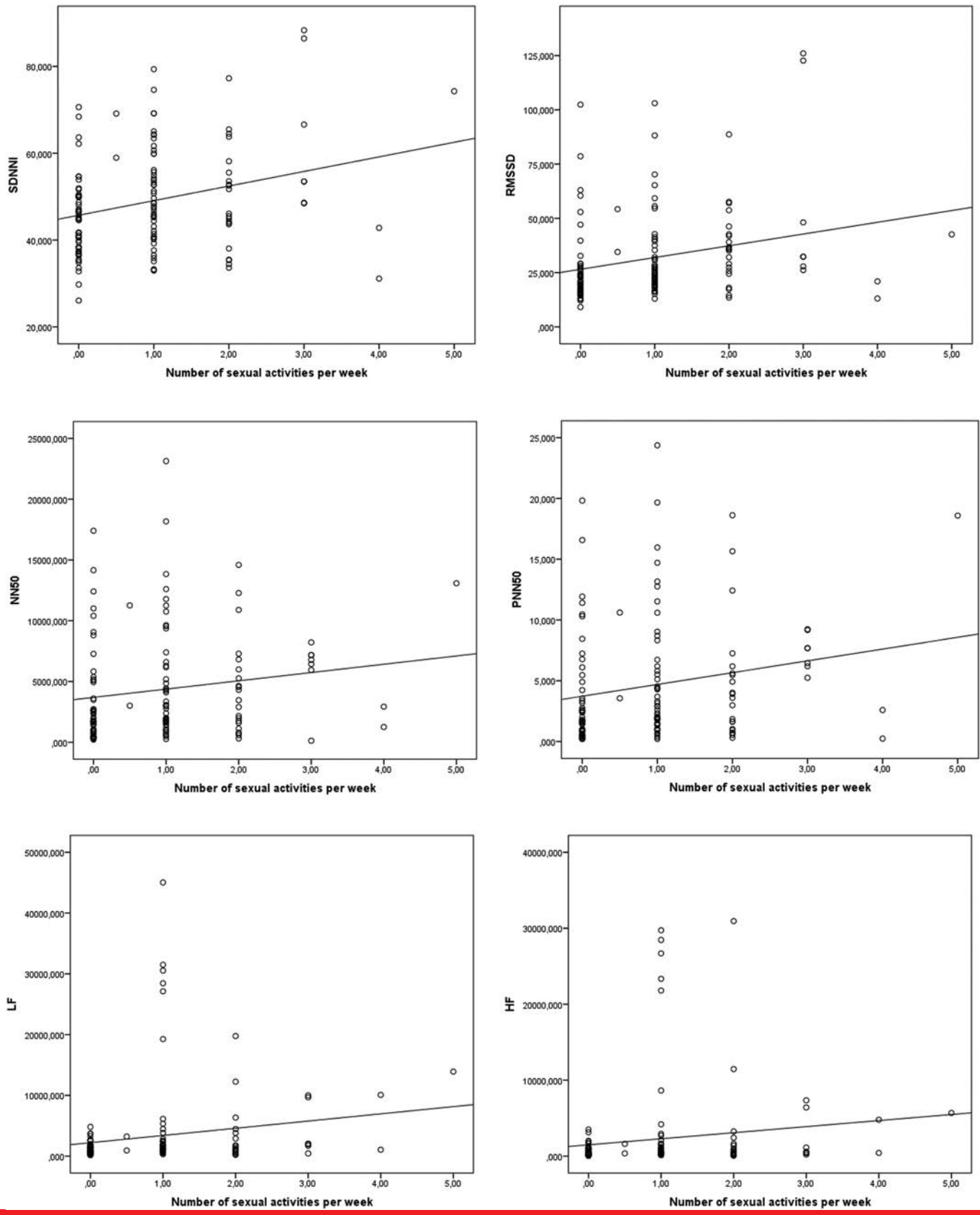

Figure 1. Scatter plots of the relationships between HRV parameters and weekly PVI number. HRV, heart rate variability; PVI, penile-vaginal intercourse.

Table 4. The Relationship Between the Number of Weekly PVI and HRV Parameters

	PVI (1 Per Week) (n = 50)	PVI ≥ 2 Per Week (n = 30)	*P*
SDNN, mean ± SD	128.7 ± 30.6	128.5 ± 38.2	.978*
SDNNI, mean ± SD	50.5 ± 11.2	52.7 ± 15.1	.460*
RMSSD, median (IQR)	24.5 (19.2-35.9)	35.5 (24.4-46.7)	**.035**±
NN50, median (IQR)	3010 (1685-6795.3)	4430 (1512-7178)	.706±
PNN50, median (IQR)	3 (1.5-7.1)	4.5 (1.5-7.7)	.676±
LF, median (IQR)	1382(1004-2610.3)	1589 (657-39-3967)	.626±
HF, median (IQR)	640.5 (381.5-1602)	456.5 (302.8-1829.3)	.294±
LF/HF, mean ± SD	2.4 (0.8-5.4)	2.5 (1.1-4.9)	.415*
Min. HR, mean ± SD	50.3 ± 5.9	51.8 ± 6.1	.282*
Max. HR, mean ± SD	127.9 ± 11.9	132.5 ± 13.1	**.016***
Mean HR, mean ± SD	76.2 ±6.9	77.5 ± 7.6	.434*

*Independent samples *t* test;±Mann–Whitney *U* test.
Continuous variables are expressed as either mean ± SD or the median (IQR): Q_1-Q_3. Statistically significant *P*-values are given in bold. HR, heart rate; HF, high frequency; LF, low frequency; min, minimum; max, maximum; pNN50, percentage of adjacent RR intervals with a difference of duration >50 ms; RMSSD, root mean square of differences between adjacent normal RR intervals, expressed in ms; SDNN, standard deviation of all normal RR intervals, expressed in milliseconds; SDNNI, mean of the standard deviations of all the NN intervals for each 5 minutes segment of a 24-hour HRV recording; PVI,penile–vaginal intercourse; SD, standard deviation; IQR, interquartile range.

menopause was associated with higher HRV, although all patients were in the passive position. This effect is expected to become evident when the woman is in an active position and with the presence of orgasm, but this prediction needs to be supported by further studies.

According to our study data, being sexually active in healthy menopausal women was associated with a significant increase in HRV time and frequency domain parameters, which are determinants of sympathovagal balance. However, when sexually active individuals were evaluated according to weekly PVI frequency, no significant difference was observed between weekly PVI number and HRV parameters other than RMSSD. In the postmenopausal period, genital atrophy, vaginal dryness, and burning affect sexual functions negatively.[31] For the patients in our study group, it was observed that the sexual activity they experienced was perceived as a disturbing element rather than a pleasurable and relaxing element. While the presence of PVI is associated with a significant increase in HRV parameters, the absence of linear increase in HRV parameters with the increase in PVI number can be explained by this. According to our study data, a significant increase in maximum HR was observed when the weekly PVI number increased. This may be due to reverse causation. In other words, it can be thought that the weekly PVI number of women with dominant sympathetic activity is high and parasympathetic activation is provided with increasing PVI.

Table 5. Relationship Between Menopause Duration and Sexual Activity and HRV Parameters

	Menopause Duration	
	Spearman Correlation Coefficient	*P*
PVI	**−0.207**	**.018**
SDNN	−0.080	.367
SDNNI	**−0.224**	**.010**
RMSSD	**−0.190**	**.030**
NN50	−0.108	.223
PNN50	−0.136	.124
LF	−0.113	.201
HF	−0.104	.240
LF/HF	0.031	.728
Min. HR	0.072	.417
Max. HR	−0.168	.055
Mean HR	−0.009	.921

Statistically significant *P*-values are given in bold. HR, heart rate; HRV,heart rate variability; HF, high frequency; LF, low frequency; min, minimum; max, maximum; pNN50, percentage of adjacent RR intervals with a difference of duration >50 ms; RMSSD, root mean square of differences between adjacent normal RR intervals, expressed in ms; SDNN, standard deviation of all normal RR intervals, expressed in milliseconds; SDNNI, mean of the standard deviations of all the NN intervals for each 5 minutes segment of a 24-hour HRV recording; PVI, penile–vaginal intercourse.

On the other hand, an increase in adrenaline and noradrenaline levels has been shown in male and female subjects during sexual arousal and orgasm.[32] Sudden sympathetic activation during coitus has been associated with spontaneous repolarization, development of arrhythmias, and sudden cardiac death. It has been suggested that sexual intercourse carries a degree of danger in individuals at risk, and the risk of myocardial infarction increases 2.5-5 times within 2 hours immediately after coitus.[33] Therefore, our study results are indicative of healthy women in the menopausal period, and further studies are required for the effect of sexual activity on HRV in those in the cardiac risk group.

Study Limitations

To determine patients' sexual activity scores, we wanted to apply validated questionnaires assessing key dimensions of female sexual function. However, a detailed evaluation of their sexual life could not be performed because the patients did not accept it. In addition, the patients included in the evaluation were passive participants in PVI,

Table 6. Multivariate Linear Regression Analysis Data for Association Between Number of PVI and HRV Parameters (Adjusted for Age, BMI, and Menopause Duration)

	B coefficient ± *SE*	95% CI	*P*	R^2	Partial Correlations Coefficient
SDNN	3.62 ± 2.8	−1.93 to 9.16	.199	0.021	0.115
SDNNI	2.89 ± 1.02	0.866 to 4.91	**.005**	**0.126**	**0.245**
RMSSD	4.57 ± 1.83	0.94 to 8.2	**.014**	**0.111**	**0.217**
NN50	569.9 ± 387.2	−196.6 to 1336.4	.144	0.058	0.130
PNN50	0.86 ± 0.44	0.05 to 1.73	.051	0.056	0.173
LF	1174.9 ± 592.2	2.9 to 2346.9	**.049**	**0.062**	**0.175**
HF	761.6 ± 505.6	−239.1 to 1762.2	.135	0.047	0.134
LF/HF	−0.99 ± 0.08	−0.27 to 0.07	.243	0.019	−0.104
Min. HR	−0.24 ± 0.55	−1.3 to 0.8	−.039	0.008	0.662
Max. HR	−0.89 ± 1.22	−3.3 to 1.5	−.065	0.082	0.469
Mean HR	−0.48 ± 0.66	−1.7 to 0.8	−.066	0.017	0.463

Statistically significant *P*-values are given in bold. CI, confidential interval; *B* coefficient, regression coefficient; S.E., standard error; R^2, the proportion of the variation in the dependent variable that is predictable from the independent variable; HR, heart rate; HF, high frequency; LF, low frequency; min, minimum; max, maximum, pNN50, percentage of adjacent RR intervals with a difference of duration > 50 ms; RMSSD, root mean square of differences between adjacent normal RR intervals, expressed in ms; SDNN, standard deviation of all normal RR intervals, expressed in milliseconds; SDNNI, mean of the standard deviations of all the NN intervals for each 5 minutes segment, HRV, heart rate variability; PVI, penile–vaginal intercourse.

and patients with active participation could not be evaluated. Also, the absence of sex hormone levels is one of the important limitations of the study. Orgasm was questioned for all patients. But some patients did not want to answer this question. Therefore, as sufficient data could not be reached, no comment could be made regarding the presence of orgasm.

CONCLUSION

In healthy post-menopausal women aged 45-60 years, PVI may have a positive effect on cardiac autonomic functions as determined by HRV, independent of age, menopause duration, and BMI. Based on the data of our study, it is important to establish training programs and inform this population regarding the importance of continued sexual activity in the post-menopausal period.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Ankara City Hospital (approval no: E1-20-815).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.T.; Design – E.Y.; Supervision – A.S.Y.; Materials – B.B., H.T.; Data collection &/or processing – Y.G., B.B.; Analysis &/or interpretation – H.T.; Literature search – Y.G.; Writing – H.T.; Critical review – M.C., U.C.Y., H.K.K., C.B.

Acknowledgments: We thank Ahmet Arslan for his support on rhythm holter monitoring.

Declaration of Interests: The authors declare that they have no competing interest.

Funding: This study received no funding.

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